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Mathematics in England's Further Education Colleges: an analysis of policy enactment and practice

The Mathematics in Further Education Colleges Project:

Interim report 2

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1. Executive summary

The importance of mathematical skills to individuals, to the economy and to society, is widely agreed and well documented. Improving the skills base in England is therefore a national priority as evidenced in the Industrial Strategy[1]. At one level this includes concerns for increasing engagement with A-level and other Level 3 mathematics qualifications (e.g. Core Maths). Yet it is in England's General Further Education Colleges (GFECs[2]) that the drive to improve the nation's mathematical skills is being most sharply felt. Here the Condition of Funding[3] (commonly referred to as the GCSE re-sit policy) is aiming to tackle low prior attainment and maximise GCSE passes at grade 4.

Mathematics education in this sector is critical to addressing national skills needs but is under-researched and poorly understood, as highlighted in Professor Sir Adrian Smith's Treasury-commissioned report (2017)[4]. The majority of 16-18-year-old students with low prior attainment in mathematics are studying in general FE colleges, mostly on vocational study programmes. Their progress with mathematics remains slow with only 18.7% of 16-18-year-olds re-sitting GCSE mathematics in 2018 achieving the required grade[5].

The Mathematics in Further Education Colleges Project (MiFEC) comprises the latest and most extensive research analysis of the state of mathematics education in England's FE colleges. The first Interim Report (December 2018) focused on a national survey of the mathematics teacher workforce. This second Interim Report is a wide-ranging analysis of policy enactment and practice in a sample of 32 English FE colleges from 2017 to 2019. The project's Final Report (due summer 2020) will synthesise the project findings and make recommendations for stakeholders including policymakers, college managers, curriculum leaders and Continuing Professional Development (CPD) providers.

This Interim Report sets out the challenges faced by colleges when enacting post-16 mathematics qualifications policy. It explores how variations in context, curriculum, management, organisation, pedagogy, attitudes and aspirations blend to shape learner experiences and outcomes. There are important differences between mathematics education in FE colleges and schools, including the nature of the student cohort, the organisation of educational provision and the teaching and learning approaches used. These differences have important implications for improving student outcomes.

The case study analysis reported herein addresses several of the project's research questions:

- How do FE colleges *mediate*, *moderate* and *modulate* government policy on post-16 mathematics education?
- What different strategies have been employed?
- How has/is funding shaping college policy and classroom experience?

[1] BEIS. 2017. Industrial Strategy: building a Britain fit for the future. London: HMSO.
[2] 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
[3] The Condition of Funding (commonly referred to as the GCSE retake, or re-sit policy) made it compulsory from September 2014 for students without GCSE Grade C (now Grade 4) to either retake GCSE mathematics or undertake a 'stepping stone' mathematics qualification, with the aim of then progressing on to a GCSE retake course.
[4] Smith, Adrian. 2017. "Report of Professor Sir Adrian Smith's review of post-16 mathematics." London: DfE.
[5] DfE. 2019. Revised A level and other 16-18 results in England, 2017/2018. London: DfE.

- What are the workforce strengths and limitations?
- How is curriculum and assessment changing?
- What are the possible unintended consequences of policy upon classrooms?

The 32 case study general FE colleges were either single providers or part of a college group and comprised around one sixth of 187 similar providers at the time (Sept 2017). This sample was stratified across the nine regions of England and based on key selection criteria: size (number of 16-18s); type of provision (vocational only or academic and vocational); location (e.g. *urban major* or *minor conurbation*); mathematics progress measure and most recent Ofsted grade.

Each case involved at least one face-to-face visit, during which individual interviews were carried out with senior leaders, managers, mathematics teachers and vocational staff as well as focus groups with students. In total the field work involved 44 site visits, 238 interviews and 62 student focus groups[6]. Documentary evidence was also provided by colleges on their structures, staffing and strategies for mathematics. Data was also collected about adult and academic provision but the dominance of GCSE and Functional Skills in policy discourse and college provision means that this is the main focus of this report. Although the interview data comprise the subjective points and angles of view of a range of actors (e.g. managers, teachers, students), the scale of the dataset, overlapping design of interview schedules and triangulation through reference to other data sources produces a comprehensive and trustworthy dataset. Whilst we cannot claim statistical generalisability we do aim for analytic generalisability.

1.1 Main findings

The main report begins with three anonymised college case reports that have been selected as a means of introducing some of the main issues faced by FE colleges. These are followed by more in-depth cross-case analysis of the full set of studies, organised into nine themes. The key points from these themes are summarised below.

1.1.1 College contexts and curriculum offers affect mathematics provision

The FE colleges in the study do not all offer the same range of vocational and academic qualifications. This affects the size and profile of mathematics provision but also impacts on teaching, since motivation to study mathematics and general study skills vary between students on different types and levels of study programme. The distribution of college provision across sites also has an impact on mathematics teachers' working practices due to variations in site cultures and resources that impact on itinerant or site-based teachers in different ways. At an institutional level, contextual differences between colleges mean that the challenges for providers with mathematics are not the same but this is not taken into account in comparisons of college performance (i.e. maths progress measure, GCSE high grade achievement).

The mathematics qualifications and progression pathways that the colleges offer to their 16-18-year-olds are not the same, which leads to variations between colleges in students' experiences of mathematics. Although colleges in the study state that students' needs are

[6] The analysis of data from the student focus groups is not included in this report but will form the basis of a separate working paper

considered, decisions are also influenced by college comparisons of performance and the efficacy of the qualifications.

1.1.2 Leadership and management of mathematics is a whole college responsibility

The management of mathematics in the case study colleges involves a sharing of responsibility between mathematics and vocational staff. Active involvement of senior leaders, in collaboration with staff at different levels, is important to support implementation and staff well-being. Full commitment from vocational staff is vital to ensure strategies and systems for mathematics provision are implemented effectively. Cross-college managers of mathematics are key players who carry out distinctive and complex roles in these shared responsibility systems. There is little evidence of any specific training for these positions but there are strong indications of the need for better understanding of these roles and a bespoke training scheme.

Structural arrangements for the management and staffing of mathematics vary widely between these colleges. A range of models is in use, each with desirable and undesirable consequences. An evaluation of the advantages and disadvantages of these models, alongside college priorities and contextual constraints, is needed to determine the 'best fit' for an individual college. Colleges would benefit from guidance on this process and how to plan accompanying actions to minimise the disadvantages of their chosen model.

1.1.3 Operational strategies are complex and dependent on the college context

Designing and maintaining effective operational systems and processes for mathematics is a complex and time-consuming task due to the size and dispersion of provision. The colleges in the study work hard to timetable mathematics in ways that will encourage good attendance, often fitting the rest of the study programme around mathematics and English. Decisions about the location of mathematics classrooms and the streaming of classes include considerations of the impact on student learning but college-specific factors such as staffing structures, student numbers and their dispersion across sites limit the practical possibilities. The teaching time allocated varies between colleges but the practice of allocating less time to Functional Skills than GCSE means that the least able students are often disadvantaged. Considerable time and resource are used to follow up on poor attendance, which is considered the largest hindrance to student achievement, but systems and resources are not always adequate for the scale of the task. Inefficiency in general college operations such as enrolment, a delayed start to mathematics courses or extended 'settlement' time for classes at the beginning of the year all result in teaching time being lost for mathematics. Colleges offer a range of additional learning opportunities for those who miss lessons or need extra support but these have limited impact since those in most need are least likely to attend.

1.1.4 Students' backgrounds, prior experiences, attitudes, and aspirations matter

Staff report how family backgrounds and the prevailing culture in the local area influence students' aspirations and values, which lead to different motivations and attitudes to mathematics. Those colleges located in socially deprived areas encounter significant challenges with mathematics, especially when students' intentions are to obtain local low-skilled employment. Those aspiring to more skilled positions or Higher Education for which

GCSE mathematics is an entry requirement typically have stronger motivation, although short-term thinking often prevails. Inconsistency about entry requirements can however undermine the key message that mathematics is important. Students with low aspirations tend to be more convinced about the relevance of mathematics when they understand why it is useful to them. Vocational teachers are seen to be in a strong position to exert positive influences over students through implicit or explicit communication but their commitment to student learning of mathematics varies.

Teachers report that students with prior experiences of failure with mathematics often have negative attitudes, which act as barriers to learning. Mathematics teachers need the skills to address these issues by using pedagogies that are responsive to students' needs, allowing them to build confidence and resilience. The prevalence of insecure foundational mathematical knowledge and under-developed study habits is also a challenge when teaching a one-year revision course. Without personal motivation and a change of attitude to mathematics, colleges find that enforced attendance is unlikely to lead to learning. There can also be a detrimental effect on students with emotional or attitudinal problems from the enactment of a compulsory mathematics policy, resulting in increased demands on mathematics teachers to manage challenging behaviour in classrooms.

1.1.5 Teaching needs adapting in multiple ways to meet students' needs

The majority of mathematics teaching in FE colleges involves students who are retaking mathematics on a GCSE or Functional Skills course. Mathematics teachers in the study identify a need for context-specific variation in teaching, using different adaptive pedagogies and resources to meet students' needs. This includes adaptations designed to engage students, differentiate, contextualise, connect to vocational programmes, align with different vocational pedagogies and make effective use of diagnostic assessment. Teachers' pedagogical choices are also influenced by organisational decisions, which determine the composition of their groups and how rigidly they are expected to adhere to pre-planned schemes and lessons. Teaching mathematics in FE primarily involves working with low-attaining students who consider themselves 'failures' and teachers in the study have concerns that the timescale for demonstrating measurable improvement on retake courses is often unrealistic. Contextual factors mean that teaching GCSE (or Functional Skills) in post-16 education can be very different from teaching the same qualification to pre-16s in school and there is a need for sector-specific training to prepare mathematics teachers for the FE context.

1.1.6 A growing teacher workforce has diverse strengths and development needs

The Condition of Funding has led to changes in the mathematics teacher workforce with more permanent positions and specialist teachers (e.g. teaching GCSE only). The colleges have worked hard to deal with the widespread difficulties of recruiting enough teachers to meet the increase demand. Expanding the workforce at the time of a national shortage of mathematics teachers has required innovative and costly recruitment strategies for colleges. Colleges would benefit from government funding and intervention to attract more teachers into FE mathematics teaching who have the motivation and personal qualities to be successful in this area of education. Mathematics teaching teams typically include teachers from varied backgrounds with diverse skills and experience who have varied training needs depending on their entry route into mathematics teaching in FE. Even those who move into FE mathematics teaching from other settings (e.g. schools) need a transition period, with targeted training, to adapt and develop specific skills for teaching low-attaining students in the FE context. The mathematics teacher workforce is under heavy pressure to produce better results, which can be demotivating and some colleges report that current staffing levels are not sustainable.

1.1.7 Training and professional development needs to be improved

There is wide variation in the quantity and type of CPD provided for mathematics teachers by the case study colleges. Designated additional funding for professional development and a personal CPD entitlement would enable a more consistent approach. Teachers report that formal CPD sessions often focus on general pedagogy without application to their own teaching situation and that CPD from external providers for mathematics is often repetitious, without evidence of impact in the FE sector. The colleges need better information from CPD providers about their offer and evidence of impact in the sector. College managers would also benefit from evidence-based guidance about effective CPD models. Teachers state that they benefit most from informal sharing of ideas in teams and CPD that is directly related to their mathematics classroom practice. There is potential for the stronger college-based professional learning communities and more robust practitioner-led research within FE but colleges need specific training and support to develop these. Teachers identify specific skills that are important to be an effective mathematics teacher in FE, such as engaging disaffected students and managing challenging behaviour, that could be more prominent in initial teacher training and CPD. For vocational teachers, the main CPD need identified is to develop personal confidence with mathematics. Colleges are addressing this in various ways but greater emphasis in initial teacher training would alleviate the need for remedial action later.

1.1.8 Change and consolidation need to be better balanced

The colleges in this study are often managing multiple overlapping changes in policy. In order to develop long-term strategies for improvement in mathematics, more clarity, support and time are needed to embed important changes. The Condition of Funding has had a positive effect by raising the status of mathematics in colleges and increasing the level of shared responsibility. Implementation has however been demanding and costly due to the extensive re-organisation, recruitment and development required. Many respondents report that student behaviour and attitudes to mathematics have deteriorated and become more time-consuming to manage. Other changes (e.g. Ofsted, mergers) have had varied effects on mathematics provision, depending on their handling by senior management. College managers express a desire for a time of policy and curriculum stability for mathematics, although they themselves perpetuate change through internal reviews and changes to strategy, driven by the need to demonstrate measurable improvement in student outcomes.

1.1.9 Towards better post-16 mathematics qualification policy

There is wide agreement across the case study colleges that the Condition of Funding is flawed and needs to be reviewed, mainly due to concerns that GCSE Mathematics grade 4 is not an appropriate or realistic goal for all students. A common view is that more appropriate qualifications and goals for all students are needed in future policy, based on a better understanding of the student cohort. Managers and teachers are generally of the opinion that extending compulsory mathematics to age 18 is unrealistic at present since it would require a suitable suite of qualifications. There are also concerns about students' responses to such a policy. Colleges identify a need for future policies and qualifications to be developed that retain the flexibility for the college to make decisions that are in students' interests, accommodating different needs and including realistic goals.

1.2 Conclusion

The comprehensive analysis set out in the full report highlights the considerable complexity of providing mathematics qualifications for 16-18-year-olds in England's general further education colleges. We have deliberately reported our findings in detail as we are keen to avoid the error of thinking that improvements can be achieved with simple solutions, or that a successful intervention in one area of the system (e.g. classrooms) can be made independently, without considering other aspects of that interconnected system (e.g. operational strategy or staffing).

The complexity of mathematics provision in general FE colleges is the product of the different spatial and temporal scales of the educational system interacting with varied local and regional needs of learners, communities and society. Understanding this multi-scale complexity, both societal and educational, is a prerequisite for considering how actors with different positions, roles and influence in this system might work to improve outcomes, whether individual, organisational or societal. Our analysis provides a detailed account of how mathematics policy is enacted in such colleges and highlights some key areas where the investment of further resources seems likely to lead to worthwhile improvement. We are not however making major recommendations at this stage. These will come in the forthcoming MiFEC Final Report, due to be published in the summer of 2020.

2. Introduction

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

In 2016/17 over a third (35%) of 16-18-year-olds studied in FE colleges compared to less than a quarter (23%) in state-funded schools[7]. Although Further Education includes other college provision (Sixth Form Colleges, designated colleges and specialist colleges), the study focuses on general further education colleges (GFECs[8]) since these are the main providers of further education in England with 174 GFECs out of a total of 257 FE colleges[9] (February 2019). These general further education colleges are also large organisations in comparison to schools or other types of FE college and provide a wide range of post-16 educational opportunities.

The research design is multi-scale[10] in order to investigate different levels of mathematics education in England's FE colleges: the national policy landscape, patterns of learner engagement over time; college level policy enactment and curriculum implementation; teacher workforce roles, skills requirements and motivations; and student learning of mathematics in vocational contexts. The project therefore has several interlinking work packages and the Final Report of the project (summer 2020) will synthesise these. The first Interim Report (Strand 4), "A survey of teachers of mathematics in England's FE colleges"[11] was published in December 2018. This second interim report presents findings from FE college case studies (Strand 3) conducted from December 2017 to April 2019[12].

The MiFEC case studies of FE colleges explore the following questions:

- How do FE colleges *mediate*, *moderate* and *modulate* 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?
- What are the possible unintended consequences of policy upon classrooms?

Since the Further and Higher Education Act (1992) further education colleges have operated as independent corporations. A typical college focuses on vocational education

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[7] 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
[8] 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
[9] 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
[10] Noyes, A. 2013. Scale in education research: considerations for a multi-scale methodology International Journal of Research and Method in Education, 36 (2), 101-116.
[11] Available at https://www.nottingham.ac.uk/research/groups/crme/documents/mifec/interim-report.pdf
[12] The final report will synthesise findings form the four strands of the MiFEC project. In in addition to the two mentioned here (strands 3 and4) this includes 1) a policy trajectory analysis from 2000 to the present day, and 2) quantitative analysis of administrative data to understand participation patterns and the relationship between policy and college practices

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 colleges. They are complex organisations with considerable variability dependent upon the context.

Since *incorporation* in 1992, responsibility for FE has moved between government departments several times. Changing priorities in policy and qualifications have heavily influenced the mathematics curriculum offer to students and, although this is not examined in depth here, it is important to recognise how this recent history of mathematics in further education frames the current position and developments. The most relevant, recent changes in government policy are summarised below:

- The extension of compulsory education to the age 18 years (in a stepped approach from September 2013)
- The Condition of Funding (commonly referred to as the GCSE retake, or re-sit policy), which made it compulsory from September 2014 for students without GCSE Grade C (now Grade 4) to either retake GCSE mathematics or undertake a 'stepping stone' mathematics qualification, with the aim of then progressing on to a GCSE retake course.
- An adjustment to the Condition of Funding from September 2015, which made it compulsory for students with GCSE Grade D (now Grade 3) to retake GCSE rather than any alternative mathematics qualification.
- An adjustment to the Condition of Funding from September 2019 making it no longer obligatory for students who achieve Level 2 Functional Skills mathematics to progress to GCSE.

The Condition of Funding is such that colleges can lose funding if students who are required to study mathematics do not attend. Performance measures are increasingly important drivers. For mathematics, these are primarily the high-grade achievement rate[13] and the maths progress measure[14]. Other significant curriculum changes such as revisions to GCSE and Functional Skills mathematics qualifications have also taken place and the impact of Local Area Reviews has been an increase in the number of college mergers, in response to recommendations. Understanding how the sample of colleges has responded to these challenges and changes is the focus of this report.

The study takes place in general FE colleges but, for simplicity, we will sometimes omit 'general' for brevity. Other types of FE college (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 general FE colleges means this has been the focus.

We will adopt the term *GCSE retake* rather than GCSE resit since this indicates that the course has been retaken rather than a student simply having a second (resit) attempt at the examination. We use the term *high grade achievement*[15] through much of the report since this is commonly used in the sector as a measure of student outcomes rather than examination pass rates.

[13] High-grade achievement is the percentage of students gaining GCSE grades 1-4 out of the total enrolled at the start of the course.
[14] See Appendix 3 and here for the full guidance.
[15] *High grade achievement* is the number of students achieving GCSE grades 9-4 as a percentage of the number enrolled on a GCSE course. The measure takes into account those who started the course and did not enter the examination and replaces what was previously referred to as the *success rate*.

Our reference to *mathematics teachers* in the report is to those teaching courses that lead to stand-alone mathematics qualifications (e.g. GCSE, A-level, Functional Skills). Although mathematics is also taught in embedded forms within other vocational or academic qualifications, including as a module examined as part of another qualification, the teaching of these is not the focus of this report.

The main body of the report is divided into three main sections. After explaining the methodology, three college case reports are used to introduce some of the main issues faced by FE colleges. These are followed by a more detailed thematic analysis of the key issues that emerged from the full set of case studies, grouped under nine headings.

3. Research methods

The research design comprised six in-depth cases of FE college providers[16] from December 2017 with the additional of 23 more providers from May 2018. These 29 providers yielded a total of 32 college case studies since some providers were groups of colleges functioning fairly independently and more than one college from the group was studied. In the first year of the project, analysis of data generated in the six main case studies produced key dimensions that were then investigated more widely in the second tranche of cases. Return visits to the initial cases investigated changes over time in more depth.

3.1 Sampling (main cases)

Selection criteria for the case studies were based on existing studies. After consideration of the quality and limitations of the available performance data (from the 2015/16 academic year), the sample was informed primarily by 1) region, 2) mathematics progress measure[17], 3) locality and 4) size. In addition, various combinations of Ofsted grades[18] and maths progress measures were included. The sample included colleges with and without substantial academic provision. At least one recently merged college was included, and several other sample colleges were involved in mergers before visits took place[19].

A full list of England's general FE colleges was divided into sextiles by maths progress measure (c.f. six main cases) and eventually sampled from the top and bottom thirds so that comparisons might be made between colleges with high and low progress measure performance. Initially four colleges were selected from each geographical area (EM/WM, YH/NE, GL/SW) to make a long list of 12 colleges. The sampling was restricted slightly to focus on colleges with large numbers of mathematics students (> 400) where there was more organisational complexity. It was then balanced by locality (e.g. rural, urban) and Ofsted grades in each of these three regions and for colleges with and without substantial academic provision for 16-18 year olds. Some adjustments were made to achieve this balance. The sample was then reduced to six colleges, including one that had undergone a recent merger. These six college were invited to participate, whilst the others held in reserve.

The provisional sample of six main colleges can be seen in *Table 1*. It was not possible to obtain full coverage of the key selection criteria (e.g. rural location) in a sample of this size but any limitations in the sampling of the main cases were noted so that they could be addressed in the selection of the additional 24 cases, which was largely based on the same criteria.

[16] The original selection was of 'providers' since the background data were categorised in this way.
[17] The DfE explanations of post-16 progress measures are here.
[18] Ofsted grades are not specifically about mathematics provision and can date back several years, particularly if the college achieved a Grade 1. Ofsted grades and mathematics progress scores are uncorrelated and grades for newly merged colleges could be misleading if the merged colleges are very different.
[19] Appendix 1 sets out the sampling framework in more detail

Region	Students at end of 16-18 study	Students at end of 16-18 included in maths progress measure	Average progress made in mathematics (sextiles)	Location	Ofsted grade
WM	4200	1300	4	Urban major conurbation	3
EM	3000	1100	2	Urban city and town	2
YH	2700	1100	1	Urban minor conurbation	1
SE	2300	1000	3	Urban city and town	2
GL	1700	600	5	Urban major conurbation	2
NW	1000	500	6	Urban major conurbation	2

Table 1: Main case study selection criteria. [NB student numbers rounded to nearest 100]

3.2 Sampling (additional cases)

Following analysis of the initial cases and identification of key features of the data, a sampling frame for the larger set of additional colleges was developed. This ensured broad national coverage but also enabled us to investigate four key areas in more depth as shown in *Table 2*.

Key area	***Sampling decisions***
Organisational features	*Multi-site strategies:* • many colleges were identified as multi-site in the sample, the actual strategy was only investigated during fieldwork.
	Multi-college groups • five such cases were included in the sample; some very dispersed
Change processes	*College mergers* • six of the colleges had been subject to recent mergers, most as a result of Local Area Reviews
	Improvement trajectory/ strategy • Ofsted grades and commentaries were used to identify high/low grade changes over time
Workforce	*Recruitment and retention* • This could only be explored through the fieldwork
	Training and PD • This was investigated through fieldwork
Teaching and learning/learners	*Curriculum planning and design* • This was investigated through fieldwork
	Student engagement / autonomy • This was investigated through fieldwork
	Student outcomes • GCSE achievement data provided by colleges were analysed over a three year period to identify outliers and other interesting cases

Table 2: The four key areas investigated in additional case studies.

Initially, 26 additional colleges were identified with the expectation that some would not consent to participate. We were able to sample effectively for some of these features using external data such as records of college mergers or published maths progress measures[20].

The teacher survey was undertaken in all of the case study colleges prior to visits for these additional cases. Although the findings from this survey did not inform the sampling of these colleges, the survey analysis did enable us to see important differences across the sample such as colleges with different levels of teacher satisfaction.

3.3 Data Generation

The case studies sought to investigate college implementation of mathematics policy and the management of mathematics provision. Current college strategies and their effects on student learning were of primary interest but also, where possible, we explored developments over the last 5-10 years. The main focus was on 16-18-year-old students and particularly those yet to achieve a Level 2 qualification in mathematics, although Level 3 and adult provision were included where appropriate.

The data for each of the main cases were generated in the following ways:

- initial telephone interviews with the principal or vice-principal;
- face-to-face individual interviews with senior managers, middle managers, mathematics teachers and vocational staff (managers and/or teachers);
- student focus group discussions and activities;
- documentary analysis of internal college policies/strategies;
- college data on student participation and achievement;
- the mathematics teacher workforce survey (June/July 2018)
- a return revisit in 2018/19.

Research instruments were built on those used in previous studies[21,22]). Semi-structured interview schedules were designed for managers (senior, mathematics), vocational staff and mathematics teachers. Although the interviewees were only a subset of college staff and therefore there is potential for selection bias, questioning sought to triangulate data from different sources. Moreover, the approach was sufficiently flexible to focus on the features of a provider setting.

Prior to the college case study visits a range of information was requested and/or collated:

- Current policy and/or strategy documents for mathematics;
- Previous college policy and/or strategy for mathematics over the last 5-10 years;
- A college organisational chart;
- A summary of the mathematics teacher staffing profile;
- Participation and achievement for mathematics qualifications over the previous 5 years.

[20] Although we have used this data as a proxy for teaching quality and college effectiveness they are partly a measure of the entry strategy of the college so we might not be comparing like with like.
[21] Dalby, D. 2014. "A study of the experiences of vocational students learning functional mathematics in further education colleges." PhD Doctoral dissertation, School of Education, University of Nottingham.
[22] Higton, J., Archer, R., Dalby, D., Robinson, S., Birkin, G., Stutz, A., Duckworth, V. (2017). *Effective practice in the delivery and teaching of English and Mathematics to 16-18 year olds*. London: DfE.

Based on this information, in particular the management structure and staffing profile, staff participation in the visits was planned together with a senior manager. The main cases involved an initial two-day visit in the first year, which typically included the following interviews and aimed to include staff with different lengths of service.

- The College Principal or Vice Principal (telephone interview)
- The most senior manager(s) with responsibility for mathematics,
- 1 or 2 managers with specific responsibilities for mathematics
- 3 or 4 more mathematics teachers
- 3 vocational managers/teachers from different vocational areas within the college.

In addition to staff interviews, up to three student focus groups were held at each visit where students engaged in group discussion and participated in an individual desk-based activity. These groups usually comprised students aged 16-19 at various points in their mathematics studies with different levels of achievement. Where possible, students were involved from two designated areas (Construction, Health and Social Care)[23]. A one-day revisit in the second year of the project focused on follow-up interviews with the same managers (or their replacements if no longer working at the college) and different mathematics teachers.

For the additional cases, a similar schedule of data collection was undertaken. A range of management and teaching staff were interviewed, although with fewer teacher interviews and focus groups to enable the visits to be completed in a single day. Schedules involved representation from different levels of management but reductions were made to the number of mathematics teachers and vocational managers/teachers interviewed.

In keeping with research ethics procedures at the University of Nottingham, the principals/CEOs of all participating colleges, as gatekeepers, were provided with comprehensive project information and asked to provide consent on behalf of the college. Individual staff and students engaged with the research on a voluntary basis. They were also provided with project information and privacy notices before giving signed consent. Colleges were asked to identify any students invited to join focus groups who were considered to be vulnerable adults so parental consent could be obtained prior to the visit.

3.4 Approach to analysis

The combined data from the main and additional cases amounted to 238 interviews, 62 focus groups and, a large volume of documentary evidence (e.g. Ofsted reports). The 238 interviews break down across the following staff types:

- 10 with college principals, 15 with vice principals, 10 with other senior leaders;
- 41 with cross-college managers, 117 with mathematics teachers (some of whom were also curriculum leads);
- 30 with vocational managers and 6 with vocational teachers;
- 9 with other managers (e.g. quality managers).

All of the interviews were transcribed and combined in a large NVivo project. By building on the sampling framework and undertaking extensive analysis of the data, an analytic

[23] The analysis of data from the student focus groups is not included herein but will form the basis of a separate working paper

framework was developed comprising nine main themes and several subthemes (*see Appendix 2*).

The findings reported below are largely based on the perspectives of teachers and managers. We have not verified, for example, whether espoused operational strategies and classroom pedagogies align with those that are enacted through any direct observation but have triangulated data from different sources. We have assumed the trustworthiness of the views expressed, ensuring a critical approach to interviewing. Where a proportion of colleges, managers or teachers hold a view we normally indicate in general terms rather than with counts or percentages. This analytic approach, when combined with the scope and scale of the dataset, means that though we are unable to make statistically generalizable claims, we can claim some analytic generalisability.

4. Case studies

Three cases are presented below as an introduction to the main body of the report. These have been selected to introduce key aspects of the nine themes, which will be discussed in more depth thereafter.

The case reports are not necessarily exemplary in their practice or policy implementation but are narrative accounts of the issues and how the college is responding to these. Each case is typical, in that it includes some of the common issues faced by FE colleges in the implementation of mathematics policy but is also distinctive, since it illustrates challenges that are not shared by all colleges. Taken together one can begin to understand the complexity of implementation and see how and why colleges respond in different ways to the same policy imperatives.

These cases are based on actual FE colleges from the study but identifying details have been changed (e.g. staff and institution names) to maintain the anonymity of the college. At the time of the study, each college had been graded as either 'good' or 'outstanding' by Ofsted at their latest inspection (although this was sometimes several years ago) but their maths progress scores covered almost the full range. Where features of each of the three cases are particularly strong and also feature prominently in the full cross-case analysis in Section 5, we have emphasised these in the reports (e.g. the impact of merger).

4.1 Case study A

In a highly deprived area of a large English city, where social problems are widespread and incomes low, sits Amberfield College. This is not the only place where young people can study post-16 nearby, but most of the lower attaining students in this community join Amberfield given its focus on vocational programmes at level 1 and 2. They transition to the college from schools that Ofsted consider 'require improvement', hoping for a fresh start on vocational programmes. It is quite understandable that some resent being compelled to retake GCSE, yet over 70% of Amberfield's entrants need to retake both GCSE English and mathematics.

Young people in the local community often have unstable home lives and low aspirations. Many of the students can name relatives who left education early and made a decent living without good qualifications. This does not inspire or motivate them to learn and neither do local employers, many of whom are only interested in trade-related skills and not mathematics qualifications. The immediate needs for (family) income draw young people towards low-skilled work as soon as possible rather than continuing with education. Many of the college staff live locally and, understanding something of the culture, are fully committed to the college's educational mission to serve the community, raise aspirations and improve future opportunities in work and life.

Although surrounded by a community with other priorities, Amberfield is evolving. National policy and curriculum requirements change frequently and, when combined with the pressure to improve performance, produce a never-ending process of internal reassessment and strategic change. The recent Condition of Funding had a huge impact and Amberfield, like most colleges, has struggled to cope with the substantial increase in mathematics (and English) provision. Changes in staffing, team structures, curriculum strategy and support systems have all happened quickly in a drive to improve student performance.

Local market conditions have made it difficult to recruit and retain the mathematics teachers now needed, particularly when nearby schools can offer better salaries or conditions. Managers have been creative though and developed their own solutions to address this problem. Amberfield has a well-developed 'grow your own' scheme that identifies staff from non-teaching areas who are then supported to train as mathematics teachers over two to three years. In the first year they observe or support classes, before moving to a part timetable the following year (alongside their original role) and then completing the transition to a full-time mathematics teaching post. Nearly half of the mathematics team are newly qualified or still in training and, although teaching skills are generally good, they are less experienced at building rapport with students.

As the importance of English and mathematics has increased, so the leadership of this area has become more senior and strategic. Jenny, the Head of English and Mathematics, carries a major responsibility for the quality and improvement of mathematics across the college but is dependent on co-operation from vocational areas. She has two assistant managers and two curriculum leads, although no one is sure whether this is the best management structure. Other colleges are using different structural models for mathematics. Many colleges, including Amberfield, are watching one another to see what works.

Mathematics (and English) have recently undergone internal reviews and remain under constant scrutiny due to under-performance. Senior leaders have worked collaboratively with Jenny in the last few years to develop strategic plans for improvement and she feels well supported. The three main areas for improvement are 1) student attendance and engagement, 2) quality of teaching, and 3) embedded approaches to support student skills development. Jenny and her colleagues seek out good practice from other colleges to inform decisions. They are proud of working in a sector that has the capacity to evolve and adapt but find the pace of change allows insufficient time for enough evidence-based assessment of what works. A positive marker in the development of Amberfield was a recent 'good' Ofsted report. This felt like a just reward for all their effort and considerably boosted staff morale.

Lesson observations and walk-throughs are used to identify weaknesses and provide support for staff. A new emphasis on coaching and a move away from graded lesson observations has encouraged teachers to take risks and try new approaches in the classroom. There is specific professional development for the mathematics department and good practice is shared. Participation in an area mathematics network and CPD provided by national organisations has helped Jenny develop the team, although there is still some way to go.

Amberfield's approach to organizing their mathematics teachers has been to form one centralised team to serve all areas of the college. Most of the 16-18 study programmes are on one site so travel is not a problem. The team like this arrangement because they gain informal support from working in close proximity, and colleagues are always available to help if poor behaviour escalates in class.

Vocational staff would prefer mathematics teachers to be dispersed into vocational areas so they can collaborate to make mathematics lessons more relevant. Amberfield's mathematics teachers know that students are more engaged when they see the relevance of mathematics and working alongside vocational staff would facilitate this. In contrast, the benefits of working together in a mathematics specialist group are also considerable. With a high proportion of inexperienced mathematics teachers in the team, the centralised arrangement seems best for Amberfield at this point in time but they have also tried to strengthen vocational-mathematics connections through designated link tutors for mathematics.

As part of the whole-college approach to skills, vocational teachers have been encouraged to embed mathematics in their programmes. Vocational staff can see where mathematics occurs in their teaching but feel that they lack the expertise to make full use of these opportunities and students still see mathematics as just their GCSE class. There is an on-going project to develop the confidence and competence of vocational staff including drop-in sessions to get advice (e.g. on percentages) and the opportunity to take a Level 2 mathematics qualification, although the latter has not been so well received.

Amberfield has recently moved to a 'blanket GCSE' strategy, with only a few students now being offered Functional Skills mathematics as an alternative. The guiding principle given by managers is that this allows all students the opportunity to gain the 'gold standard' of a good GCSE qualification but they also mention an additional motive in the positive impact this strategy has on the maths progress measure (e.g. increasing one GCSE grade scores higher than achieving the equivalent level of Functional Skills).

Teaching staff are unconvinced that endless re-sitting of GCSE is the best policy. There are also some concerns about those who do make the grade and whether they sustain this level of competence. For these reasons, teachers and managers would like to see an alternative to GCSE that is better suited to the needs of their students.

New arrivals to Amberfield get two 90-minute sessions of mathematics a week. Adults also receive 3 hours for GCSE but 2 hours for Functional Skills. Teachers struggle with the rapid pace of the GCSE course and the lack of time to make lessons more enjoyable and engaging. Basic number operations are a priority and initial assessments show students are often a grade lower when they enter the college compared to their GCSE result, even on the same paper. Teaching focuses on addressing individual needs and 'gap filling' rather than covering the entire curriculum. Teachers enthusiastically tackle the difficult task of transforming student outcomes in 8-9 months but know that expectations of increasing even one grade in this time are unrealistic for many of their students.

The wide range of prior knowledge in classes tests the skills of teachers. Amberfield have experimented with streaming by prior attainment but mid-year changes to groups (e.g. merging due to low numbers) makes this difficult to achieve across all the provision. Moreover, streaming produces mixed vocational groups so liaison between vocational and mathematics areas becomes more challenging. Students prefer to be in their vocational peer groups but the numbers of students within some vocational areas are insufficient to stream.

By far the biggest problem facing teachers is knowing how to re-engage students' who have only ever experienced failure with mathematics. Teachers try to build rapport by getting to know the students and designing interactive lessons that they think will be engaging and perhaps even enjoyable. Some teachers would like to use more technology but with the present level of funding there are insufficient resources such as laptops and high-quality Smartboards. Teachers at Amberfield are highly committed and often give additional help to students outside class by responding to questions by email, or sending additional work, videos and other support materials for the topic covered that week.

Poor behaviour in mathematics classes is an issue at Amberfield, which is often rooted in negative prior experiences and the poor motivation that results from repeated failure. Teachers struggle to find a balance between tolerating trivial incidents and being strict in what is supposed to be a more adult learning environment. Having stable teaching groups helps to establish behaviour expectations and positive classroom cultures but such stability is often elusive. For example, initial timetabling fixes mathematics and English and vocational programmes are then fitted around these but the prior grades that inform this process are not always a good indicator of level, so students end up being reshuffled.

Poor motivation and engagement results in low attendance in mathematics lessons. Considerable time and effort is spent on tracking and following-up absences through electronic systems and circulation of reports. Limited support from vocational areas is perceived to be a problem, although things are improving. More recently, attention has turned to rewards (e.g. trips out) rather than punishment but it is not clear yet whether this strategy has been successful. The ultimate sanction is for the student to be excluded from college but this presents a dilemma when the aim is actually to engage them.

In summary, the location of Amberfield and the range of provision offered present distinctive challenges. The local culture generates specific barriers to student learning whilst the curriculum offer leads to lower than average student skills profiles. Amberfield faces a number of issues that are common in colleges such as poor student motivation and engagement and these result in low attendance. Typically they find deficits in students' basic knowledge of mathematics that need addressing before they can realistically hope to achieve grade 4 GCSE. Staff are working hard to overcome organisational issues such as timetabling and to improve liaison with vocational areas. Managers face dilemmas when all the options have disadvantages as well as advantages. Despite these challenges, Amberfield has tackled issues such as staff recruitment with creative strategies and is optimistic about maintaining their improvement trajectory.

4.2 Case study B

Bradshaw College is situated in the centre of a post-industrial town and is a popular destination for students at age 16 in the local area and beyond. With a high rating by Ofsted some years ago, it maintains a strong reputation and is the main provider of post-16 vocational and academic programmes in the immediate locality. The college comprises four sites, three in the town centre and one several miles away offering land-based programmes only. The three town sites are quite different, with two catering for clusters of vocational programmes and the other being the sixth form centre. Whilst other teachers only work on one site, those teaching GCSE mathematics and English to the vocational students are peripatetic, encountering distinctively different cultures in each location.

Managing this multi-site mathematics offer is challenging. It requires skilled coordination by a senior leader with authority to implement strategic plans across sites. The growing scale and complexity of the mathematics provision has demanded new cross-college approaches but Bradshaw is a college with strong senior management who are quick to identify problems and take action. Strategic decisions are principally aimed at maximizing student performance with an approach considered by some teachers to be more managerial than student-centred.

Following the demise of traditional employment, the town has slowly recovered and is no longer an area of high social deprivation. Many of the town's young people still have relatively low aspirations and are content to seek employment in the area after college or attend local universities. Raising these aspirations is a challenge, with many students' future horizons stretching no further than the surrounding hills. Those horizons were fine in times gone by, but this generation of local young people have yet to adapt to changing work opportunities. Unsurprisingly, they often lack motivation for continuing their study of mathematics and so disengage. Yet Bradshaw is ambitious for these young people. For example, students who have already achieved GCSE Mathematics at grade 4 or above are encouraged to re-sit and improve their grade to widen their future educational and life choices. This boosts college measures of performance for mathematics. Underperformance of this community's 16-year-olds relative to national averages means there is considerable potential for Bradshaw to add value and students tend to make good progress in the college.

Most students stay at the college for at least two years since there are few other places to go. The college sees the GCSE retake course as, in effect, a two-year GCSE mathematics course with up to three opportunities to retake during this time. Managers believe this two-year strategy has a positive impact on achievement rates, and is worth the risk when there are few local competitors. The college sets high aspirations and clear targets to "push them beyond where they previously have been" so changing mind-sets about mathematics and breaking down previous barriers is an important part of the teaching approach.

As elsewhere in the sector, the college is juggling the pros and cons of different organisational approaches. The centralized approach to GCSE was an attempt to both standardize and improve teaching across the college. The teachers appreciate being able to collaborate but offset this against the time spent travelling between sites and the increased liaison needed when they work in several different vocational areas. Each vocational department has a lead for functional skills who sometimes voluntarily supports the GCSE students out of class since their mathematics teachers are present only once or twice a week for lessons. Although vocational areas value greater consistency in GCSE mathematics teaching, they would prefer a site-based team with whom they could collaborate more closely. This would aid relationship building with students and enable teachers to co-develop curriculum links more effectively.

A senior manager is responsible for the peripatetic GCSE re-sit team and oversees the dispersed Functional Skills teachers. Core Maths is offered to vocational students by this team, but numbers are low and the main interest comes from curriculum areas such as Business and Engineering. The sixth form has its own mathematics teachers who deliver A level, GCSE re-sits and Core Maths solely on the sixth form site. Although there is some liaison between mathematics teachers in academic and vocational areas, there seems to be no strategic intention of further integration. Bradshaw does not have <u>one</u> team of mathematics teachers, it has multiple teams. This hybrid arrangement includes a dispersed team of Functional Skills mathematics teachers, a centralised team of GCSE retake teachers and a site-based team who teach A-level, Core Maths and GCSE re-take courses in the sixth form. The arrangement is a pragmatic compromise to address issues identified but results in a fragmented mathematics teacher workforce with less naturally-occurring opportunities for informal professional learning.

GCSE mathematics is normally taught as two 1.5-hour sessions but because of the multi-site timetabling challenges, this is not always by the same teacher. In the past, some departments have tried GCSE in a 3-hour block but teachers (and no doubt students) found that unappealing. Those in the sixth form centre have 4.5 hours a week for a GCSE retake course; time for Functional Skills varies between departments but is around 2 hours per week. It seems that the amount of time allocated to mathematics is roughly correlated with the level of study, with the weaker students getting less time and the more able getting more.

Higher and Foundation tier GCSE are taught in separate classes. Bradshaw uses initial assessment as well as prior attainment to establish target grades and GCSE tier, but movement is possible depending on progress. Teachers report large gaps in students' mathematical knowledge and insecure foundations. They favour interactive approaches and encourage discussion through questioning, video and short focussed tasks. The pedagogy relies on students being independent learners, able to engage in self-directed study to supplement their lessons. Teachers find, however, that many students do not have these skills. This is a problem area: Bradshaw can see the potential for additional learning and reinforcement offered by a wealth of electronic resources but students are unable, or unwilling, to make use of these. They can, however, get additional face-to-face support in weekly intervention sessions, revision classes in holidays and one-to-one sessions.

Whereas independence is valued for learners, schemes of work and lesson plans are provided for GCSE teachers and they are expected to stick to them. This contrasts with the approach in most colleges whereby teachers adapt the college scheme to suit their students' needs. A more managerial, standardised approach is helpful for inexperienced staff but limits the adaptation that the more experienced feel is needed to meet the varied needs of students.

Vocational staff perceive retaking GCSE mathematics to be a rigid, backward step for FE students when they have failed in school. They see mathematics as more about employment or life skills and argue that some students, such as on craft courses (e.g. bricklaying, plastering) would derive greater benefit from Functional Skills than GCSE since this is more closely related to the mathematics they are using. For these students there is more value in understanding mathematics rather than gaining a GCSE qualification: "GCSE maths is about passing the exam. Functional skills is far more, in my belief, about understanding mathematics". However, as one teacher explains, Functional Skills Level 2 examinations have become so 'cryptic' that teachers themselves feel it is "like doing the Guardian crossword" to work out what is required.

Functional Skills attendance is higher than GCSE, though both fall below the college average. Electronic systems provide useful records and notifications, but these systems work best when supplemented by staff. Responsibility is officially shared with vocational staff being held responsible for attendance in mathematics lessons but teachers being accountable for results. In practice, teachers find these responsibilities overlap and it is easy to blame the other party when outcomes are not good.

Despite Bradshaw's reputation, finding sufficient mathematics teachers has been difficult. Recruiting new graduates who are undertaking their PGCE in the college has been the most effective way of growing the staff base but the college has on-going teacher retention challenges and needs to recruit more resilient teachers. Enhanced pay for GCSE and A level mathematics teachers has helped, but good teachers are easily enticed away by schools. The college works hard to provide a supportive environment in which teachers want to build their careers, yet staff turnover is higher than they would like and has resulted in short-term agency cover.

Bradshaw wants everyone to work toward being a 'Grade 1' teacher. There are graded lesson observations, leading to individual targets and support to meet these. Managers do checks for compliance and 'quick-fix' professional development where necessary. Course leaders support staff development and mentor new staff; an Advanced Practitioner for mathematics supports teacher pedagogy; there are weekly CPD sessions and other internal or external events. With high levels of support however come high expectations and teachers feel burdened by the performative demands of managers. This can be quite a drain and teachers find it disappointing when the results are poor despite their best efforts.

The upskilling of vocational teachers is another area of CPD need. Some teachers lack confidence, and some are taking an additional mathematics qualification to improve their subject knowledge. Vocational teachers can identify mathematics in their areas but are not convinced that students recognise that they are using mathematics when it occurs naturally in vocational learning. Teachers believe that contextual links to the vocational area or to 'real life' applications are useful but find students from different vocational groups very different to teach.

In summary, Bradshaw is a successful, ambitious and tightly managed college but, like many colleges, it is still struggling with the organisational changes needed to cope with large numbers of mathematics students. The dispersion of these students across sites at Bradshaw adds a further twist to the problem of a staffing structure for mathematics, since teachers need to be either itinerant or become site-based. Bradshaw's pragmatic solution is a hybrid arrangement but this is not ideal. As the main provider in the area and with a strong reputation, Bradshaw has little difficulty attracting students. Although aspirations are still limited, the social problems in the area are less severe and many make good progress in college. Bradshaw has more difficulty finding experienced mathematics teachers and retaining them. Efficiency and enthusiasm are evident in the management and teaching of mathematics but the Condition of Funding is challenging to implement and the task of improving student achievement for mathematics remains a concern.

4.3 Case study C

Colston College is still finding its way through a transition period following a merger of a large city centre college (Central) and a smaller college based in a nearby town (Westbury). The merger has involved a prolonged transition and has been full of challenges. There is still a sense of uncertainty and the process has felt very much like a takeover to staff at Westbury.

The merger initially produced much anxiety about job security and this led to staff changes, particularly at Westbury. Some mathematics teachers decided to leave and these vacant positions proved difficult to fill. It has taken time to get back to a fully staffed situation for mathematics, during which time compromises have had to be made and emergency solutions found to make sure classes could be staffed at all.

After strenuous efforts to recruit teachers, the two main sites (Central and Westbury) now have their own teams of mathematics teachers, who also service the smaller sites. On the whole, the two teams work separately, each with a local manager. Tom, the Head of English and Mathematics, has overall cross-college management responsibility and moves between sites spending half the week on each if possible. The two teams rarely meet, which is understandable given the distance between them. Tom would like to see more sharing of good practice between the teams but the travel time makes this impractical and teachers find it difficult to establish relationships when they do not meet face to face.

Colston does not have any academic provision so mathematics teachers only teach GCSE and Functional Skills. The distribution of vocational curriculum areas across college sites mean some sites host quite specialist areas and the student cohorts can be very different. Teachers find they have to adjust to different site cultures and student cohorts when they travel which adds to the extra planning and resources needed when away from their base.

The mathematics curriculum offer includes Foundation tier GCSE and Functional Skills mathematics but, until recently, the college made innovative use of a Free-Standing Mathematics Qualification (FSMQ) as a 'bridging qualification'. Changes in regulations have now excluded the FSMQ option so only GCSE or Functional Skills mathematics are taught.

Historically, mathematics strategies at Central and Westbury have been quite different. At Westbury staff have tended to take a very individualized approach to planning and teaching. In contrast, the Central mathematics teaching team, under Tom's leadership, has developed collaborative ways of working. Most of the Central teaching team have worked together for several years and communicate a shared sense of pride in how they have developed the mathematics provision over time. Lessons are planned collectively but teachers adapt activities to suit their particular group or style. Schemes are now being 'shared' across all both teams, although there are some doubts about how easy it will be to get all staff to use them.

Mathematics teachers, particularly at Central, aim to stimulate greater motivation and engagement. Some teachers make use of mathematical investigations and others mathematical 'games', although these get a varied response. Teachers have tried various approaches to group work, but find they need to be flexible in their approach since some students can be resistant to working with others. There is general agreement that teachers need to have a range of techniques available to them in order to work with different groups. Extra support for students is provided outside class but not generally staffed by mathematics teachers and so rather unconnected from the main teaching.

Examination performance exerts a heavy influence on the mathematics classroom. Teachers would like to focus more on developing basic skills, confidence, technical fluency and problem-solving but this is difficult given the quantity of GCSE content that needs to be covered. They would also like to adopt a more holistic, student-centred and 'pastoral' approach to students but instead are compelled to drive them towards examination success. One teacher explains that these students need more than a good mathematics teacher, they need “a space that allows them to be as good as they can”. She is not alone in thinking that changing a students’ mind-set is important if they are going to make progress with mathematics.

This year Colston has sought support from a local university as they look to improve their schemes of work and lesson structures. These involve more structured revision as well as new material each week, although teachers are not confident that this will affect results significantly. Some teachers have followed this new scheme and structure closely whilst others have adapted it considerably to suit different groups, or even continued using their own approach. Next year, the college is adopting more of a ‘mastery’ approach with support from an external consultant. This will focus on teaching ‘the basics’ until students have grasped these, with an emphasis on using a different approach to school.

Learning mathematics is very different to students’ experiences of vocational programmes, where assignments and portfolios are developed and improved over time. Teachers at Colston recognise that embedding and contextualisation help to engage and motivate students because they can see the relevance of mathematics when explained in relation to a real workplace issue (e.g. pay). At Colston it is recognised that there needs to be greater support for vocational teachers to develop their own mathematics skills and upskilling has been offered. The response to this has been slow, even though vocational staff have themselves identified that they need to improve their mathematics skills.

The college tries to group students for mathematics by vocational area as teachers think this works better than mixed groups, but it is not always possible. Functional skills mathematics is allocated 1.5 hours a week and GCSE 3 hours, often as two 1.5-hour sessions. For some vocational areas mathematics is however timetabled as a 3-hour block due to practical issues and staffing constraints, especially when mathematics teachers have to travel to the site from their base. Maintaining student engagement for this length of session is very difficult. Mathematics teachers at Colston think this once-a-week timetabling is detrimental to learning and is letting down young people that have already failed. Nesting mathematics sessions amongst the vocational study programme, as opposed to being on a different day, is the preferred approach but it does not always seem to happen.

There is agreement across staff at Colston with the principle of encouraging students to improve their mathematics but the privileging of GCSE and relative undervaluing of other qualifications is seen as a problem. Vocational staff are supportive of qualifications and teaching that are more closely aligned to the mathematical applications of their industries. They understand the applications of mathematics within their areas and are enthusiastic about improving their students’ skills but note that students find it hard to see the relevance of GCSE. To them, GCSE Mathematics is more about reasoning and not the skills with ‘arithmetic’ that they value most in their areas. Both mathematics and vocational teachers find Colston’s new student arrivals each year typically lack fluency with basic mathematics, such as multiplication, and the familiarity with numbers that vocational staff expect. One construction teacher explains how few students can calculate areas or read a tape when they start his construction course and this is, naturally, his priority.

Examination time for mathematics is challenging for the whole college. The numbers of students involved and the proportion with special arrangements means that the college is entirely taken over. Vocational programmes are, in the main, assessed through coursework and students often struggle to retain mathematics knowledge so they find terminal examinations challenging. Some need individual support and encouragement just to enter the examination room.

During the year student attendance at mathematics lessons is an on-going problem. The e-tracker system is intended to signal up issues with attendance but Tom thinks it is not as effective as when an administrator walked around classrooms 30 minutes after the sessions had started. Tracking attendance has become a much bigger task with the massive increase in student numbers retaking mathematics and Colston, like many colleges, is trying to establish some shared responsibility with vocational areas. Mathematics teachers feel they get insufficient support from the vocational staff at present and, despite a recent change in strategy to make vocational managers responsible for attendance at mathematics lessons, there are doubts about whether this will work. One of the stumbling blocks in the system is that the college is reluctant to take hard action, such as excluding students, because of the funding implications, and students soon become aware that strong action will never be taken.

As the merger has progressed, changes in departments have resulted in more mixing of students from different courses in mathematics groups. This is making liaison between mathematics and vocational tutors more complicated. Mathematics teachers are frustrated by a lack of communication about vocational events that impact on their lessons. It is not uncommon to find a mathematics lesson is cancelled because a trip, visit or placement has been arranged, usually without any consultation. This communicates that mathematics is less important and hampers progress. Mathematics teachers also find some students are allowed to miss college towards the end of the year if their vocational assignments are completed, which means they also miss important examination preparation for mathematics. Things are not yet quite as 'joined-up' as mathematics staff at Colston would like.

There are many competing interests and pressures for 16-18 students due to their vocational course, jobs, relationships, social lives and parental expectations. Tom finds parents in this area are not always convinced that students need to do mathematics. Some ask if their child can be exempt due to doubts about its relevance, or the anxiety their child has about attending mathematics classes. Mental health issues concerning mathematics are not uncommon and managers like Tom find themselves in a difficult position since they are obliged to implement policy but also have a responsibility for the well-being of students.

The challenges of the merger linger on and major hitches in trying to standardise systems have caused disruption to processes that were beginning to run fairly smoothly for mathematics. Problems with the new shared electronic record system, for example, caused delays and confusion during the enrolment period and it was some weeks before Tom could get a grip on the allocation of students to mathematics classes. A disorganised start to the year such as this does not encourage students to attend, even if they get the correct information about where to go. Mathematics teachers are looking forward to reaching a more stable situation where they can focus on longer-term plans for improvement.

In summary, the biggest issue for Colston College has been trying to work through a merger. This has diverted attention away from some of the common issues in colleges with mathematics and caused additional problems. Management time has been occupied with short-term troubleshooting as structures, systems and strategies have proved problematic to align. Cross-college provision such as mathematics has been particularly difficult during the transition, especially with the resulting staffing crisis and learning how to coordinate multiple sites up to 20 miles apart. Meanwhile student attendance remains low and mathematics staff feel the need for more support from vocational areas. Like many colleges, Colston is working hard to ensure teachers have opportunities for CPD and sharing good practice. Their engagement with a local provider network and the national Centres for Excellence programme has been invigorating during a time of instability but many of the common problems encountered by colleges still remain in the background without long-term strategies to address them.

4.4 Case study comparisons

These three cases highlight commonalities as well as differences. Each college encounters attitudinal problems amongst their student cohorts, deploying similar approaches to address these whilst constantly seeking better solutions. For example, electronic registration systems and disciplinary processes aim to address poor attendance, though these need supplementing with more personal actions. Whilst teachers strive to make lessons more engaging, they would also like greater support for mathematics learning from vocational colleagues.

Other aspects of students’ behaviour are also a concern in all three case studies. Many students *lack motivation* to study mathematics and are *reluctant to engage*, even if they attend mathematics lessons. Mathematics teachers are constantly looking for new approaches that might engage and motivate students. They typically adapt, experiment and share good practice to meet students’ needs.

The organisation of staffing structures, the curriculum offer for mathematics, qualification pathways available to students and the timetabling of classes are also common challenges but colleges tackle these in quite different ways depending on local constraints and values. These are complex issues for which there are no ideal approaches. Colleges make independent decisions about the suitability of different approaches but are constantly watching others in the sector for new ideas.

The case studies also illustrate how differences in local communities and in the college curriculum offer can affect students’ aspirations and attitudes to mathematics. These are important variations which result in colleges facing different challenges depending on the composition of the student cohort.

Approaches to mathematics in these colleges also differ due to organisational features such as the dispersion of provision across sites. This is turn limits the practicality of certain staffing structures and affects timetabling. Although leadership and management styles vary, differences often arise from local conditions and organisational constraints that cannot be solved by a ‘one size fits all’ approach.

5. Main findings

The three case reports above highlight the complex amalgam of challenges faced by general FE colleges as they seek to improve their mathematics provision for 16-18-year-olds. The colleges in this study respond to these in different and context-specific ways, trying to maintain some coherence in their overall approach. These case reports show these multi-layered webs of strategies and practices in a way not possible through simply presenting a cross-case analysis. The report now turns to explore the issues in depth through the nine main themes that emerged from careful analysis of the full set of case studies:

- college context
- leadership and management
- operational strategies
- students
- teaching and learning
- workforce
- professional development
- change
- policy

The rationale for the ordering of these themes is to start and finish at larger scales. We begin with the social and economic context that frames what each college can and should provide (outside-in) and we end with the education system and its policies which also frames possibilities and products of the FE sector (inside-out).

The *college context* strongly influences the shape and size of the college, its curriculum offer and the nature of *leadership and management.* In turn, these contextual constraints and leadership approaches influence *operational strategies* that shape the learning experiences of *students.* Our analytic sequence proceeds to the familiar educational scale of classroom *teaching and learning* and then widens again to consider the *teacher workforce* and the *professional development* needs thereof. Finally, we return to large scale themes of sectoral *change* and FE *policy*, particularly as it relates to 16-18 mathematics education.

This *context to classroom to change* journey oversimplifies the relationships between these scales of activity but aims to show how policy changes are experienced and interact at different scales in the system. Where ideas could be discussed in more than one place we have tried to reduce repetition, though some ideas surface in more than one theme.

The discussion that follows is based on detailed analysis of the large dataset generated in our study of 32 colleges, which is a sizable proportion of England's FE colleges. When we refer to 'colleges' the reader should consider this a shorthand for the colleges in our sample, and similarly for managers and teachers. Where only a proportion of colleges, managers or teachers hold a view we try to indicate in general terms rather than with counts or percentages.

5.1 College context

College leaders highlight how several aspects of their general provision influence the organisation of mathematics:

- The range of educational provision;
- The balance between vocational and academic programmes;
- The allocation of students to mathematics qualification courses;
- The progression pathways between mathematics qualifications.

The range of study programmes offered by a college and the balance between vocational and academic provision influences the nature of the student cohort and their mathematical needs. This in turn affects the organization of mathematics. Although the qualifications offered are constrained by funding regulations, decisions about what mathematics qualifications 16-18-year-olds access and the progression routes they can take vary between colleges. These variations mean that students are getting different opportunities and experiences of mathematics depending on the strategy adopted by their college.

5.1.1 College provision

Differences in the range of vocational and academic programmes offered by colleges affect the mathematics provision required, students' motivation to achieve and their study skills.

Descriptive accounts from the case study colleges and college data show how some colleges have substantially more students on level 3 programmes, including A-levels, whilst the majority of students in others are studying at level 2 or below. As one college principal explains, in a comparison of their own college to another in the same city:

> *The College […] is a classic general further education college and therefore we offer exclusively vocational and applied courses in construction, engineering, business studies, hair and beauty, etc. Just about everything except agriculture and horticulture. Whereas […] College do offer a range of vocational courses - and a pretty wide range - but also have a significant A-level sixth form provision as well and that means that their 16 to 18 cohort across the college is very different from ours.*

Staff in the case study colleges highlight several ways in which differences in the college offer have an impact on the student cohort studying mathematics. In summary:

- Colleges with more level 3 provision typically have a smaller proportion of their 16-18-year-old cohort retaking GCSE mathematics since it is often an entry requirement for level 3 programmes;
- Students on level 3 programmes who are retaking GCSE mathematics are more likely to be aiming for Higher Education and tend to show a stronger motivation to pass GCSE mathematics;
- Level 3 students are reported as generally having stronger overall GCSE profiles and better study habits.

The impact of size is important since colleges with smaller mathematics provision are likely to experience less complex operational challenges. Variations in the motivation and study skills of students lead to differences in the challenges for teaching and learning mathematics, with some colleges finding this more problematic than others.

Variations in the composition of the student cohort affect the challenges faced by colleges and learner outcomes for mathematics. Current comparisons of college 'performance' do not take this into account.

As highlighted above, differences between colleges in their vocational and academic offer affect the nature of the student cohort and lead to different challenges for colleges in their mathematics education. At the commencement of the project over half of general FE colleges in England offered substantial[24] academic provision in the form of Advanced level qualifications (A-levels). Our sample included 18 colleges with a large A-level programme, 2 with small provision and 9 colleges that offered vocational programmes only. The colleges in the sample with the highest maths progress measure were those with academic provision. Furthermore, several of these were the largest providers of post-16 academic education in their area, whilst managers in other colleges reported the struggle to maintain viable student numbers on academic programmes in the face of strong competition from local schools or other colleges. The practice of re-entering students who have already achieved GCSE grade 4 in order to improve this grade impacts on performance measures (see *Bradshaw* case above). Current college 'performance' measures for mathematics (maths progress measures[25] and high grade achievement[26]) do not take these contextual factors into account. As studies from similar performance measures in school show[27], this is likely to introduce bias.

The range of programmes offered by a college and their distribution across sites has an impact on mathematics teachers' working practices.

All the colleges in this study offer a range of vocational study programmes and 18 (of the 32 colleges) run an A-level programme for 16-19-year-old students. Over half (18 colleges) offer programmes in all areas of learning, with land-based provision (i.e. those focused on the rural economy) being the most common exception. Where provision is spread across two or more sites, each typically hosts a different combination of vocational areas, with some being more specialised than others. Distinctive cultures develop on each site and this impacts *site-based or itinerant* mathematics teachers in the following ways:

1. Some site-based teachers become specialists in teaching mathematics to students from the specific vocational programmes on the site.
2. Site-based or itinerant mathematics teachers adjust their pedagogy in response to the distinctive cultures, behaviours and attitudes to mathematics on a site.

Travel between sites by itinerant teachers (up to 20 miles in the sample) affects their work routine, resources, break times and interactions with colleagues. As one teacher explains:

> *I work across three different sites which has pluses and minuses to it. The minuses are that you don't have everything you need all the time with you, or you end up having to carry lots of heavy things from one site to another. The pluses are that you pick up lots of good ideas which you can transfer from one site to another.*

[24] 54% of GFECs had 50 or more students at end of 16-18 with at least one A or AS entry
[25] The maths progress measure compares the highest maths qualification achieved by a student in college to their prior attainment. See Appendix 3 for further details.
[26] 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.
[27] Leckie, G. and 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.

In a simple arrangement with a single, site-based, centralised team of mathematics teachers there is less travel and adjustment to context but more opportunity for frequent interaction with mathematics colleagues. Most colleges in the sample have more dispersed provision than this and multiple site-based teams are sometimes a pragmatic solution. These geographical arrangements impact on professional development needs, opportunities and teaching approaches (see *Teaching and Learning*).

5.1.2 Mathematics qualifications offered

Colleges offer different balances of mathematics qualifications but provision is dominated by GCSE mathematics (retake) as a consequence of the Condition of Funding.

Mathematics is taught in various forms within FE colleges:

- Stand-alone mathematics qualifications;
- Specific mathematics modules within a vocational qualification (e.g. Engineering, Applied Science, Business);
- Embedded mathematics within vocational learning.

This report is largely concerned with stand-alone qualifications since these were the primary focus for colleges at the time and are central to government policy.

The majority of stand-alone mathematics qualification courses in the sample colleges are at Level 2 and below, with the majority of the provision being for 16-18-year-olds. Colleges also offer adult mathematics provision, although the extent of this varies. The mathematics qualifications offered by the colleges range from Entry Level to Level 3, although most providers without A-level provision do not offer a Level 3 qualification. Short qualifications such as Free-Standing Mathematics Qualifications (FSMQs) have been offered by a few colleges but only as bridging courses or short courses for adults.

Opportunities and approaches to embedded mathematics are discussed in *Teaching and Learning* below.

Core maths is a low priority for colleges and there is uncertainty about its positioning within vocational or academic programmes.

Within the sample, just over a quarter (9/32) colleges were offering a Core Maths qualification to students at the time of the visit but the numbers of students studying Core Maths in these colleges was small. Two other colleges had taught Core Maths in a previous year but were not continuing and two were considering starting in the following academic year (2019/20). The qualification was sometimes only offered to students on specific study programmes (e.g. Level 3 Engineering students; Level 3 Business students) or to those taking an A level subject such as Biology. Other colleges were trying to create a wider 'market' by promoting Core Maths across the college but mathematics managers report that support for Core Maths is variable and recruitment is dependent on how convinced individual vocational managers or course leaders are about its added value to students. The typical challenges for Core Maths in the case study colleges are explained by one manager as follows:

> *As a relatively new qualification, it's been an interesting one for us and we're trying to build up both the recognition of it as a valid progression because sadly in any vocational college, often the focus is upon meeting the conditions of funding and then looking at Level 3 only where it's applicable and appropriate.*

The priority for vocational staff is to enhance student achievement within their own programme and, although they state that good mathematics skills are important, additional studies are often considered to be a distraction rather than adding value.

5.1.3 Progression routes to GCSE

Mathematics progression routes to GCSE vary between colleges, resulting in inconsistent mathematics learning opportunities and experiences for students.

Colleges in the sample adopt different strategies for students to progress from their existing GCSE grade towards retaking the qualification. Different qualifications (GCSE or Functional Skills) are used as the starting point and the 'stepping stones' for students with the same prior attainment. The main approaches for 16-18-year-olds in the 32 colleges are as follows:

1. *Blanket GCSE strategy*: as many students as possible are placed directly onto a GCSE mathematics course, regardless of their prior grade. Students without a prior grade (including those new to the country) are assessed and may be placed on a Functional Skills course or GCSE, depending on an estimate of their potential.
2. *Skills improvement strategy*: 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[28].
3. *Bypass strategy*: 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[29].

Figures 1-3 show the progression pathways offered to students for the three main approaches listed above.

Student progression and achievement of different qualifications and the extent of their experiences of success or failure can vary considerably depending upon the approach. A 'Blanket GCSE' strategy offers an earlier opportunity to achieve GCSE grade 4 and stop studying mathematics but can result in a series of additional 'failures' for those with low grades. The colleges that adopt a 'skills improvement' strategy consider GCSE to be an unrealistic initial goal for students with prior attainment below grade 3. They suggest that focusing first on skills enables them to make better progress later. The *Bypass strategy* involves a large step from Functional Skills Level 1 to GCSE but deliberately avoids Functional Skills Level 2 because teachers report that this is a very challenging qualification for students, especially those with weaker language skills.

[28] 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.
[29] 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.

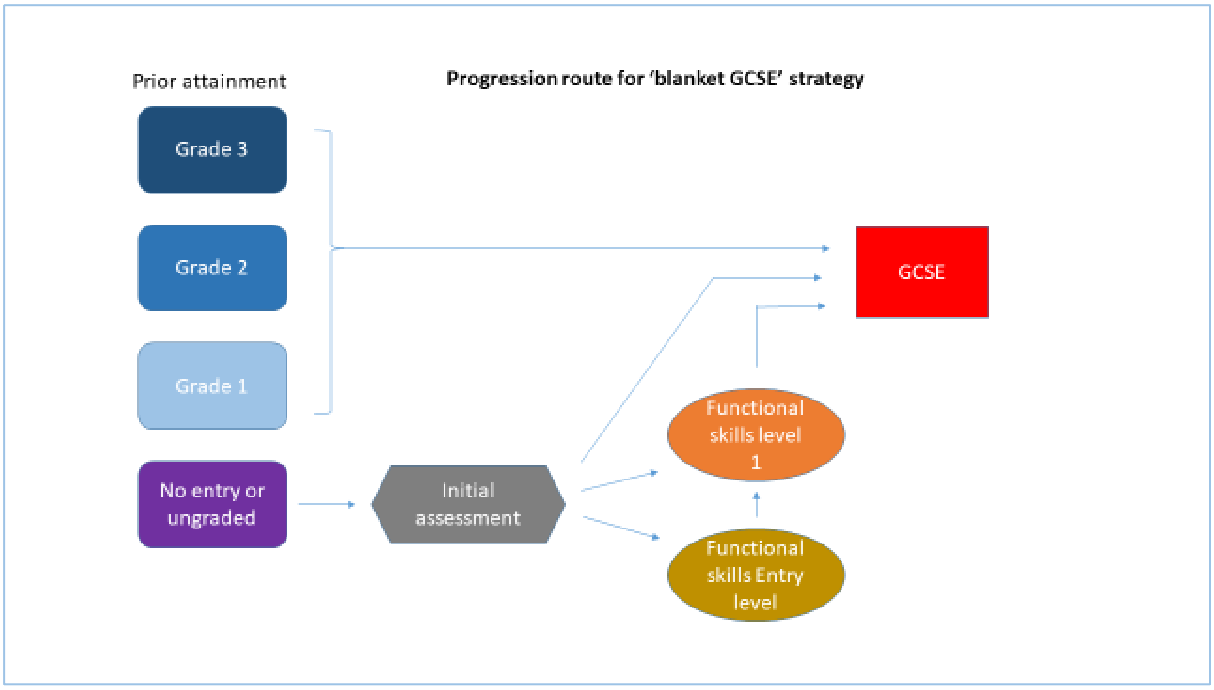

Figure 1: Progression route for 'Blanket GCSE' strategy.

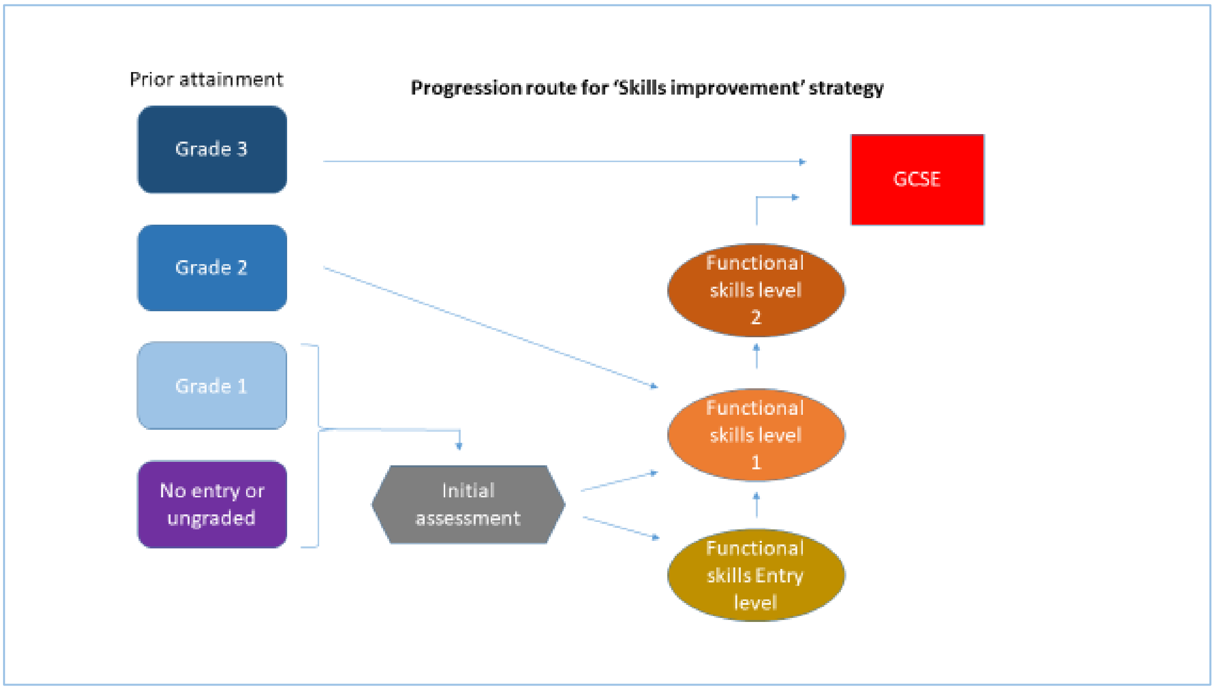

Figure 2: Progression route for 'Skills improvement' strategy.

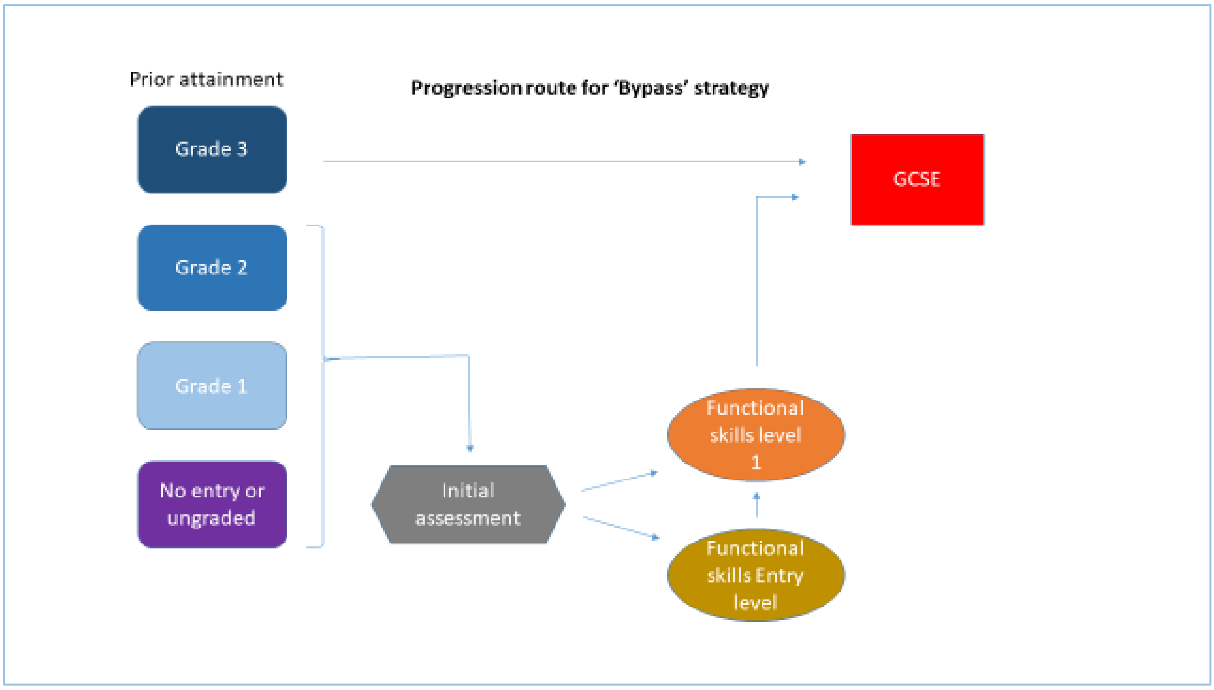

Figure 3: Progression route for 'Bypass' strategy.

College decisions about progression pathways for students are strongly influenced by college performance measures and perceptions of the qualifications.

The Condition of Funding requires students with GCSE grade 3 to be placed directly on to a GCSE retake course. Students with grade 2 or below may take a Functional Skills qualification first or retake GCSE but colleges can decide what qualification this will be and the progression route they will then follow towards GCSE. The rationales given by colleges in the sample for different strategies are based on:

- Perceptions of the value of Functional Skills mathematics compared to GCSE.
- The impact of a strategy on a college's prioritised performance measure.

Table 3 shows the number of colleges in the sample using each approach at the time of the visit (2018/19).

Progression strategy	Number of colleges
Blanket GCSE	4
Skills improvement	7
Bypass strategy	17
Data unclear	4

Table 3: Number of sample colleges using different progression strategies for mathematics

There were strong indications that more colleges were intending to move towards the blanket GCSE approach in the near future and that the mathematics progress measure was becoming important to some colleges. The values given to qualifications and grades at the time of the study are shown in *Appendix 4* and, although a later adjustment was made, improvement of a single GCSE grade still scores more highly than a progression from Functional Skills Level 1 to 2. Using Functional Skills qualifications as stepping-stones to GCSE is therefore an unattractive strategy if a college is aiming to maximise their maths progress measure.

The difficulty of Level 2 Functional Skills mathematics and its unsuitability as a 'stepping stone' to GCSE means a common strategy amongst the sample colleges is to move students straight from Functional Skills mathematics level 1 to GCSE. Teachers consider this to be a large step due to the additional content and focus on knowledge rather than skills and application but this is often outweighed by the argument that students find Functional Skills level 2 assessments to difficult and inaccessible.

A summary of the three most common strategies in the 32 colleges, the stated value for students, impact on the college and other effects is shown in *Table 4*.

5.1.4 Summary and implications

The FE colleges in this study offer different ranges of vocational and academic qualifications. The scale of mathematics provision as well as the nature of the cohort studying mathematics can therefore vary considerably. Students on different types and levels of programme can have quite different levels of skills and motivation to study mathematics. The challenges faced by the colleges in raising student attainment in mathematics are therefore not the same and to gain a more realistic view of college performance these contextual factors would need to be taken into account.

The mathematics qualifications and progression pathways that the case study colleges offer to their 16-18-year-olds are not the same, which leads to variations between colleges in students' experiences of mathematics. Performance measures influence college management decisions in different ways but can lead to a narrow focus on examination success rather than broader development of relevant mathematical skills. Such progress models encode particular values and priorities that are intended to drive behaviours. It would be worth considering whether the right outcomes are being achieved for learners with the current measures.

Variations in the student cohorts studying mathematics affect the teaching skills and professional development needed. The dominance of GCSE mathematics (retake) in colleges means this should be priority area for training and professional development but colleges also need to develop context-specific strategies that are tailored to address their students' needs. Questions raised about the suitability of Core Maths for vocational students and its place in vocational education need to be further investigated.

Strategy	Value for students (as stated by staff)	Impact on college	Other effects
Blanket GCSE	Students have a chance to re-enter for GCSE without wasting time over interim qualifications of less value. GCSE is the 'gold standard' so it should be the priority and all students should have the opportunity to study it. Students are better motivated because they recognise the market value of GCSE. Continuity in studying GCSE is better than an interruption to study for an interim qualification before retaking GCSE.	Maths progress measures are likely to be maximised. GCSE achievement (high grade) is likely to be low. With more students on GCSE it is easier to have streamed groups.	Students are more likely to experience multiple failures at GCSE before achieving, which is demotivating. Students' chances of passing decrease with each successive failure.
Skills improvement	These are the skills students need for the workplace. Many students do not need GCSE for their career. Working on these skills help fill gaps and secure important foundations that will subsequently help students succeed with GCSE. Working on these skills helps equip students to use mathematics confidently in work situations.	GCSE achievement (high grade) is not threatened by entries from students with low prior attainment who are unlikely to achieve grade 4. Maths progress measures are likely to be low.	Students work towards an achievable qualification. It is easier to convince students that these skills are relevant, which can increase motivation and engagement. Students gain confidence and motivation from passing an interim qualification.
Bypass	Working on skills secures important foundations but Level 2 Functional Skills is not an effective 'stepping stone' to GCSE since the approach and content are too far apart. (e.g. reduced content, no non-calculator assessment). Level 2 Functional Skills assessment questions use language and scenarios that are difficult to understand, especially for second language speakers and those with weak English skills or narrow social experiences. Progression to GCSE is not hindered by taking an alternative challenging qualification at the same level (but with lower value) first.	Maths progress measures are likely to be better than for a 'skills' approach but not as good as for the 'blanket GCSE' approach. GCSE achievement (high grade) is better than for the 'blanket GCSE' but not as good as the 'skills improvement' approach.	Students commence by working towards an achievable and relevant qualification. There are opportunities for students to pass interim qualifications and gain confidence. Students can spend time developing basic skills and filling knowledge gaps before retaking GCSE. The step from Functional Skills level 1 to GCSE is large due to differences in approach and content.

Table 4: The value for students, impact on college and other effects of the three main strategies.

5.2 Leadership and management

The Condition of Funding has resulted in a massive increase in the number of students taking mathematics courses in the case study colleges, especially at Level 2 or below. This rapid expansion has had an impact on:

- the leadership and management of mathematics
- staffing structures for mathematics
- roles of senior leaders and vocational managers

Approaches to the leadership and management of mathematics are contingent upon the size of this provision and its dispersion across colleges. These organisational challenges are notably different from schools, where mathematics is one of several similarly sized clusters of teaching activity. In colleges, mathematics and English are major, cross-cutting subjects. It is common practice for mathematics teachers to work across vocational areas where there are different cultures and approaches to learning. Oversight of the mathematics provision is often held by a single cross-college manager, whose role is wide-ranging and demanding. The colleges have adopted various management and staffing models, each with a mix of advantages and disadvantages which need considering alongside college priorities and contextual constraints.

5.2.1 Leadership and management of mathematics

Management of mathematics requires effective coordination and collaboration between staff at different levels of the organisation to provide the necessary leadership, organisational and curriculum expertise.

In our sample, cross-college management structures and roles vary, but a typical structure in a large college would include:

- A senior leader with strategic cross-college responsibility (usually as part of a portfolio of curriculum areas);
- A senior or middle manager with cross-college responsibility for the coordination and/or management of mathematics provision, either across the full college provision or just 16-19 study programmes (sometimes combined with English or other provision);
- A curriculum lead for mathematics with subject specific responsibilities;
- Two or more course leaders (e.g. GCSE, A level, Functional Skills) with responsibility for particular operational tasks (e.g. scheme of work, examination entries).

Job titles, roles and responsibilities of these managers vary between colleges, even if the same title is used for a role, but together they perform a range of functions that require a combination of strategic leadership, organisational skills and curriculum expertise. *Figure 4* shows how responsibilities may be mapped to roles in these hierarchical structures. The size and complexity of mathematics provision means that strong management skills are critical and some of the colleges prioritise these over mathematics specialist knowledge.

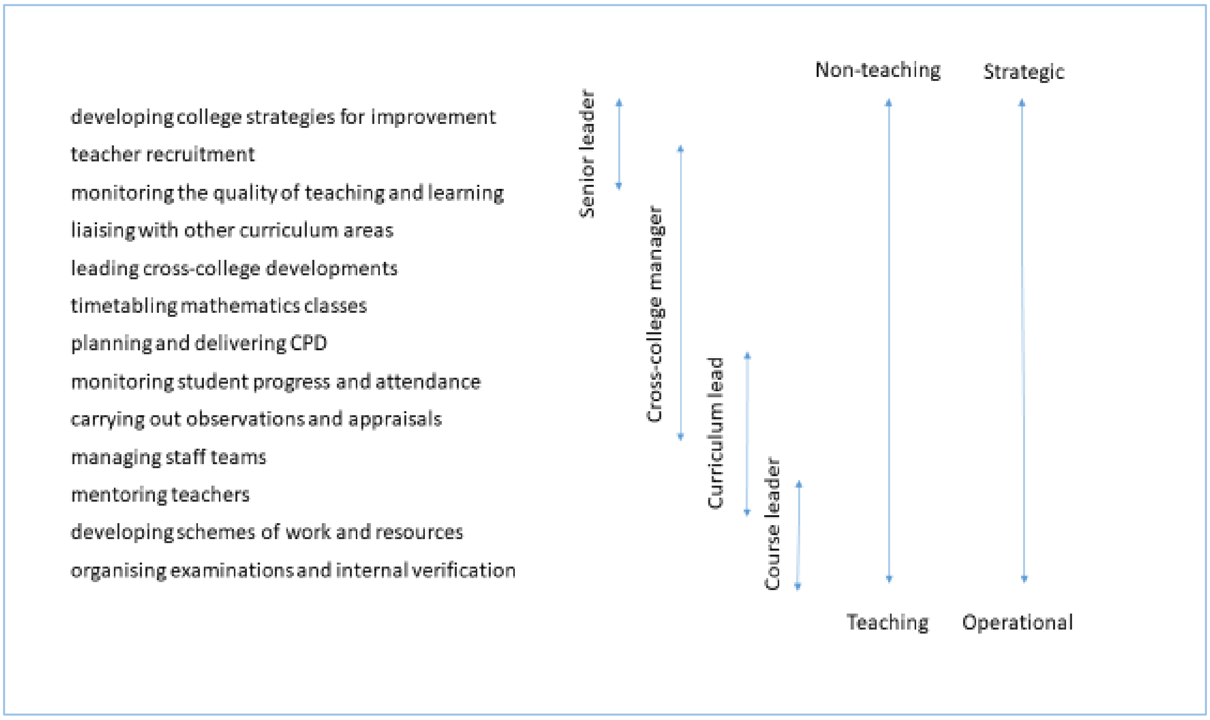

Figure 4: Responsibilities and functions of individuals in management structures for mathematics.

A collaborative approach to decision-making from senior leaders enhances implementation of cross-college strategies and the well-being of mathematics staff.

Senior leaders in the sample colleges have different levels of engagement with mathematics provision. Strategic oversight is usually delegated to a single senior leader but in some cases the college principal and other senior leaders are also actively involved, both strategically and operationally.

Middle managers and mathematics teachers report positive effects from strong senior staff support and collaboration. For example, one cross-college manager explains how they are offered an "open door" to discuss issues directly with senior leaders as they arise. This means action can be taken quickly to find solutions when problems arise. In another college, meetings take place regularly with representatives from all levels within the structure to solve problems together:

> *So that's sort of five or six tiers of the management structure where we get down to the nitty and gritty of what are the issues around maths curriculum…*

In contrast, where senior managers are remote and make decisions without consultation, middle managers report that operational issues are difficult to resolve and staff morale is low. Direct effects are felt by mathematics teachers when, for example, mathematics classes are moved to less convenient or suitable rooms at short notice, without consultation, and students (who are reluctant to attend anyway) become less likely to attend. This frustrates efforts by mathematics staff to encourage student attendance and becomes discouraging for staff who cannot influence such decisions.

Figure 5 summarises the two dimensions of senior management team (SMT) involvement and collaboration with teachers evidenced in the study from the perspective of mathematics teachers and middle managers.

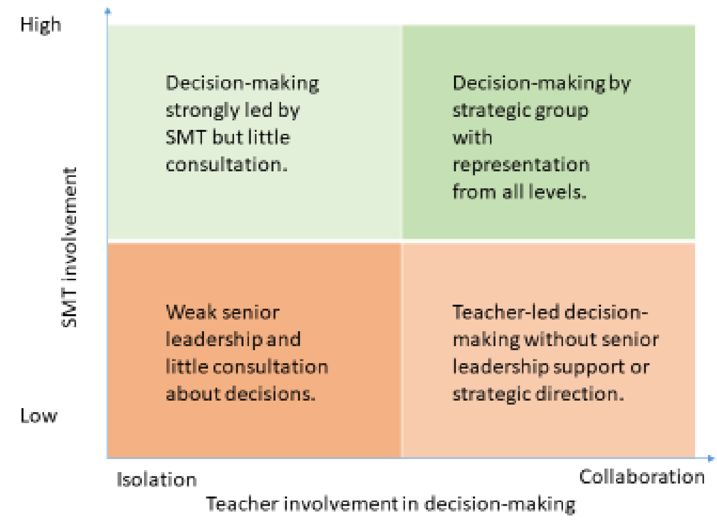

Figure 5: Senior management team involvement and collaboration with teachers.

Cross-college management of mathematics is challenging and requires extensive liaison, coordination and management of complex college-wide systems without direct control.

The role of cross-college manager for mathematics differs from most curriculum manager roles in a typical FE college. Firstly, the students studying GCSE and Functional Skills mathematics are dispersed across the organisation on a wide range of study programmes so extensive coordination and liaison is needed to arrange classes, track attendance and resolve issues. The location of classes and the mathematics teachers themselves may also be dispersed across one or more sites. In contrast, vocational managers are responsible for a more limited and discrete area of curriculum, staffing and space.

Secondly, responsibility for mathematics is shared with other vocational and academic managers. Vocational staff are responsible for students on their programmes but rarely have full responsibility for the mathematics classes attended by those students. The division of responsibilities varies between colleges but generally a cross-college middle manager for mathematics has overall responsibility for the quality and organisation of mathematics classes.

Cross-college managers report spending considerable time trying to streamline systems for others to implement and then tracking, monitoring and fixing problems. Their authority to enforce implementation plans for mathematics or make changes is affected by their level within the college structure and the effectiveness of their liaison with other curriculum managers.

There is little evidence of management training designed for cross-college managers of mathematics.

The responsibilities of cross-college managers for mathematics are challenging and distinctive. One of these managers explains the range of their responsibilities as:

So we're responsible for actually I think, if you like, the strategy right down to the shop-floor what's going on …

Figure 4 illustrates the way in which these responsibilities are often wide-ranging, straddling a combination of strategic and operational functions. These roles are vitally important in the implementation of policy yet colleges do not have access to bespoke training programmes to equip these managers. A national programme for managers of mathematics (and other cross college subjects) that focusses on the distinctive challenges of these roles would be beneficial.

When making key strategic and operational decisions, managers tend to adopt a 'try it and see' approach, often imitating what appear to be good ideas from other colleges. There is limited evidence in the sample colleges of robust evaluations of 'what works' in context or understanding of contextual factors that affect the transferability of strategies between colleges. Planning, implementing and evaluating in context appears to be a neglected area where better training for cross-college managers may facilitate more effective practices.

5.2.2 Staffing structures

Different staffing models have advantages and disadvantages depending upon contextual factors and college priorities.

Mathematics teachers may comprise a single, co-located team of teachers with a line manager, or, more often, the college adopts a hybrid arrangement based on a *multi-team* model. The following basic types of model evidenced in the case study colleges are:

- A *centralised* model in which a dedicated mathematics team is centrally located and managed but services all other curriculum (mainly vocational) areas;
- A *dispersed* model in which mathematics teachers are based in different vocational areas and managed by vocational staff;
- A *multi-team model* with separate teams for different sections of the college mathematics provision. This might be arranged:
    - By programme, with separate teams for the 16-18 study programme, the sixth form centre and adult provision;
    - By site, where there is a separate team on each site, each with their own team manager.

In practice, several hybrid variations of these basic models are used. *Table 5* shows how the models used in the sample colleges might be categorised.

Basic model	Variations	No. of colleges
Centralised	Centralised team on one site under one manager	9
	Site-based teams under one manager	4
Dispersed	Teachers based in vocational areas and managed by vocational staff.	3
	Teachers based in vocational areas but managed centrally	2
Multi-team	Separate teams for different types of programme (e.g. adults, sixth form, 16-18s) with different managers	8
	Separate teams for different college sites with site managers	6

Table 5: Structural models for staffing and management and number of sample colleges.

In some cases the model involves a further layer of sub-teams, whereby mathematics staff teaching different qualifications are managed separately. The example below shows how, within a multi-team model by programme, teachers of GCSE and Functional Skills on the 16-18 study programme are managed in different ways in a more complex hybrid arrangement:

> *The model for the college is that for Functional Skills, we deliver it within the actual vocational or other departments. For GCSE we deliver it centrally at the college sites. The only exception to that model is the Sixth Form which we run as a separate institution effectively which has its own GCSE and A-level staff.*

The model used is sometimes a pragmatic solution to a logistical problem but the case studies show that colleges are often influenced by models from apparently more 'successful' providers (e.g. with better high grade achievement). Changes between models are common, as one college manager explains:

> *I know colleges who've perhaps had centralised provision before, have decentralised and vice versa, to try and find if there's a better way forward.*

There is a tendency amongst the colleges to move between different models in a 'try it and see' approach, rather than attempting to understand and address the disadvantages of their existing arrangement.

Reaching agreement on a suitable model is also difficult since vocational and mathematics staff within the same college typically favour opposite approaches and each approach has disadvantages, one vocational manager suggests:

> *So there's swings and roundabouts, benefits and disadvantages, to both the systems really. I think there's more advantages to them being embedded within the curriculum team than there is them being separate.*

Our analysis suggests that there is no 'ideal' model but that colleges need to evaluate the suitability for their own situation and plan how to minimise the disadvantages of any model they utilise as part of their implementation strategy. For example, a *centralised model* is likely to result in weaker links between mathematics and vocational teachers so these need strengthening in other ways. This might be achieved by planning a link tutor system or a joint meeting structure to accompany the introduction of a centralised arrangement. In a *dispersed model*, mathematics teachers are more isolated and opportunities for informal professional learning are infrequent so other professional development opportunities may need to be created.

Contextual factors and college priorities have a bearing on whether a specific arrangement is feasible or desirable, as summarised in *Table 6* for the basic categorisation into centralised and dispersed models. In the case studies, although most colleges have a more complex hybrid arrangement involving multiple teams, a thorough assessment of suitability against criteria such as these would be useful for colleges before making decisions on changes to staffing structures.

5.2.3 The role of vocational staff

The commitment of vocational staff is essential for the effective and consistent implementation of strategies and systems for mathematics.

Only three colleges in the sample use a fully dispersed model in which vocational departments take the main responsibility for mathematics provision for their students. In some staffing structures they might take responsibility for Functional Skills but not for GCSE mathematics. In all the models identified, responsibility is shared, to some extent, with a cross-college manager of mathematics (at least for students on 16-18 study programmes). The division of responsibilities in these shared arrangements varies between colleges and boundaries are not always clear. In practice, there is also variation between vocational areas in the same college, even if there is a common internal policy. Shared responsibility is reported as working well in some colleges, with a sense of vocational and mathematics working together to tackle problems. In other colleges, or departments, relationships are uneasy and both parties seem more inclined to attribute blame than collaborate to find solutions.

Responsibility for the quality of teaching typically sits with mathematics managers, whilst vocational departments are often held accountable for their mathematics results. Vocational managers find this incongruous and do not always feel they have sufficient control to make the necessary changes. In most colleges vocational managers are also expected to take some responsibility for the attendance of their students at mathematics classes. There are examples of this co-dependency working well, with mathematics teams and vocational managers feeling mutually supported, but also evidence that other managers, both mathematics and vocational, find it difficult to handle shared responsibility and try to establish direct control.

In shared responsibility arrangements, cross-college managers find that commitment from individual vocational managers is critical for effective implementation of college mathematics strategies. Reports of variations in student achievement between vocational areas are common and the commitment of an individual vocational manager is frequently stated as the reason. College culture is also seen to be an influential factor. In some case study colleges, teachers report how mathematics is widely viewed as an essential part of the study programme whilst in others vocational managers perceive it to be an inconvenient addition to students' vocational studies.

Cross-college managers also have expectations that vocational areas will take responsibility for the embedding of mathematics[30] into their vocational sessions. There is considerable variation between the colleges, with some having well-established practices whilst others encounter resistance. Vocational and mathematics managers both attribute this reluctance to either the vocational staff having a lack of confidence with mathematics or being unsure about the ways in which embedding can be done. Embedded approaches and the implications for training and CPD are discussed later (see *Teaching and Learning*, *Professional Development*).

[30] The embedding of mathematics into vocational teaching and learning is a widely discussed practice with various interpretations. The newly accredited A levels and forthcoming T-levels have mathematical elements that will also need to be embedded within subject learning. We discuss findings about embedded practices in more detail later.

Type of issue	Situation	Centralised model	Dispersed model
Practical	The college is spread across several sites.	*Disadvantage:* A centralised model involves staff travel.	*Advantage:* A dispersed model ensures close links to curriculum areas.
	There are unequal numbers of students needing to retake mathematics on different sites or in different departments.	*Advantage:* A centralised model allows for flexibility and efficient utilization of teaching staff.	*Disadvantage:* A dispersed model may lead to under-utilisation of teaching staff.
Priority	An inexperienced or new mathematics team means that opportunities for **professional development** are a priority.	*Advantage:* A centralised model facilitates informal professional development since teachers work together in close proximity. *Advantage:* A centrally managed model makes it easier to hold regular meetings.	*Disadvantage:* A dispersed model isolates staff. *Disadvantage:* There are divided priorities (e.g. for meetings) when mathematics teachers are managed by vocational staff.
	Inconsistency or underperformance for mathematics in different vocational areas means **building stronger operational links** is a priority.	*Disadvantage:* A centralised model involves less frequent interaction between vocational and mathematics teachers. Disadvantage: A vocational manager often has more mathematics teachers servicing their area and making connections about operational issues is more complicated.	*Advantage:* A dispersed model strengthens links through frequent interaction of vocational and mathematics teachers. *Advantage:* A dispersed model means vocational teachers can more easily be involved in operational issues such as monitoring student attendance.
	Variations in expertise between mathematics teachers teaching different qualifications means that liaison between teams is a priority.	*Advantage:* A centralised model facilitates sharing of expertise.	*Disadvantage:* A dispersed model leads to localized practices and less sharing of good practice across the college.

Table 6: Reported advantages and disadvantages of the main two structural models for different college contexts and priorities.

5.2.4 Summary and implications

The management of mathematics provision across FE colleges in this study is complex due to the size, dispersion and shared responsibility involved. College managers identify a need for mathematics to be a whole college responsibility, with full support from senior leadership and vocational staff. Multi-level collaboration involving senior leadership and prioritization in areas such as timetabling are key elements of this approach.

Management of mathematics typically involves a team of staff at different levels working together but the cross-college manager with specific responsibility for mathematics is a key player. This distinctive role needs to be better understood and supported since these managers are important change leaders. The case studies provide little evidence of bespoke training for these positions and there would be merits in developing a national training programme, based on detailed examination of the functions and skills required.

Structural arrangements for mathematics staffing and management vary between colleges but there is no ideal solution. Colleges would benefit from better guidance on how to determine the 'best fit' for their situation, bearing in mind contextual constraints and priorities, since each structure brings different advantages and disadvantages.

5.3 Operational strategies

Colleges make their own independent decisions about the strategies, systems and processes they will use to implement mathematics policy. Students' experiences of mathematics are affected by a number of these key operational issues. In the case studies, these issues are primarily concerned with the time allocated to mathematics, the timetabling of lessons, the location of mathematics classrooms, the extra support provided and strategies for addressing poor attendance. College staff report that they consider the impact on students in many of these areas but decisions are also influenced by strategic priorities and contextual constraints. These influences result in varied opportunities and experiences for students in different colleges, which do not always seem best suited to their needs.

5.3.1 Teaching time

The time allocated to GCSE and Functional Skills mathematics varies between colleges but the time allowed and session lengths can result in the least able being disadvantaged.

In the sample colleges, GCSE mathematics is timetabled in discrete taught sessions, varying from 2 to 4.5 hours in total per week but typically being 3 hours. For 16-18-year olds this is most commonly timetabled as two sessions of 1.5 hours a week, although some colleges teach a single session of 3 hours. Colleges identify advantages in having two shorter sessions such as:

- Long sessions are demanding for students and teachers. Students' concentration spans can be quite short and teachers need to plan a variety of activities to keep students engaged in learning mathematics for 3 hours.
- Learning seems disjointed when there is only one session a week and students are likely to forget what they have learned before the next session.
- Timetabling as two sessions a week means students with irregular attendance may still access one session and make some progress. Some colleges also find they can offer 'catch up' sessions if a lesson is missed early in the week.

Colleges encounter barriers to timetabling two sessions or more a week, mainly due to established vocational practices. Vocational programmes are sometimes timetabled in 3-hour blocks because of the nature of the work (e.g. hair and beauty salon work; automotive, construction, or engineering practical workshops; restaurant or kitchen duties for catering). It is convenient to timetable mathematics to be compatible, especially if the provision is on a separate site and inter-site travel is involved for mathematics teachers. Weekly mathematics sessions of 3 hours are more common for students on these practical vocational programmes, although these are typically the students who are least likely to maintain concentration in a classroom setting for this length of time.

Timetabling mathematics more than twice a week is often impractical due to the constraints of inter-site travel, or additional time needed for movement between classrooms dispersed across a large site (by teachers or students), or because students are only on site for three days a week. It only appears to be feasible for single-site provision where there are less practical and more classroom-based vocational or academic programmes.

The time allocation for Functional Skills mathematics is within the range 1.5 to 3 hours a week and normally less than that for GCSE. Some teachers express concern that this disadvantages lower grade students who face greater challenges with learning mathematics and need more support in order to make progress.

5.3.2 Timetabling

Students are more likely to engage with mathematics when timetabling in colleges prioritises mathematics and is responsive to students' preferences.

The timetabling of sessions for GCSE and Functional Skills mathematics is a complex and time-consuming task. There are four main approaches in use within the case study colleges:

- A *mathematics priority* approach in which mathematics sessions are timetabled first and vocational areas have to timetable around them.
- A *negotiation with vocational areas* about where mathematics sessions would best fit, sometimes from a selection of options;
- A *negotiation with individual students* about which mathematics sessions would work best for them, from a number of options available;
- A *vocational* approach in which vocational areas take full responsibility for timetabling mathematics.

Reports from these colleges indicate that a *mathematics priority* approach has become more common in the last few years due to the Condition of Funding but the task is still challenging, as one vocational manager explains:

> *So we timetable around English and maths but it can be difficult and there's an expectation from students, even though there shouldn't be, that they'll only be in three days for the study programme. So timetable clashes and fitting all the elements of the study programme together with English and maths as well is a challenge. I think for any college of this size or bigger, it is a significant challenge.*

There is evidence that timetabling for mathematics is generally motivated by two main considerations related to student learning:

- To arrange sessions at times that encourage students to attend;
- To provide good conditions for students to learn.

Attendance is important to the college because of the financial penalties for non-attendance under the Condition of Funding and the resulting effect on achievement rates. Colleges therefore favour approaches to timetabling that maximise student attendance and learning. For example, colleges try to avoid times when student concentration is likely to be low (e.g. after 4pm or Friday afternoon) or days when students have no vocational sessions. Others try to minimise any gaps in student timetables so they are not tempted to leave the site and then fail to return for their mathematics session.

Colleges operate however under multiple constraints so compromises with timetabling must be made by considering, for example:

- The need to achieve good staff utilisation;
- The need to avoid time-consuming inter-site travel during the working day;

- The type of vocational provision and specific demands (e.g. service times for catering students, work placements);
- Unpredictability in the number of students who will need to take mathematics in a vocational area and at what level.

5.3.3 Location of classes

The location of mathematics classrooms has an impact on student attendance and vocational staff involvement.

The location of the classes is, to some extent, governed by localised college arrangements of sites and buildings but there is evidence of two contrasting strategies with different lines of reasoning:

1. Mathematics sessions take place in rooms within the vocational area. The justification for this approach is that it encourages good attendance since students do not have to move to unfamiliar parts of the college.
2. Mathematics sessions take place in dedicated rooms in a centralised area on a site. This is also justified as a way of achieving good student attendance, but on the grounds that students (and vocational staff) are in no doubt about where students should go for mathematics lessons. Once in the dedicated area any queries about the exact room are easily resolved.

Both strategies are designed to maximise attendance by making it easy for students to find their mathematics classroom. The first also promotes a message about the importance of mathematics as an integral part of the study programme whilst the other gives mathematics a clear identity within the college. Colleges find both messages useful and provide some evidence that both strategies can work. The second approach does, however, provide less opportunity for vocational staff involvement in monitoring attendance unless, as some colleges report, vocational teachers personally escort their students to the dedicated area.

5.3.4 Enrolment and induction

A delayed start to mathematics courses or an extended time for 'settlement' of classes at the beginning of the year has a detrimental effect on student progress.

In the case studies, references were made to a 'settling' period over the first few weeks of the college year, during which student timetables are subject to change. This results from uncertainty about the level of recruitment to each study programme, since students' GCSE grades determine whether they are accepted for the programme originally offered or directed to an alternative. These changes mean vocational groups can become too large or small and adjustments have to be made to split or merge groups. This in turn affects the size and timetabling of mathematics classes which may also need to be adjusted. Furthermore, diagnostic assessment in the first few weeks of the year leads to movement between mathematics groups in some colleges since they use this in conjunction with prior attainment grades to decide which mathematics qualification course is most suitable for a student. One college principal explains the difficulties as follows:

> *It's a big timetabling problem and it's meant that we've had to accept in some cases that the class size is not ideal because obviously you can't predict how many in each vocational area might be lacking in maths for example. So you very quickly*

> *at the beginning of each academic year have to try and sort them. Also we found that sorting them by prior qualification is surprisingly ineffective in the sense that they may have claimed that they've got a GCSE Grade C or D, but when you actually get them in the classroom, it doesn't appear to be that their maths skills are consistent with the grade that they appear to have got.*

A 'settling' period in September each year is accepted as an inevitability by many colleges despite the impact on teaching, which one teacher summarises below.

> *We start effectively teaching October, the start of October, because FE is quite chaotic at the start by the nature of it …*

Some colleges delay the start of mathematics lessons until the second or third week of term to avoid this uncertain period but valuable teaching time is then lost and an implicit message is sent to students that mathematics is a secondary concern in their study programme. Mathematics teachers report that an uncertain start to the year also hinders the establishment of good attendance patterns and collaborative classroom cultures. Colleges that have been able to start teaching mathematics from Week 1 report better attendance over the course of the year.

5.3.5 Student groups

Different organisational arrangements for mathematics classes, for example by vocational area or prior attainment, have advantages and disadvantages but decisions are contingent on the college context and priorities.

There are two key priorities evidenced in the case studies underlying the approaches used when arranging GCSE (and Functional Skills) students into classes:

- by vocational course;
- by prior achievement.

The sample colleges expressed a general preference for organisation by vocational groups on the grounds that keeping students from the same vocational course together provides a comfortable learning environment, facilitates meaningful contextualisation of the mathematics (in a vocational context) and makes liaison with vocational staff easier.

Some of the colleges had recently moved towards an arrangement into streamed classes rather than by vocational area though, based on students' level of prior attainment. This narrows the attainment range in a group and allows teachers to focus on the needs of students who are at similar stages in their progression towards GCSE grade 4. A few colleges identify other advantages in such mixed-vocational groups such as better classroom behaviour when students are away from familiar peer groups, or positive effects on the whole class when there are better motivated students present (e.g. Engineering students). Some "bad mixes" of vocational areas are however identified that do not work well together (e.g. Sports and Hairdressing) and other colleges take the opposite view that students work better in familiar groups.

Contextual and logistical factors such as the staffing structural model and college layout affect the feasibility of these arrangements. Managers explained how they have to consider the financial viability of group sizes. A dispersed structural model, for example, is compatible with arrangements into vocational groups but it is difficult to also achieve any streaming without having small, uneconomical groups. Broadly grouping by vocational area, rather than by course, sometimes makes streaming feasible since larger numbers of students are involved and several parallel groups can be scheduled at the same time. Such arrangements require several mathematics teachers to teach concurrently, which can present further obstacles, depending on the college staffing resources and other timetabling demands. Colleges that want to prioritise streaming therefore find a centralised model more suitable.

Even in a streamed approach, teachers commonly report a wide range of prior knowledge within a class. For example, some GCSE classes include:

- students who have never studied (or attended) a GCSE course for whom much of the course content in entirely new;
- students with GCSE Grade 3 who are close to passing and need targeted revision;
- students who have progressed from Functional Skills mathematics at Level 1 and need development in areas not covered in Functional Skills.

The colleges explain that previous GCSE attainment grades from school are an unreliable indicator of the level a student is working at. Groups that are streamed by prior attainment alone still contain students with very different knowledge, skills and approaches to mathematics. Although classes are often smaller than in schools, teachers still find some groups too large to adequately address the range of students' needs. Initial or diagnostic assessment results are therefore used by some colleges in conjunction with attainment grades to place students into appropriate classes.

5.3.6 Support for students

Colleges provide extra support for students but the impact is limited since those in most need are least likely to access that support.

Colleges offer various forms of extra support for mathematics such as workshops, 'catch up' sessions, one-to-one support, additional classes in the college week and revision classes in the holidays. Most colleges also have an e-learning platform where students can access further resources and any lessons they may have missed. These are mostly intended to help students who are struggling or miss lessons, but some colleges also aim to stretch and challenge students who are considered capable of higher grades.

Extra support and targeted interventions are considered by staff to be important elements of college strategies to improve students' achievement in mathematics but the overall effects are unclear. Few colleges systematically collect evidence of the impact of any specific interventions and, although the sample colleges report some evidence that students who attend extra sessions are more likely to achieve, the extra support is often only accessed by a small group of well-motivated students. Those in most need are unlikely to attend since these are often the least motivated students.

In some colleges, mathematics staff teach these extra sessions, workshops or interventions as part of their recognised workload, or they are provided by support staff such as learning assistants. For others it is a voluntary addition to their contracted workload. It appears that much effort is being made to support students, as either an unpaid increase to workload for teachers or, alternatively, at additional cost to the college. Despite these opportunities, students' reluctance to engage remains a major challenge.

5.3.7 Student attendance

Poor attendance at mathematics lessons is the biggest hindrance to student progress and achievement but current systems and resources are inadequate for the scale of the task.

Student attendance for mathematics is widely reported by the sample colleges as being lower than the college average. Teachers can often identify students who might be capable of making good progress with mathematics if they would attend the lessons more regularly and make a greater effort. As one teacher explains:

> *So I think the biggest issue that I would say with FE is attendance. We can't teach invisible people. So when the students start attending, then we can make a difference.*

Much effort is expended on tracking student attendance and taking follow-up action in the sample colleges. This is costly and time-consuming. Electronic systems are widely used to record and monitor attendance, some of which automatically generate text and email messages to vocational tutors, students or parents. The effectiveness of these electronic systems is variable, with breakdowns or slow systems being reported by several colleges. Colleges find that even the best systems still require individual staff to take action in response to electronically-generated communications. When initial actions fail to change attendance patterns, formal disciplinary meetings usually take place in which action plans for students may be agreed. The ultimate sanction for non-attendance is to withdraw the student from their college programme but this step is rarely taken unless there are wider concerns than just non-attendance in mathematics. Students soon become aware of weaknesses such as this in the system, which is disempowering for mathematics teachers.

The level of involvement of mathematics teachers in such processes is variable, with some making phone calls to students themselves. One mathematics teacher explains the reasons why:

> *If there's a problem with a student or a group or there's some issues, it's far more effective having that verbal conversation with them than email or on the communication system.*

This involvement can be empowering but is accompanied by the risk that vocational staff will become distanced from attendance issues. When mathematics teachers report absence rather than take action themselves, they are not always aware of the outcomes or even whether action has been taken. Good communication between mathematics and vocational staff is crucial and fewer problems are reported by colleges when:

- face-to-face communication is frequent, such as in a dispersed structure;
- vocational or admin staff personally visit mathematics classrooms to check attendance;
- immediate action is taken such as phone calls or text messages.

In some colleges there is good support from administrative staff (e.g. attendance officers) or vocational staff but not in others, even if attendance issues are designated as a shared responsibility.

Student absence from mathematics also occurs as a direct result of other actions taken in the vocational area. For example, mathematics staff in a few of the colleges reported that work placements, visits and other events are sometimes arranged at times that conflict with mathematics sessions. These take priority over mathematics and mathematics teachers are not always even informed in advance. Apart from the reduction in teaching time for mathematics, practices such as these indicate to students that mathematics is a low priority and undermine messages about the importance of mathematics that the colleges are trying to promote.

5.3.8 Summary and implications

The organisation of mathematics provision in the case study colleges is complex and time-consuming. The geographical layout of the college and other cross-college processes (e.g. enrolment and induction) present a range of challenges that affect the student experience of mathematics. College-specific factors such as staffing structures, student numbers and their dispersion across sites limit the practical possibilities for timetabling mathematics and arranging groups by prior attainment and/or vocational area. Managers would benefit from more support to evaluate the likely impact of different operational strategies within their own context.

Poor student attendance at mathematics lessons remains a major issue with a significant impact on learning. Managers and teachers report committing considerable time and human resource to dealing with attendance issues despite wide use of electronic support systems. Operational decisions that take student preferences into account are reported to have a positive effect but remedial strategies such as extra support are rarely accessed by the disengaged students who have the greatest needs. The colleges need additional resources and new college-wide strategies to improve attendance.

5.4 Students

This section reports teachers' and managers' views of their 16-18-year old students, their responses to mathematics and the reasons for their behaviours in the case study colleges. These students' attitudes and motivation for learning mathematics are influenced by family and social backgrounds as well as their prior learning experiences. The prevailing values and family aspirations in the local area can generate different challenges for colleges, which performance measures fail to take into account.

Vocational teachers play an important role in influencing students' views of mathematics and in ensuring that consistent messages are communicated throughout the college about the importance of the subject. Employers and higher education institutions signal the value of mathematics qualifications but inconsistencies and exceptions in entry requirements undermine this signalling. Students' tendencies towards short-term thinking means that communicating the 'use value' of their mathematics is likely to be more motivating than a longer term 'exchange value'[31]. Negative attitudes and emotional responses to mathematics, along with poor motivation and engagement, are commonly reported problems in the colleges. Unlike in school, many post-16 students wear the badge of mathematical 'failure' which decreases confidence and self-efficacy. Teachers need well-developed skills to address these barriers and associated behaviours.

5.4.1 Student backgrounds

The prevailing values and aspirations of the local area influence students' motivation to study mathematics and their likelihood of success but college performance measures do not take this into account.

Colleges in the sample typically draw the majority of their students from their local area, although some have a wider catchment because of a rural location or a specialist curriculum offer. Educational and life aspirations are lower in some local college communities than in others. Where aspirations are low, colleges report that students need encouragement to aim beyond locally-available low-paid employment which is achievable without qualifications such as GCSE mathematics. In a college where employment aspirations are higher and continuing into Higher Education is common, there is often a deeper commitment to gaining a better mathematics qualification since this is often needed for progression.

Teachers in some of the sample colleges express concerns about the number of students with 'troubled backgrounds' and issues in their home lives that affect progress, such as taking on increased responsibilities for siblings or being under pressure to make a contribution to family income by working part-time. These impact on students' college studies since classes may be missed and time available for out-of-class work reduced but the most serious effect is often on mathematics since students commonly view this as the least important part of their study programme.

Colleges also differ in the ethnic profiles of their student populations and in the proportion of second language speakers taking mathematics. Culturally embedded values from minority (or majority) ethnic groups affect students' attitudes and motivation. Several colleges in the sample, for example, note differences between students from Eastern

[31] Williams, J (2012) Use and exchange value in mathematics education: contemporary CHAT meets Bourdieu's sociology, Educational Studies in Mathematics, 80, No. 1/2, pp. 57-72

European countries, who show a "very positive orientation towards mathematics culturally compared to home students" and are motivated to work hard until they achieve. Other colleges identify how, in contrast, language issues can hamper students' understanding of mathematics questions, thereby affecting performance in class and in examinations.

Colleges in the sample often recognise these localised challenges and some are very focused on ameliorating them rather than excusing student under-performance. These differences, and the need for appropriate strategies to address local issues rather than adopting a 'one size fits all' model, are not always recognised more widely. Differences in college student cohorts evidenced in the study suggest that it not appropriate to assume that what works in one college is transferable to another with a different social milieu, or that the impact on achievement rates will be similar. Differences in the student cohort, as mentioned earlier (See *College context*), are not taken into account in comparisons of college performance with mathematics.

5.4.2 Influences on students

Family educational values and patterns of employment influence students' attitudes to, and engagement with, mathematics.

Teachers in the study report that students' attitudes and motivation to engage with learning mathematics are influenced by the views of family members who may promote alternative values to those espoused in colleges, including a lack of value for education. One manager, for example, finds that

> *A lot of parents aren't interested. So we call the parents, in the vocational areas. They have less interest than their children. So they're not getting the support at home.*

The main issues are summarised in *Table 7,* along with some of the common implications evidenced in the study from interview data. The effects of family values may primarily be on individual students but can also affect college culture when similar values are common across the local community. Dissonance between family and college values can hinder operational processes where the college might seek parental support (e.g. in action to address poor attendance for mathematics) and can undermine the college position on the importance of mathematics.

Vocational teachers' views of the importance of mathematics are influential but can vary widely within and between colleges.

Students on vocational study programmes spend most of their time in college with vocational staff, who have the potential to act as role models in relation to students' future careers. Unintentionally or otherwise, vocational teachers signal whether mathematics is important for success in their field. Actions such as timetabling mathematics lessons at unpopular times, or arranging placements or visits at the same time as scheduled mathematics sessions communicate a lack of value to students, whereas prompt follow up on absence from a mathematics session highlights its importance. Colleges repeatedly identify the importance of consistency in vocational teachers' positive messaging about mathematics.

In some colleges there is a clear and consistent message about the importance of mathematics whilst in others mathematics managers and/or senior leaders report that vocational teachers are not yet fully supportive.

Value statement	Typical source	Implications for student	Implications for college
One can have a successful career without a mathematics qualification	Family members with successful careers or businesses (e.g. construction trades, agriculture)	Low motivation to study mathematics, especially if intending to enter family business	Undermines the college message that mathematics is important
The mathematics you learn in college is not necessary for real life	Families who have not enjoyed or needed mathematics	Low motivation	Hinders college efforts to deal with poor attendance
Studying mathematics is too stressful for my child	Parents who see severe negative responses	High anxiety even if attending lessons	Conflict for college managers as they need to implement policy and promote well-being
Earning money is a priority	Families with low income	Mathematics is not a priority so effort and attendance suffer	Attendance is likely to be sporadic with no impact from actions to address this
Education is a waste of time	Parents who have not found value in education for themselves.	A general lack commitment to college studies and unlikely to attend parts of their course that they do not enjoy	Parents are not reliable sources of support for college in efforts to improve student progress or attendance

Table 7: Values communicated to students with sources and implications (for student and college) as reported by teachers

Employers and universities signal the value of mathematics to students in various ways but inconsistencies and exceptions result in some students being unconvinced that mathematics is important.

Teachers observe that when their students are aware that employers or universities require a mathematics qualification for their intended progression pathway, they often have greater motivation to achieve this. Colleges in the sample widely promote the message that mathematics is important to gain employment or progress to Higher Education (HE) but vocational teachers explain that, in practice, some local employers are only interested in the occupational skills of students and rarely ask about mathematics. Students who become aware of this typically lack motivation since mathematics does not have an immediate value. Teachers also report cases where motivation has quickly decreased because requirements for progression to HE have changed and some students have found themselves not needing a mathematics qualification for a specific HE course, or they receive an offer without mathematics. These inconsistencies undermine the messages that colleges are trying to promote about the 'exchange value' of mathematics.

5.4.3 Prior learning experiences

Students who have experienced failure in the past often demonstrate negative attitudes to mathematics that become barriers to learning. Teachers need skills to address these.

Teachers in the case studies frequently refer to students having negative learning experiences of mathematics in the past, resulting in one or more of the following:

- Low levels of confidence and self-efficacy;
- Negative attitudes and emotions;
- A lack of motivation and engagement.

These are points are discussed further in the following sub-sections. The proportion of students within GCSE retake or Functional Skills mathematics with negative prior experiences of mathematics reported by the teachers interviewed and the prevalence of the above attitudinal issues means that these are a significant part of mathematics teaching in FE colleges. Teachers need strategies to help students overcome these considerable affective barriers rather than focusing merely on cognitive development.

Students who have struggled with mathematics often have insecure basic knowledge and under-developed study habits.

Teachers in the study make frequent references to students not having some of the 'basic' mathematics knowledge and skills that they would expect. They comment on the need to teach basic concepts and processes before progressing to other work to avoid over-reliance on memorisation of routines by students rather than understanding. They find that developing understanding of fundamental concepts and processes is not however compatible with the aims or pace of a revision course and this presents teachers with a dilemma. There is a need for preparatory courses for students to develop conceptual understanding and this is one of the reasons why some colleges favour the *skills priority* progression route (see *Organisational Strategies*) in which students take Functional Skills mathematics before they embark on a GCSE revision course.

Teachers report that often the skills and knowledge of students do not match the grade achieved. A common conclusion is that the intensive revision methods used in schools leave some students reliant on memorisation of routines rather than understanding of the mathematics. Furthermore, students seem to have taken little ownership of their own learning and are reliant on instructional 'spoon feeding' rather than independent study. This makes the task of making measurable improvement in a year (i.e. improving by one GCSE grade) challenging since:

- the distance students need to travel is larger than one grade;
- the teaching time allowed is constrained;
- the extra support that can be provided in FE tends to be less than in school;
- students are less likely to undertake or benefit from independent study.

Other barriers to learning mathematics are identified by college staff, such as language demands, which can affect students' access to curriculum materials and examination questions, for native speakers as well as second language students.

In summary, prior learning affects students' progress with mathematics in the following ways:

- Mathematical (cognitive) – prior difficulties in making progress with understanding mathematics, leading to low attainment, knowledge gaps and insecure foundations for future learning.
- Non-mathematical (cognitive) – language difficulties that hamper students' understanding of questions even if their mathematical knowledge is secure.
- Emotional – negative responses to learning experiences and outcomes such as failure which result in low confidence, a lack of self-belief and a reluctance to engage in further learning.
- Habitual/social – prior establishment of habits unhelpful to future learning or the adoption of unhelpful values concerning mathematics from family or other social groups.

Acknowledging and understanding these barriers and developing appropriate strategies to help students overcome challenges to learning in all four areas is a key challenge faced by the colleges in both teaching and operational management.

5.4.4 Attitudes and emotions

Overcoming students' negative attitudes towards mathematics and perceptions of failure is a priority in FE mathematics teaching.

Teachers in the sample report that the emotional and attitudinal responses of low-attaining 16-18-year-old students to retaking mathematics in college are often negative and strongly influence behaviour. One manager summarises the situation as follows:

> *They just don't want to do it. That's the most popular one. It can be mental health issues. It can be that fear of where they've had a bad experience coming from secondary, to us where there's that big barrier to break down in the first place. So they've already got the barrier before we've even begun. And why do they need to take it again when they've already failed it once? There's they have to repeat. It's just they've lost the interest. They've lost heart or belief in themselves and it's re-building that.*

Teachers in the study report that only a minority show an interest in the subject and many fail to see any value in trying to improve their mathematics skills. Others accept the need to study mathematics but still lack interest in doing so. This produces a lack of motivation and engagement so that students either fail to attend lessons or avoid participation in learning activities.

Previous 'failure' in mathematics examinations is identified as a factor that reinforces low confidence and poor self-efficacy; students are even more convinced that they do not have the ability and will never succeed with the subject. Students with low levels of confidence are often afraid to make mistakes and fear being seen as stupid by their peers. They may be reluctant to try a question or quickly give up because they have no confidence that they can succeed. This lack of self-efficacy and low resilience leads to reduced effort and disengagement.

Teachers need to develop student-responsive pedagogies and skills in building resilience, improving confidence and changing mind-sets in order to counter prevailing poor attitudes.

Teachers in the case studies indicate that issues of low confidence, self-esteem and resilience with mathematics can be overcome with skilful teaching using, for example, a scaffolded approach for individuals so they make progress and become more inclined to make further effort. Timely intervention with individuals can also help avoid periods of inactivity and help them to make progress.

Evidence from the interviews indicates that negative attitudes and emotions can be manifested in a variety of ways:

1. Avoidance through non-attendance or infrequent attendance
2. An apathetic approach in class and little effort to engage with learning
3. A low level 'surface' engagement with the learning which results in limited actual understanding and only short-term retention
4. Disruptive behaviour in lessons
5. Excuses for why they cannot get on with the work
6. Blaming the teacher for not explaining well enough
7. Using distractions such as mobile phones or conversations with peers to avoid engaging with learning.

Dealing with a mix of attitudes, emotions and behaviours in a classroom situation is challenging since the causes are often quite personal and require an individualised approach. These issues will be familiar to teachers in other phases of education and are sometimes ameliorated with the different learning environment that many FE teachers aim to provide. Other issues are rooted in deeply embedded beliefs and involve long-term strategies to change established mind-sets.

Current policy and its enactment can have additional negative impacts on those students with emotional or attitudinal difficulties with mathematics.

Teachers report that students tend to lose hope of ever succeeding with mathematics if they experience further examination failures in college. Those who start from a low prior attainment grade often perceive the goal of passing GCSE mathematics to be unattainable and evidence of improvement (i.e. increasing one grade) still seems like failure when there is so much emphasis on achieving a grade 4.

The compulsory retake policy opens up opportunities but can also lead to resentment and resistance from students who are already disaffected. Starting a new programme in college, with a vocational orientation, signals a break with students' past experiences but compulsory mathematics does not fit easily alongside this new phase where students have otherwise had some choice, albeit restricted, about what they are studying.

Teachers report examples of very strong emotional responses to mathematics from some students. These include anxiety and fear, which result in some individuals becoming angry or crying at the prospect of having to attend mathematics lessons, or in the classroom. Anxiety leads to poor examination attendance and performance, which further reduces confidence and self-efficacy in what can be a vicious circle. Colleges report that students often do not attend mathematics examinations, or leave early, because they are too nervous or have no expectation of being able to succeed. The effects of compulsory mathematics on mental health are a serious concern for some college staff when they see the consequences of increased anxiety in already fragile lives.

5.4.5 Motivation and engagement

Low attaining students often have limited aspirations and are more likely to be motivated to learn mathematics because of its use-value rather than its exchange-value.

Motivation to learn is closely entwined with students' attitudes, beliefs and emotional responses to learning mathematics. There is a consistent message from teachers and managers across the sample colleges that many 16-18-year-old students who are re-taking GCSE mathematics or taking Functional Skills mathematics lack motivation to study the subject, although those close to passing (i.e. holding a grade 3) may be more motivated. Very few appear to have any intrinsic motivation to study mathematics, even though they acknowledge that mathematics is important.

The aspirations of these students influence their views of mathematics and whether they are motivated to try and achieve a better grade. For example, students are more likely to be motivated to study GCSE mathematics if they intend to:

- Progress to a higher-level course in college for which GCSE mathematics is an entry requirement;
- Progress to Higher Education, since GCSE mathematics is often an entry requirement;
- Follow a career path or undertake employment where GCSE mathematics is a requirement.

For these progression routes, GCSE mathematics is a requirement and therefore has an 'exchange value' for the student. The qualification has less value for students without these aspirations, or for those aiming to enter employment where GCSE mathematics is not a requirement and therefore offers little market advantage.

Short-term thinking is reported as common amongst 16-18-year-olds in colleges. Those who are intending to progress to HE often become more motivated in their final year at college whilst others cannot see beyond the immediate goal of low-skilled employment. For most students, mathematics is not a priority and only becomes important when there is direct and immediate relevance.

Students do become motivated if the skills they are developing appear to have some personal relevance and 'use-value'. Connections to their vocational study programme or the use of relevant contexts (e.g. vocational, life experiences, students' interests) can highlight the 'use value' of mathematics but when the content of mathematics lessons has no obvious connection or practical use, students are reportedly less inclined to engage with the subject matter.

5.4.6 Student attendance

Lesson attendance is necessary for learner progress but enforced attendance without personal motivation increases the demands on teachers for behaviour management.

Student attendance is typically polarised into a group of reliable, regular attenders and those with irregular patterns of attendance, including 'persistent offenders' who sometimes refuse to attend at all. Teachers report that poor attendance affects the progress of an individual and can also disrupt learning for others in the class if irregular attenders then need extra support or extended recap of work missed. However, enforced attendance can result in resentment and avoidance behaviour. Some avoidance behaviours in the colleges are passive (i.e. not participating in learning activities) but others are more aggressive (e.g. verbal comments to distract or argue with peers or the teacher). This increases the demands on teachers to develop engagement strategies and techniques for managing challenging behaviour.

A commonly held view amongst staff is that students are more likely to attend if they find the lessons interesting and engaging. Connections between different levels of engagement, with possible reinforcement loops between participation and attendance are shown in *Figure 6*.

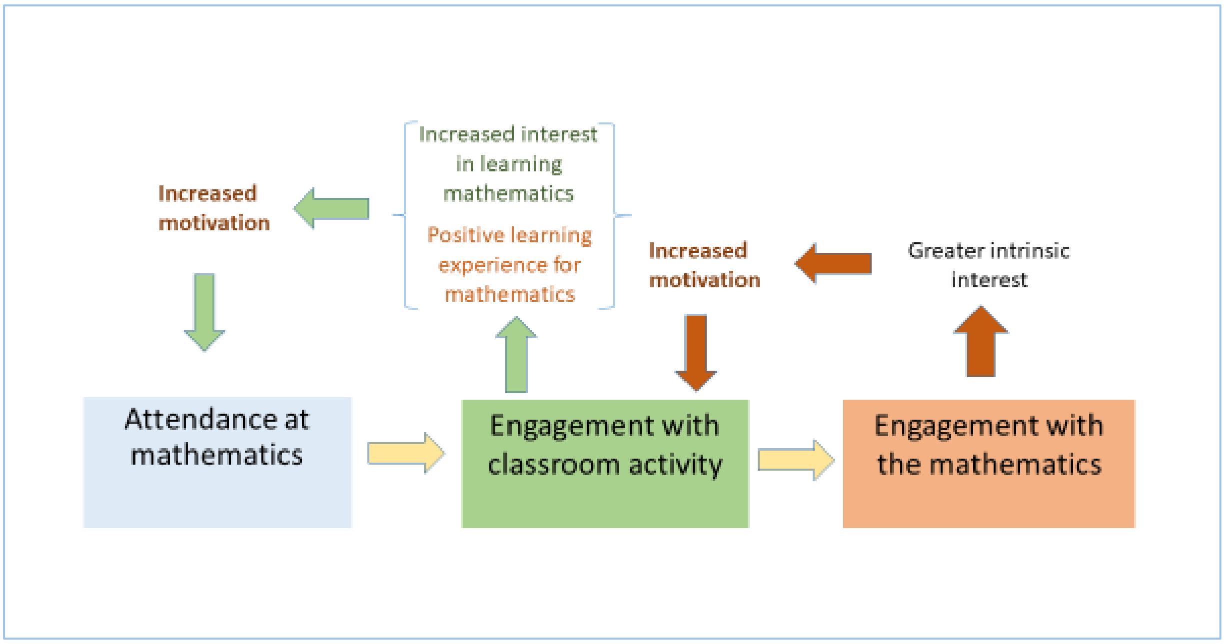

Figure 6: Levels of student engagement and reinforcement loops.

Mathematics teachers report a constant pressure to make lessons more and more interesting and engaging, particularly so where this becomes the primary strategy to improve attendance. Yet there are multiple and sometimes complex individual issues that affect students' motivations and responses to mathematics lessons.

The main reasons reported by teachers for the poor attendance of 16-18-year-olds are:

1. Students may lack motivation to study mathematics because they do not see the relevance to their intended careers or occupations.
2. Students may avoid mathematics lessons because they dislike the subject.
3. Students may be trying to avoid a situation that causes increased stress, anxiety or fear.
4. Students may avoid mathematics because they find the subject difficult to learn and lack the resilience or motivation to persist.
5. Students may prioritise their vocational study programme and miss mathematics lessons when they are under pressure to complete assignment work (or prepare for examinations).
6. Students may prioritise paid work and take on part-time jobs, sometimes due to parental pressure because the family needs money, or because the short term

gains from having a personal income seem more important than a longer term investment in education.

7. Students may prioritise their social lives and make decisions that result in late arrival for morning classes or after lunch.
8. Students may avoid mathematics due to resentment about being forced to study the subject.

This variety of causes highlights the challenge of tackling attendance problems. Greater understanding of these root causes is needed in order to develop better strategies and reduce the time invested in addressing secondary behaviours.

5.4.7 Summary and implications

The local communities and family backgrounds of students in the case study colleges influence their general aspirations and motivation to study mathematics. Teachers recognize that they have opportunities to influence attitudes to mathematics by highlighting the qualification requirements of employers and Higher Education providers, and the value of mathematics skills in vocational employment. The research highlights the need for greater consistency with signaling the value, especially from vocational staff. Teachers identify the need for an emphasis on the 'use-value' of mathematics over and above its possible 'exchange-value' since this is more convincing way of engaging some students.

Across our colleges, the teaching of mathematics is dominated by the need to address negative attitudes, increase motivation and engage students who often have insecure basic knowledge of mathematics and poor study skills. An unintended consequence of the Condition of Funding seen in the case study colleges is the negative effect of compulsory mathematics on students who are already disaffected. Teachers report how enforced attendance can intensify negative emotional responses and lead to a deterioration in classroom behaviour. Resources and specialist skills are needed by mathematics teachers to deal with these increasing problems and these could be given greater emphasis in sector-specific training.

5.5 Teaching and learning

This section of this report is organised in three distinct sections that focus in turn on three scales of activity: classroom-level pedagogies, college-level organisational factors, and external factors such as policy constraints and qualification structures (see *Figure 7*).

The majority of mathematics teaching in FE colleges involves students who are retaking mathematics on a GCSE or Functional Skills course. Teachers' pedagogical choices in the classroom are framed by the results of organisational and external decisions that determine the nature of the course and the student cohort that they teach. These can be understood as nested but interlinked spaces (classroom, organisation and system), as summarised below (see *Figure 7*).

1. Mathematics teachers in FE colleges report multiple ways in which they adapt their practice to meet learners' needs, either within groups or between groups. We find it helpful to refer to this range of approaches to context- and cohort-dependent teaching as a set of adaptive pedagogies. This incorporates, but goes much wider than, the notion of differentiation since it also includes responses to the vocational context and emotional needs of students who have already 'failed'.
2. Teachers work within colleges where organisational decisions determine the situations in which they teach and the composition of their groups. This affects the range of flexibility allowed and how closely teachers are expected to follow pre-planned schemes and lessons.
3. Teachers work within a system where external policy and curriculum decisions frame the nature of the courses taught and the key features, i.e. being primarily a compulsory revision course, designed for students who are 'failures' and accompanied by time-bound expectations of success.

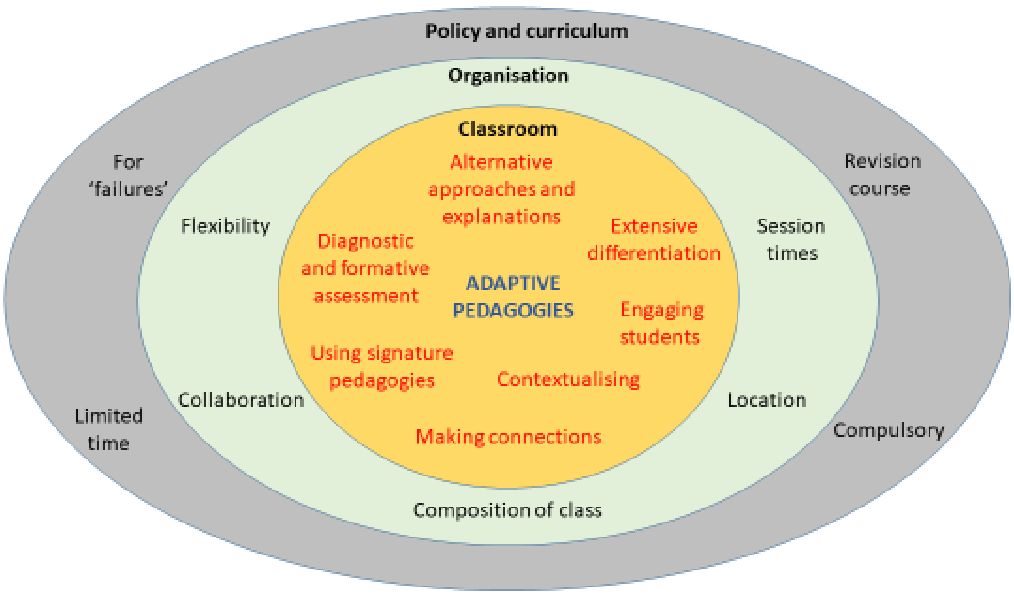

Figure 7: Nested influences on classrooms that lead to adaptations in pedagogy

There is wide agreement amongst teachers in the study that adaptation is a prominent and necessary element of their teaching of mathematics in the FE college context. This is understandable given the peculiar challenges facing teachers in FE colleges. Without observations of classrooms we cannot confirm the extent to which adaptive approaches are applied or their effects. Further research and development would be needed to establish this. The core elements of teachers' reported adaptive pedagogic approaches that emerge from the study are however discussed below. Following this, the contextual factors are explained to show why teachers claim that teaching GCSE retake courses (and Functional Skills) in post-16 education is different from teaching the same qualification to pre-16's in school.

5.5.1 Adaptive pedagogies

Adaptation is reported by mathematics teachers to be a strong feature of their teaching in FE which enables them to meet the wide range of students' needs they encounter.

Mathematics teachers report that they frequently adapt their lessons and resources because of the multiple differences within and between student groups. Having the flexibility to select and adapt appropriate approaches and resources allows them to find 'what works' for different groups in terms of engagement and cognitive processes. The main adaptive pedagogies evidenced are summarised below and then discussed in more detail:

- Providing alternative approaches and explanations to those encountered previously by students;
- Extensive differentiation of teaching approaches and tasks for different groups or individuals due to differences in prior knowledge;
- Engaging students with different attitudes, goals and mathematical identities;
- Contextualising mathematics in different ways to highlight the usefulness and relevance in relation to different student interests;
- Making connections to mathematics that is embedded in different vocational programmes;
- Understanding, and aligning where possible to, the particular pedagogic strategies used in different vocational areas;
- Using diagnostic and formative assessment to identify needs and revise teaching plans so these are addressed.

Teachers need a toolkit of alternative methods and explanations for students whose prior learning experiences of mathematics have not been successful so they can adapt to meet students' needs.

Mathematics teachers in the colleges find that students whose previous learning experiences have been unsuccessful often gain better understanding when offered an alternative method or explanation. Teachers explain how they frequently demonstrate different methods to a class or to an individual student in order to find one that they understand, or they try to explain a concept or process in a different way. This approach involves frequent and multiple adaptations to offer alternatives to students when they are having difficulty understanding mathematics. Teachers' pedagogic content knowledge needs to be excellent so that they can confidently use a range of alternatives. They also need to be able to innovate when standard approaches do not work.

Extensive differentiation is required to accommodate the range of prior attainment and student knowledge within mathematics classes.

The demand for differentiated approaches in FE mathematics classes is high due to:

- the range of abilities and prior achievement within a class;
- the range of needs and knowledge deficits, even for students with the same nominal achievement.

Despite widespread use of initial assessment to ascertain the level at which students are working and attempts by some colleges to stream groups, teachers refer to classes with a wide range of prior knowledge. GCSE groups, for example, may include students who:

- have recently narrowly 'failed' GCSE in school and are retaking for the first time;
- are re-sitting GCSE for the second or third time in college;
- have recently passed Functional Skills mathematics level 1.

The learning history and knowledge base of students in these three categories can be very different. Similarly, students in functional skills classes may range from Entry level to Level 2 but colleges may have limited options other than teaching these together.

Differences in prior knowledge are often addressed by using differentiated tasks for individuals or small groups within a class. This allows teachers to focus on individual weaknesses but is demanding in terms of planning, supporting and adapting. As one teacher explains, "the concept of helping each student in class, it is difficult, and it was tiring to begin with". Teachers need well-honed skills to assess students' needs and identify how to adapt resources accordingly in order to achieve this in-class differentiation of tasks.

Teachers need to use a range of different approaches to address low levels of student motivation and engagement.

The problems of low levels of motivation and engagement with mathematics learning in FE have been discussed above (see *Students*). These present barriers to learning and teachers find they need to design lessons that specifically address these, rather than merely focusing on subject content.

Students are better motivated and engaged with mathematics if:

- they have a personal reason to gain a better qualification in mathematics;
- they understand how mathematics is relevant to their own lives and interests.

Motivation improves when students feel that they are making progress. As one teacher explains, "if you can get them to make progress, then they feel a great sense of satisfaction". For this purpose, realistic individual short-term goals can be helpful, especially if these are set and reviewed frequently with students. This may happen on a lesson-by-lesson basis by individuals rating their confidence with a topic and reviewing later how their understanding has improved.

The evidence from the study indicates that engagement with mathematics needs to be stimulated on three levels:

1. Attendance at mathematics lessons.
2. Engagement with classroom activity.
3. Engagement with the actual mathematics.

Teachers strive to use varied and interesting materials to meet the needs and preferences of different students. Yet interesting lessons can only do so much. Teachers need to understand the causes in order to help students overcome the barriers and establish learning processes that are more student-centred.

Teachers talk about the need to change students' mind-sets and self-efficacy through, for example, celebrating what an individual can do, rather than what they cannot. Changing behaviour typically involves highly individualised approaches that build relationships with students and understanding of their backgrounds. This is a responsive, relational approach of adaptations to individual needs requiring a range of strategies.

Using contexts of relevance or interest to students increases both engagement and conceptual understanding.

Using contexts that are relevant to students is widely considered by the teachers in the study to be one of the most effective approaches for teaching mathematics to 16-18-year olds. This is mainly due to the positive effect on engagement when students see that mathematics is relevant and has 'use-value'. This is especially important for those aiming for skilled employment after college rather than academic study.

Using a familiar context can also help students to grasp concepts and processes that they can then learn to apply more generally. Teaching mixed vocational classes increases the difficulty of finding meaningful contexts that suit all students but teachers find that they can use contexts of relevance to different vocational subgroups to stimulate useful discussion, or focus on other shared interests. Mathematics teachers also find interest amongst 16-18 year olds in areas that relate to their future personal lives such as personal finance, mortgages, tax, checking pay or topical issues that are related to their current experiences such as statistics on knife crime, the gender pay gap or world events.

An emphasis on contextualisation is not well aligned with preparation for GCSE and Functional Skills examinations. This influences how much contextualised problems are used. In Functional Skills examinations the contexts are often unfamiliar so only using familiar contexts in teaching is insufficient. Being able to apply mathematics in realistic contexts is not important for achieving a 'good' grade in the GCSE examination so it is not a priority when teaching time is constrained.

Meaningful and timely connections between mathematics in vocational programmes and mathematics classrooms emphasises the relevance and 'use-value' of mathematics.

Aligning the mathematics curriculum to students' vocational study programmes can reinforce the relevance of mathematics. Links between schemes of work are made in some of the sample colleges but few teachers feel able to make meaningful connections between what is taught in mathematics classrooms and the mathematics in vocational areas. This requires knowledge of vocational practices and adaptation of mathematics schemes of work to match an occurrence in the vocational programme (or vice versa). Opportunities for vocational and mathematics teachers to collaborate are considered beneficial but rarely prioritised. This is an under-developed area of teachers' adaptive pedagogies. In mixed vocational classes it is more difficult to make timely links, although there are more examples to draw on of the occurrences of mathematics when dealing with several different vocational programmes.

Mathematics teachers need to understand vocational learning and the pedagogies within different vocational areas to best adapt their approaches to suit vocational students.

Teachers in several colleges report how students from different vocational areas have particular behaviours and they have to "teach for what works for their particular cohort of young people" because "different vocational groups will react differently to different styles of teaching". Art and Design students are described as rarely interacting with each other, but Sports students are typically active so "you're lucky if you can get then to sit down for half an hour … they're like little whippets just running around." These variations are attributed to the way students with different personalities are attracted to particular vocational areas but it does affect their response to the teaching approaches used in mathematics lessons. Teachers find what works for hair and beauty students, for example, does not necessarily work with sports students. Vocational learning generally utilises a different pedagogical approach to teaching a subject such as mathematics and vocational areas also have their particular pedagogies that reflect the values and priorities of the occupation (e.g. social interaction, teamwork, physical activity). Understanding how students learn within a vocational area is important so mathematics teachers can appropriately adapt their approaches to suit students on vocational pathways.

Diagnostic and other assessment data is not always used very effectively in planning.

Teachers talk about the need to fill knowledge gaps rather than re-teach the entire qualification content (especially for GCSE) but some are hesitant and feel more comfortable trying to cover the entire content. Colleges usually have an agreed strategy which generally falls into one of three main approaches:

- Teachers cover the entire content because they want to give every student the best chance and students have different areas of weakness;
- Teachers focus on the most common areas of weakness in a group which they identify from diagnostic assessments or from experience or examination reports;
- Teachers develop individual plans for students from diagnostic assessments (which may be ongoing) and provide differentiated resources in class to address individual identified weaknesses.

Addressing weaknesses, for individuals or groups, requires detailed diagnostic work and adaptation of planned schemes of work. Although colleges carry out diagnostic assessment the use of this information to make appropriate adaptations is often under-developed. This suggests an area where teachers would benefit from further guidance and training so assessment data is used to adapt teaching in a more formative process.

Training for teaching mathematics in FE needs to have a greater focus on the skills needed to adapt pedagogic approaches to suit different student needs.

An *adaptive* approach to pedagogy demands an extensive toolkit of resources and skills in order to assess students' needs, identify appropriate methods and teach the same concept or process in different ways. Key areas need to be considered in teacher training (and CPD) such as being able to utilise alternative methods and re-design resources to suit different needs. The extent of adaptation is summarised by one teacher as "Everything from picking a resource to how you talk to that person is totally different in each cohort that you pick up" and teachers explain how they frequently adapt a scheme of work "because my students have different needs". Important aspects of this adaptive approach to pedagogy are often only learned from experience but could be usefully incorporated into training for FE mathematics teachers.

5.5.2 The effects of organisational decisions

College decisions about strategies and systems affect teaching approaches in a variety of ways since these determine the context in which teaching takes place.

Colleges in the sample make decisions about strategies, systems and planning that construct different teaching situations and affect the approaches teachers use. The main elements that influence teachers' approaches in the classroom are:

- College decisions on strategies and timetabling, since these determine the composition of classes, session times and the location of classes;
- Collaborative planning of schemes of work and lessons provide a framework within which teachers in different colleges have varying degrees of flexibility to change or adapt their teaching approaches.

The effects of college strategies and systems have already been discussed (see *Operational Strategies)*. These lead, for example, to either vocational groups or streamed groups, which may be taught in dedicated mathematics classrooms or in vocational areas and in short or long sessions. These factors influence the approaches used by teachers since classes with different ranges of prior attainment and lengths of session may require different resources and structures. The location of a class also affects the availability of resources which may constrain the approaches that can be used.

There is variation between the sample colleges in the extent of shared practice and effectiveness of collaborative planning but there are three main approaches:

1. There is a shared scheme of work but individual teachers plan their own lessons. There may be a shared resource base (e.g. on Moodle) to support individual lesson planning but teachers also look elsewhere (e.g. by searching websites for resources they think might work).
2. There is a shared scheme of work, lesson plans and resources. The resources are sometimes pre-printed and appear in staff rooms at the beginning of the week. Teachers may use their own resources if they wish.
3. There is a shared scheme of work, lesson plans and resources. These are mandatory and compliance is monitored.

The level of standardisation within the third approach constrains adaptation but is perceived as a way of controlling quality, supporting inexperienced teachers and has attractive practical effects, such as:

- Making it easier to cover classes at short notice;
- Ensuring continuity if students need to move between classes;
- Being able to sometimes offer students who miss a session the opportunity to attend a class later in the week where the content will be identical to that missed.

These benefits need balancing against the effectiveness of approaches that are adapted to suit different students' needs.

5.5.3 The influence of external policy and curriculum decisions

Government policy and curriculum decisions influence the teaching of mathematics to 16-18-year-olds by defining the main purpose, course parameters and the student cohort.

A number of key features of teaching mathematics in FE can be identified from the analysis of staff interviews:

- It is a **revision course** leading to a mathematics qualification so p*reparation for the examination* needs to be included;
- It is a **compulsory subject** for many but students are often reluctant to engage so teachers encourage participation through activities involving *interaction* and *collaboration,* as well as using contextualisation and making connections;
- **Teaching time is limited** so teachers supplement class time by encouraging *independent learning*, often *using technology* and have expectations that students are supported by *embedded approaches* in other parts of their study programme;
- The course is for **students who have 'failed'** with mathematics so *basic skills development* is often needed and *an alternative classroom culture* to that experienced in school.

This combination is challenging for teachers, who feel under pressure to 'teach to the test' but recognise that students' emotional responses are a significant barrier and that their cognitive needs often require much more than a quick revision course. Teachers address the different aspects highlighted as follows.

The aim of achieving GCSE grade 4 means examination-focused teaching is often prioritised over skills development.

Students often lack confidence and have poor examination skills so teachers find it important to incorporate examination preparation into lessons. The issues for students are typical responses from teachers in the case studies are summarised in *Table 8*.

Student issue	Teacher response
Students do not have effective strategies to tackle examination questions.	Teachers incorporate examination-style questions into most lessons, teaching how to get marks even if students have insufficient knowledge to complete a question.
Students struggle with the terminology and wording of examination questions.	Teachers spend time specifically teaching language and interpretation.
Students do not easily recall what they have learned (even in the previous lesson).	Teachers include recap, revision and repetition at frequent intervals.
Students have anxieties about taking mathematics examinations.	Teachers try to develop students' confidence. Colleges develop support systems for examination days (e.g. phoning students, meeting and escorting them to the examination, providing refreshments).

Table 8: Issues for students with mathematics examinations and teachers' responses.

The teaching of GCSE re-take courses in particular focuses on the goal of performing well in the examination. Teachers admit that they often 'teach to the test' in mathematics lessons, although they realise this is not the best approach. As one teacher explains:

What you should be doing, I know, is to reignite their interest in mathematics and develop their mathematics skills as much as possible. However, the reality of the situation is that we're trying to get them from the three to the four.

Teachers find that interactive and collaborative approaches stimulate participation and engagement.

There is wide agreement from teachers in the case studies that interactive approaches work well for many students but teachers understand this in different ways. Some refer to physical activity or group work, whilst others talk about verbal interaction with the whole class or the use of games and quizzes.

Examples of physically active approaches include practical 'hands on' measuring that might lead to constructing a scale drawing, or providing a 'carousel' of different learning activities that students move round during a lesson. Demonstrations using real objects (e.g. different shaped containers and water for work on volume) are also helpful to some students.

Teachers in the study indicate that they try to use group or paired work to increase dialogue but some are conscious of the time this takes. As one explains "I've had to jettison that to get through the work". They report that students do all interact readily but that group work can stimulate discussion and involve useful peer learning opportunities. Interactive whole class discussions are used to stimulate verbal participation and some teachers explain how they incorporate questioning techniques to probe for explanations rather than just answers.

Teachers find that competition between individuals or teams can encourage active participation and that the structure of a competitive activity (e.g. game or quiz) can make answering mathematics questions more appealing than working through a traditional routine exercise. Some students respond well where there is an element of competition, although this does not appeal to all.

Supplementing limited class time with additional out-of-class learning is often ineffective since students lack the necessary skills or motivation to learn independently.

Several approaches to learning mathematics used in the sample colleges are built on assumptions that students can, and will, participate in independent learning but teachers report that this is not always the case. Students often struggle to take responsibility for their own learning. Independence is encouraged by involving students in identification of realistic short-term learning goals, self-assessment of their pre-activity confidence levels and post-activity reflection on what they have learned.

Students' capacity for independent learning affects the approaches the colleges take to homework (or out of class learning). Some have extensive resources available on e-learning platforms and teachers can track students' completion of work but the approach is dependent on students' willingness to engage and their ability to work independently. In practice, few colleges have been successful in establishing regular homework as part of their strategic approach to mathematics teaching and only a minority of students complete the work set, whether written or involving e-learning. Given the problems with attendance this is hardly surprising and shows the importance of attitude changes as well as developing independence.

Technology is used creatively by some teachers to enhance learning, but such approaches are constrained by the resources available.

The *use of technology* contributes to the teaching and learning of mathematics in the sample colleges mainly in the following ways:

- Use of monitoring systems where students' targets and/or progress are recorded and tracked by teachers;
- Use of specific programmes in class on mobile phones or computers or iPads, if available;
- Use of college-learning platforms out of class, which may include links to commercially produced independent learning materials or web-based materials.

The barriers to better use of technology identified from the study include the limited availability of computers or portable devices for use in mathematics classrooms and the unreliability of systems. Some of the mathematics teachers explain how they have to change rooms to access a computer suite but the rooms are not always available. Some teachers make use of students' mobile phones but the difficulties of keeping them 'on task' can make this unproductive as a teaching approach.

Most colleges have resources available on-line for further practice, as revision or homework, but as stated earlier, few students complete any mathematics learning outside class. Teachers also try to support students in other ways, for example using Facebook to post messages, posters and video links, or emailing students directly. Practices using technology in and out of class are highly variable and teachers would benefit from better resourcing.

The practice of embedding mathematics within vocational learning and its effect on student understanding needs clearer definition and more robust evidence of impact.

The practice of embedding mathematics is not the responsibility of mathematics teachers and therefore constitutes a separate learning experience to that provided in scheduled lessons. It is included here since there is an expectation amongst managers in the sample colleges that it will contribute to mathematics learning and support the teaching taking place in mathematics lessons.

Vocational teachers in the case studies readily identify where mathematics is being used in their lessons and can draw students' attention to this but embedded approaches often go no further. A lack of personal confidence about mathematics has been identified as a barrier that constrains vocational teachers. Another is the unrealistic expectation that vocational teachers have the subject-specific pedagogy to be able to teach mathematics. Colleges provide support for vocational teachers to improve their subject knowledge (sometimes taking a higher qualification in mathematics) or to learn appropriate teaching approaches. These attempts to support vocational staff are well-intentioned but not always met with enthusiasm since mathematics is not their first priority. Ideally, mathematics teachers would like vocational teachers to make the links more explicit and to spend additional time when mathematics occurs naturally to ensure students understand the mathematical concepts or processes behind the vocational application. This however requires skills in teaching mathematics beyond those normally developed by vocational teachers.

There are contrasting views from staff about whether embedded approaches are effective. Some teachers explain how students sometimes grasp a concept or process in a vocational context that they have struggled with in mathematics lessons. There is however wide agreement that attempts to "shoehorn" mathematics into vocational provision are unhelpful for students and should be avoided. Some teachers still believe they are improving students' mathematics skills "by stealth" without making clear references to mathematics when students are using mathematical processes in a vocational context.

Even when highlighted by their teachers, students rarely see any link from mathematics in a vocational context to the content of their mathematics lessons. One manager states that:

> *Most students, I would suggest, their experience of mathematics here would be 'Maths is when I'm told to go and sit in that lesson and I'm being taught GCSE'.*

This may be due to:

- Differences in the mathematics being used in vocational learning and the mathematics being taught in mathematics lessons (curriculum disjuncture)
- The mathematics within a vocational process being so well embedded that it appears as part of the work process rather than an application of mathematics (situational disjuncture)
- Insufficient emphasis from vocational teachers on the mathematics, as a result of prioritising the vocational skills and/or a lack of confidence with mathematics (occupational disjuncture).

The term 'embedding' needs to be more clearly defined for colleges but there is also a need for more robust evaluation of the benefits or otherwise to student learning of mathematics from this addition to vocational practice.

Students need to develop basic conceptual understanding and procedural fluency but this is not easily incorporated into a one-year GCSE revision course.

The teachers frequently refer to students coming to college without understanding 'the basics'. This includes knowledge of basic number bonds, fluency with the 'four rules', single digit multiplication (times tables) and mental mathematics. Students also struggle with rounding, interpreting remainders, fractions, decimals and percentages. When the gaps in knowledge are explored, they often reveal a lack of understanding of fundamental concepts which are essential to making further progress.

These students need more than revision of the topics but teachers feel constrained on a GCSE retake course because of the limited time available. Teachers easily revert to didactic methods to quickly cover the curriculum or teach procedural shortcuts. Functional skills courses have less time pressure and this gives teachers more opportunities to develop secure conceptual foundations and teach for understanding. For this reason some colleges retain Functional Skills as a stepping stone qualification because it gives teachers the opportunity to establish foundational concepts before progressing, or returning, to GCSE.

Students benefit from a new learning environment where mathematics classrooms are characterised by an inclusive culture and positive teacher-student relationships.

The most common comment by teachers in the case studies about mathematics classrooms in FE colleges is that they need to be different from school. Early establishment of new working norms in the classroom is a priority. The aim is to get students to "work well and try their hardest" in a new environment rather than feeling a failure. Teachers report trying to make students feel at ease, become comfortable with making mistakes and use praise to encourage them. The emphasis is on providing a contrasting experience with teachers asking themselves "How do I change my approach in terms of what everyone else has done before?"

The teachers find that establishing an open, inclusive, welcoming classroom where students feel comfortable encourages participation in learning activities and useful discussion. Building relationships with individual students is essential to developing this culture and although it takes precious time away from the actual teaching many teachers feel it is necessary to do this before they can begin teaching students mathematics.

Relationships are developed by regular communication with individuals within the classroom. Treating students as adults is often mentioned as a guide to the sort of relationship teachers are aiming for, although they find not all students respond appropriately. Developing mutual respect and trust is important, as one teacher explains "So it's just building up that relationship where you've got that trust, that I respect them, they respect me".

Teachers explain how they develop positive relationships by listening to students, showing an interest in them, building rapport (e.g. through the use of humour) and through group activities such as starting the lesson with 'meet and greet' time. This helps teachers to establish good group behaviours and develop the learning environment. One teacher explains that:

> *I think you can bring more to the classroom than just the curriculum and a good mathematics teachers, because I don't think these students just need a good mathematics teacher. I think they need a space that allows them to be as good as they can.*

Providing a contrasting social learning environment to a school mathematics classroom can encourage students to re-engage.

Some teachers explain how they use their personality to project a contrasting identity to students' perceptions of a traditional mathematics teacher, so they know "I'm a human being first; I'm not a maths teacher" or "I don't come across as a mathematician". This disassociation with identities that are traditionally remote from low-attaining students helps students relate to their teachers.

The effects of relational approaches are dependent on choosing an appropriate response at a given time but this does demand additional skills from teachers that are not required when simply teaching the mathematics. One teacher explains that "A lot of the teaching is not teaching, if you know what I mean?"

5.5.4 Summary and implications

Mathematics teachers in the case studies report that multiple types of adaptation to meet the needs of different student groups or individuals is necessary within their teaching in FE colleges. A large toolkit of methods and resources is required for these adaptive pedagogies and this includes approaches to address various attitudinal issues, personal interests, prior knowledge gaps and vocational links. Although it is easy to see how the FE contexts and operational strategies create the necessary conditions for adaptation, considerable expertise and skill is required to do this well. A clearer categorization of this approach, and a greater focus in training and professional development on equipping teachers to adapt their classroom pedagogies effectively would be of benefit to the sector.

The colleges' strategies and national policies combine to form a framework of priorities and constraints which affect the teaching approaches used. The tensions experienced between the needs of the system, the college and the students need to be recognised and balanced and the colleges and teachers report doing this in different ways. There is a need for better FE-specific evaluation of the impact of teaching approaches such as interactive, collaborative methods; out-of-class independent learning; and, the use of technology. In the sample colleges, the practice of embedding mathematics in vocational learning is inconsistent and poorly understood. This needs better definition, with realistic expectations of vocational teachers and a thorough assessment of the impact on student understanding to inform future practice.

5.6 Workforce

The composition of the FE mathematics teaching workforce in the sample colleges and the nature of teachers' work differ in several ways from that typically seen in secondary schools. The findings discussed below echo those in the previous interim report "A survey of teachers of mathematics in England's Further Education Colleges"[32] but also complement them by building understanding of why and how the mathematics teacher workforce is different from that in schools. Descriptions of teaching roles from mathematics teachers and managers place an emphasis on certain distinctive functions, skills and personal qualities. Recruiting and retaining mathematics teachers is challenging for these colleges but some employ creative and often costly strategies to ensure that can meet the Condition of Funding.

5.6.1 Roles of mathematics teachers

Specialisation of mathematics teachers is a pragmatic approach to addressing recruitment challenges and operational issues but can lead to fragmentation of the workforce and reduced flexibility.

Although some mathematics teachers interviewed in the case studies teach a wider range of different courses and age groups, the work of most focusses mainly on one of three areas of specialisation defined by:

- the *level* of mathematics course (e.g. A Level teacher; Entry level teacher)
- the mathematics *qualification* (e.g. GCSE only)
- the *age group* (e.g. adults only).

A large proportion specialise in teaching mathematics courses at Level 2 and below (GCSE and Functional Skills) since this is the largest section of the provision but this sometimes includes teaching both 16-18-year-olds and adults.

The type and degree of specialisation is often linked to the college staffing structures since some models are suited to greater specialisation or generalisation (e.g. when teams are site-based and specialise in sixth form or adult provision). Colleges sometimes deliberately offer a narrow specialisation because this is thought to be attractive to new recruits (e.g. GCSE teaching only or a combination of GCSE with A level). Although specialisation can offer solutions to some operational or recruitment problems, it is important to consider potential unintended consequences. Examples from colleges include a fragmentation of the workforce when mathematics teachers with narrow specialisms work in separate teams or fail to interact because they see their roles as different. This restricts informal professional learning between colleagues who may well have expertise worth sharing. Planning for the implications of a specialist approach as well as the solutions it offers is needed to develop an effective college workforce.

[32]https://www.nottingham.ac.uk/research/groups/crme/documents/mifec/interim-report.pdf

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 contracted teaching hours for mathematics teachers in FE vary between colleges in the sample but are typically around 24 hours a week for a full-time member of staff (i.e. 830-850 hours a year). Variations between colleges in the positions offered, conditions of service and timetabling have some effect on workload, especially with respect to expectations regarding additional duties.

Interviews with mathematics teachers indicate that they are generally highly committed to their students, working outside normal timetabled hours and during holiday periods to provide additional revision lessons, one-to-one sessions, workshops and email support. Some colleges recognise selected activities (e.g. workshops) as important and count these towards annual contracted teaching hours, or mathematics teachers work on reduced weekly hours in the expectation that they will cover classes for absent colleagues and teach a quota of extra revision classes. In other colleges these activities are voluntary and overall it appears that much of the extra support offered to students is not recognised within contracted teaching hours.

Teachers also give examples of taking on additional responsibilities that support the smooth working of operational systems. Defined additional roles, such as being a link tutor to a particular vocational area, sometimes involve a time allowance in contracted hours but, again, this varies between colleges. There are also differences due to the dispersion of teaching across college sites and the structural arrangements since these affect factors such as the amount of inter-site travel expected.

The degree of specialism in the positions offered by a college has implications for workload. For example, teaching a range of different mathematics qualifications or age groups may be stimulating and useful for personal development but it can be more demanding than a specialist role due to the amount of preparation required to teach additional content and/or adapt between age groups. The number of actual classes taught also has an impact. To achieve a weekly class contact time of 24hrs, a GCSE teacher would typically have 8 different classes (of 3hrs) and a functional skills teacher may have 12 classes (of 2hrs). Some mathematics teachers highlight the proportion of their out-of-class time that is needed when they are tracking and monitoring 160-200 students but only teaching them once or twice a week. This load reduces when teaching smaller groups, or courses where the weekly contact hours with the same group are greater, as may happen with A-level specialists.

As independent organisations, colleges decide whether activities are part of teachers' contracted hours or not, with a resulting impact on their actual workload. Despite the appearance that these support roles and activities are essential, teachers report that many are regarded as voluntary. Conditions of service can vary considerably for mathematics teachers, depending on the college in which they work.

5.6.2 Recruitment

Increased demand for mathematics teachers as a result of the Condition of Funding has caused substantial recruitment and retention challenges which have required creative and sometimes costly solutions.

Almost all the case study colleges report difficulties in recruiting and retaining good mathematics teachers such as having to advertise widely two or three times before appointing. College managers who have been able to successfully recruit sufficient numbers of teachers explain that they are not always satisfied with their quality.

The colleges report that agency staff are rarely suitable and avoid using them. Some explain that they prefer to cover classes using managers or give additional hours to existing mathematics teachers. A range of strategies have been used by the sample colleges to recruit and/or retain mathematics teachers, including:

- Paying higher basic salaries to mathematics teachers than other teaching staff or offering additional enhancements;
- Offering other conditions of service that might be attractive, such as career progression pathways or reduced weekly teaching hours;
- Re-training vocational teachers in the college who have an aptitude for mathematics and/or are needing redeployment;
- Using graduate schemes to recruit new young teachers into FE;
- Designing 'grow your own' schemes by which business support staff or teaching assistants, already employed by the college, move into teaching and are provided with formal training (e.g. PGCE);
- Making the workplace attractive by building a team that is collaborative, supportive and well-managed;
- Using personal and community contacts to find people interested in training to teach mathematics.

Most of the above strategies involve additional costs to the college, either in the form of enhanced salaries or the training needed when recruiting untrained or inexperienced teachers but colleges find these are often the only options available.

Colleges make substantial efforts to address the mathematics teaching workforce problem.

Colleges report greater recruitment challenges in areas where there are local competitors within easy travelling distance, especially if others are able to pay higher salaries. An effective approach in this situation seems to be "If you pay the highest rates, you'll get the best teachers". This does not however solve a nationwide problem if the teacher market merely circulates existing resources away from poorer educational institutions.

Managers explain how the staffing challenge has led colleges to make more teacher positions permanent in order to attract good mathematics specialists. They also recognise that prioritising mathematics recruitment has led to difficult decisions in other areas of the college, such as relying more heavily on agency staff in vocational areas in order to balance the college staffing budget.

Instability and high turnover in the mathematics teaching workforce increases workloads and interrupts strategies for improvement.

College managers report that losing teaching staff is a major concern since immediate replacements are hard to find and the only other options are short-term agency staff (which they wish to avoid) or placing an extra burden on existing staff to provide cover. For example, one manager reported four out of five teachers leaving at the same time from the same site and only managing to recruit replacements by pursuing multiple time-consuming strategies which led to:

- retraining a technician from a vocational area
- retraining a teaching assistant
- recruiting someone with experience of student support work in another country
- arranging an internal temporary transfer from another site.

This manager also highlights that the training, professional development and support needed to shape a group of new teachers such as these into an effective site team is extensive.

Recruiting managers for mathematics is also difficult. Colleges find that good cross-college managers for mathematics are in demand and easily enticed away by higher salaries elsewhere. Several senior leaders explain that losing their cross-college manager for mathematics can affect the whole strategy for the college and progress can stagnate until a new post-holder becomes established.

New recruits to teaching and teachers transferring from other educational contexts need a transition period that includes appropriate training.

Colleges in the study frequently state that they would like to recruit well-qualified mathematics specialists with teaching qualifications, mathematics degrees and experience but rarely have applicants with this combination. Some prioritise the general skills needed to work with FE students over having degree level mathematics because subject knowledge-enhancement CPD can be provided. The colleges also report that well-qualified subject specialists are not always skilled at teaching those who struggle with mathematics. In contrast, others think that high-level subject knowledge is more important because the college can train someone to teach if they have sound understanding of their subject. In either case, the development of mathematics-specific pedagogic content knowledge (PCK[33]) is needed for both those with strong mathematical subject knowledge (SK) or good general pedagogic knowledge (GPK). Whatever the background of new mathematics teachers, the colleges find that it takes much time and effort to develop new teachers, especially in the absence of mandatory pre-service training.

Some colleges have attracted mathematics teachers from secondary schools but find these teachers do not always have sufficient experience of teaching disaffected students. Managers observe that this transition frequently requires a period of adjustment as school teachers learn to adapt their pedagogy to suit FE and also understand how to work with the complex systems and communication channels within a large FE college. Similarly,

[33] Shulman, L. (1987) Knowledge and teaching: foundations of the new reform. *Harvard Educational Review,* 57 (1), 1-21

those transferring to GCSE mathematics from teaching other subjects or vocational content need to make adjustments to teach a different subject and type of course.

New mathematics teachers in the sample colleges are typically expected to undertake some formal teacher training, if they have not already done so. A mentor is provided by some colleges but practices vary. The specific needs of those transferring between different educational contexts are not recognised in national policy and there is no bespoke training available. Analysis of the observations made by college managers indicate that teachers undertaking these transitions need time to adjust and would benefit from a national programme of support.

5.6.3 Qualities of mathematics teachers

Important personal qualities are needed to teach in the FE sector and these should be a priority in the recruitment and training of new mathematics teachers.

Teachers and managers identify several personal qualities of effective FE mathematics teachers that they feel are just as important as relevant qualifications. One senior manager summarises the qualities they are looking for when interviewing prospective teachers as:

> *I'm interested in teachers with the qualifications, with stickability. So I've got to be sure through proven track-record that this teacher will stick the whole year out. So they've got to be able to hack it. They've got to be able to cope with it. They've got to be able to really relate to the students. So at interview, I'm interested in the qualifications. I'm interested in experience and also the personality as well.*

In summary, managers are looking for teachers who can:

- Relate to students in FE colleges;
- Demonstrate some character, personality and enthusiasm in their teaching;
- Provide evidence of resilience or 'stickability';
- Fit well into the existing teaching team.

Teachers themselves often describe a pastoral dimension of their roles, which requires patience with, and understanding of, these students. Some see themselves primarily as an expert in managing student behaviour and a "counsellor", "psychologist" or "coach" with teaching the subject content sometimes seeming like a secondary consideration. There is wide agreement amongst managers that teaching students who are retaking mathematics needs a special type of teacher, one who preferably has a background of working with lower level learners and can build relationships with them but is also sufficiently robust to deal with the challenges. Some teachers feel they need specialist skills training to deal with the level of emotional and behavioural difficulties that they encounter in their mathematics classes.

Mathematics knowledge is viewed with varying degrees of importance. There are examples of teachers who are considered to be very effective in the case studies but do not have a mathematics degree. Opinions vary on whether the role is best suited to a mathematics specialist who has to adapt their approach to suit FE students or a good teacher who has to upgrade their mathematics knowledge. Some non-specialist teachers believe that their own struggles with mathematics in the past help them relate to students. These discussions are academic since the increased demands for teachers resulting from the Condition of Funding means there are insufficient teachers with both attributes and colleges have to make difficult choices about what to prioritise.

5.6.4 Pathways and roles

Mathematics teachers in FE have diverse backgrounds which prepare them well for aspects of the role and, when combined, provide a rich resource for collective professional learning.

Very few of the mathematics teachers interviewed had begun their working lives with the intention of being a mathematics teacher in an FE college. Most had worked outside education (e.g. industry, business, self-employment) before moving into FE as a second career[34]. Some had taught another subject or vocational programme in FE before deciding to teach mathematics, usually as a personal preference but sometimes as a result of redeployment. Examples of how other teachers have become interested in teaching mathematics include vocational teachers' experiences of teaching Key Skills and English/ESOL teachers' involvement in adult community learning where they have taught a some Entry level mathematics. Some teachers have moved into FE from school, either due to a preference for teaching older students, or because the conditions of service have been better suited to their personal needs or preferences, even if the pay is lower.

There is evidence of connections between the backgrounds of mathematics teachers in the case studies and their own descriptions of their roles, in which there are variations in the professional identity they present. Some examples of these connections are shown in *Table 9* below.

Background	**Identity**
Social worker	Specialist in engaging and relating to young people
Teaching assistant	Specialist in finding alternative methods to explain mathematics to students
School teacher (with mathematics degree)	Subject specialist sharing expert knowledge of mathematics
Probation officer	Specialist in working with 'difficult' students and managing challenging behaviour
Vocational teacher	Specialist in understanding FE students
Industry or business expert	Specialist in understanding the links to the workplace.

Table 9: Teacher backgrounds and self-perceptions of role as a mathematics teacher.

These variations highlight different parts of the role of a mathematics teacher in FE and show how teachers from different backgrounds can offer specialist skills and expertise that are relevant to different aspects of the role. Their existing specialisms and skills can become a useful resource within a college mathematics team when deployed appropriately. For example, several managers explain how they try to place teachers with student groups that suit their strengths and one teacher reports in detail how those with high-level mathematics qualifications or strong backgrounds in handling difficult students support others in their team.

Diversity in teacher backgrounds and the varied pathways into mathematics teaching have implications for training and professional development. This was reported in our earlier survey of the mathematics teacher workforce[32] and will be discussed again later (see *Professional Development*). It is worth noting that the views of mathematics teachers in FE suggest a rather different role and set of skills to that traditionally expected in school.

[34] This aligns with findings in the first MiFEC Interim Report which is available at www.nottingham.ac.uk/research/groups/crme/documents/mifec/interim-report.pdf

5.6.5 Motivation and sustainability

National recruitment strategies are needed to attract mathematics teachers into FE who have appropriate motivation, contextual understanding, relevant skills and experience.

Mathematics teachers in the case studies give a range of reasons why they enjoy working in FE but the primary motivations to teach (mathematics) are:

- the daily social interaction with students;
- the challenge of helping students to succeed where previous efforts have failed;
- seeing students understand mathematics as a result of their teaching;
- seeing students elated at their achievement in the examination (even though only a minority achieve);
- feeling that they are shaping the futures of young people through a 'second chance' opportunity;
- having the flexibility to adapt and be creative in their teaching.

As one teacher explains:

> *I'm enjoying teaching learners that have struggled previously in mathematics, that have had a bad experience in secondary school and come to us without having the qualification.*

This role attracts a type of teacher who specialises in teaching students who struggle with the subject and thrives on working with young people who are sometimes difficult to handle.

A sustainable mathematics teacher workforce is more likely to be achieved by developing a more holistic view of the systemic reasons for poor achievement, thereby relieving the pressures on teachers.

Despite their enthusiasm for teaching mathematics in FE, teachers report that they also find the work demanding and stressful. Some long-serving teachers explain how the job has become more difficult for them and several new recruits state that they are not intending to continue teaching in FE long-term. The sustainability of the current workforce is uncertain unless these challenges can be addressed[35]. The main sources of pressure and stress are highlighted below.

Several mathematics teachers in the sample refer to the relentless pressure to improve results. They feel under continual scrutiny from management and take all the blame for unsatisfactory outcomes, from managers and government. This gives the impression that "no matter how hard I work, it's never good enough". Teachers feel they are working hard but that the task of improving the performance of unmotivated students in FE colleges is a wider problem, some of which is beyond their control. Our analysis in the previous sections supports this view, that the problem is not just about classroom teaching, and that a broader understanding of the reasons for low attainment is needed. Strategies to improve teaching, whilst necessary, are insufficient to produce a step change in results without also addressing complex systemic issues that impact on mathematics classrooms.

Poor attendance for mathematics lessons frustrates teachers' efforts and they feel others hold them responsible, assuming that they are failing to make their lessons sufficiently

[35] See previous Interim Report on workforce survey

interesting. Mathematics teachers feel this criticism is unfounded and that a lack of engagement cannot be overcome solely by making lessons more engaging, but it adds to the pressure. As one explains:

> *They can keep training me from morning 'til night and I become like this great teacher and my colleagues become great teachers and I think we're good teachers and the college is great; if they're not in the class, no one benefits. So I think that is the biggest problem.*

Teachers find it challenging to continually teach students who are not motivated to learn mathematics. One teacher summarises the situation as "You kind of know they didn't come to do mathematics. So I'm the person they don't want to see". Teachers explain how they work hard to engage students and plan interesting lessons but the rewards are often not forthcoming. One teacher states that it can be "soul-destroying" to find students are still not engaging when they have spent extra time designing an interesting lesson. Daily battles over student behaviour and frequent negative feedback are reported in some colleges, which teachers find exhausting. The emotional effects, especially for Newly Qualified Teachers, are captured by one teacher as they explain "I thought about quitting two times in my first year" and by another who states that "It was the third week and I was walking and crying back home 'What have I done? … I'm not getting anywhere with them'".

Despite these challenges, teachers frequently express a preference for being in the classroom to doing "that other stuff" they are required to do out of class. Many find the administrative tasks excessive, with attendance monitoring, reporting and follow-up being particularly time-consuming. Even when responsibility for student attendance lies with vocational or other staff, some mathematics teachers feel obliged to supplement this with their own actions but this becomes a huge task when teaching 8-12 classes a week and dealing with up to 200 students.

Student outcomes are referred to as a source of personal disappointment by teachers, especially since this typically means finding out at the end of the year that most of the class have failed again. Teachers sound enthusiastic and dedicated to the task but sometimes appear to be in denial about the likely outcomes until the examination results appear. One teacher explains, for example, how devastated they were at the end of their first year to find most of their students had failed, until they realised this was the norm. Another teacher highlights how discouraging it is to be graded highly in classroom observations but then find they still cannot evidence good student outcomes at the end of the year. This contradiction is difficult to accept but reinforces the point that poor student outcomes are not just about the quality of teaching.

The pay differential between FE and school was rarely mentioned in interviews, which may be due to the higher salaries now being paid to mathematics teachers in many colleges as part of their recruitment strategy. Views of differences in conditions of service between FE colleges and schools were both positive and negative, which may depend on individual experiences (or perceptions) in situations where, as already noted, workloads and expectations of teachers are not the same. If new and experienced mathematics teachers are to stay teaching in FE it seems to be the motivation, not the pay, that needs most urgent attention, including some relief from the pressure to 'perform' by recognising and addressing the wider issues that affect student learning of mathematics.

5.6.6 Summary and implications

The recruitment and retention of mathematics teachers in these colleges has been particularly challenging since the introduction of the Condition of Funding but workforce stability is considered important in order to sustain an improvement trajectory and avoid pressures on other staff. The colleges have used creative and often costly methods to attract and retain teachers but there is an outstanding need for a better national strategy to attract and retain mathematics teachers suited to working in the sector.

Specialisms, conditions of service and workloads vary between the colleges, with many of their teachers taking on additional responsibilities voluntarily. This lack of parity adds to the difficulty of retaining staff in a competitive market. There needs to be wider recognition that teachers who transfer from other learning environments or subjects need a transition period to undertake training and adjust their pedagogy.

A more holistic view of the systemic issues that affect student outcomes and less attribution of blame to mathematics teachers may increase job satisfaction and contribute to better teacher retention. The diversity of knowledge and experience in the mathematics teacher workforce is a valuable resource for professional learning which could be better utilized in colleges.

5.7 Professional development

The Condition of Funding has resulted in significant changes in the size and composition of the mathematics teacher workforce in the sample colleges and has re-shaped the demands on both teachers and managers. Despite these reforms, and the national step-change that they are intended to deliver, approaches to professional development for mathematics in the case studies are localised, inconsistent between colleges and often fragmented, with few colleges having a long-term professional development plan for their mathematics teacher workforce. A more consistent and planned approach to CPD for mathematics teachers seems unlikely without designated funding for colleges and entitlement to a personal CPD quota. Evidence from the case studies indicates a reliance on formal CPD models based on knowledge transmission, without links to classroom practice. Better understanding of alternative CPD models would be useful to ensure the opportunities provided have maximum impact. Descriptions from staff of informal professional learning opportunities show there is potential, with appropriate leadership, for the development of effective professional learning communities in these colleges by using the wide range of expertise available in teachers from diverse backgrounds. There is also scope, with suitable training, for increasing the rigour of practitioner research so the colleges can build strong evidence of 'what works' in their FE mathematics classrooms.

5.7.1 CPD for mathematics teachers

Additional designated funding for professional development is needed for mathematics teachers in colleges.

The amount of CPD offered to mathematics teachers varies widely between colleges, according to their statements in interviews. This is also evident from the MiFEC workforce survey report. Such variation is not surprising, since there is no designated funding to support formal CPD in colleges and no entitlement to any personal quota of CPD for mathematics teachers. The colleges therefore make independent decisions about how much CPD to provide and the priority given to mathematics-specific professional development. Mathematics teachers in some colleges report at least 5 days of CPD sessions per year whilst others get considerably less and the proportions that are mathematics-specific vary widely[36]. Evidence from interviews indicates that professional development opportunities for mathematics teachers are heavily dependent on the financial health of their college and senior management decisions about priorities.

In addition to planned CPD sessions, managers in the case studies use other strategies such as weekly meetings, observations and mentoring to support and develop mathematics teachers. Opportunities provided by the colleges include:

- Practitioner-led CPD sessions;
- CPD sessions provided by external consultants or examination boards;
- Generic CPD provided for the whole college, either face-to-face or online;
- Regular team meetings for sharing good practice or addressing specific issues;
- Mentoring and coaching activities;
- Peer observations;
- Informal sharing between colleagues.

[36] See www.nuffieldfoundation.org/wp-content/uploads/2018/12/interim-report.pdf

Mathematics teachers in the sample report that many of the CPD sessions provided by the college are concerned with college policies and procedures or general pedagogy rather than being mathematics-specific. They find that sessions about generic approaches to teaching and learning rarely address the issues they face and value CPD that is more subject and sector specific, enabling them to address the specific issues related to mathematics in FE that have been discussed earlier. The response below from a mathematics teacher captures a common opinion about formal CPD sessions.

> *Honestly I think the CPD is a waste of time … Because it's never ever relevant. I always feel that the CPD that we get is based on the perfect class and the perfect lesson and that's not the real world is it? So, in an ideal world that training would work brilliantly, but then you take that training to one of my classes with my students, that wouldn't work.*

Opportunities to attend external training or events vary considerably between the case studies and reference is often made to being constrained by the cost or the difficulty of covering classes. New mathematics teachers are generally supported to undertake initial teacher training or updating, which is sometimes available internally but only in a few cases do other mathematics teachers feel confident that requests to managers to attend an external event will be approved.

Mathematics is a high-profile subject in FE colleges but the CPD offer for mathematics teachers does not always appear to be a priority. In view of the barriers highlighted by the sample colleges, a first step towards addressing the inequity in the CPD offer available to teachers in different colleges would be specific ring-fenced funding for mathematics CPD and entitlement to a specific personal CPD quota that is widely embraced or enforced.

Colleges need guidance on effective CPD models and greater transparency from CPD providers about their offer, including evidence of effectiveness in the FE context, in order to make informed choices concerning their support for mathematics teachers.

Analysis of staff interviews in the sample colleges indicates that CPD sessions are often provided internally by college staff, who may be part of a college team of mentors/observers/teaching experts. Alternatively colleges purchase CPD sessions from external providers. Mathematics teachers find that formal CPD sessions from external providers are often disconnected from their classroom practice and tend to focus on a knowledge transmission approach. Opportunities to explore and evaluate the approaches within their particular classroom contexts are rare. The weaknesses of CPD that is not linked to practice are evidenced elsewhere[37,38] but the sample colleges seem unaware of these limitations. Where a consultant has worked with a college for a longer period of time and/or observations of practice are involved, there are more positive reports from teachers.

Teachers in the sample colleges also report a tendency towards repetition of generic ideas from external CPD providers and a lack of direct application to FE mathematics teaching. One manager explains the problem as follows:

[37] Cochran-Smith, M. & Zeichner, K.M., 2009. *Studying teacher education: The report of the AERA panel on research and teacher education.* New Jersey: Lawrence Erlbaum Associates.
[38] Matos, J.F., Powell, A., Sztajn, P., Ejersbø, L., Hovermill, J. & Matos, J.F., 2009. Mathematics teachers' professional development: Processes of learning in and from practice. *In* R. Even & D.L. Ball (eds.) *The professional education and development of teachers of mathematics.* US: Springer, 167-183.

> *I think the sort of consultancy circuit of training gets a bit dry and repetitive sometimes and the staff feel like they've done this before. They're shown all these wonderful generic things and then told, you know, "Go away and think how you'd use this in a maths classroom." I don't think they always see them as practical ideas and particularly they don't see them as realistic in terms of their own students.*

Others have concerns that there is often insufficient evidence that the approaches promoted lead to improvement in the FE context or that CPD providers have experience of the FE sector. Data about the effectiveness of the approaches these CPD providers are promoting and the quality of CPD they offer does not appear to be readily available and this adds to the difficulty of selecting suitable CPD providers.

Colleges need to develop better strategies for the professional development of mathematics teachers.

There is little evidence from the case studies of any systematic training needs analysis or long-term strategies for the development of their mathematics teacher workforce. Formal lesson observations and/or 'walk through' observations of teaching are commonly used to gather information about classroom practice but this often leads to an approach to professional development that is reactive and short-term. Weaknesses identified from observations generally lead to short-term individual action plans with, in some cases, support from a coach or mentor.

Alternatively, in some of the colleges, teachers are asked to self-assess their needs. Again, the emphasis is typically on short-term goals to address personal weaknesses, rather than developing wider skills as a professional. Moreover, the focus is typically on general pedagogical skills rather than mathematics pedagogic content knowledge. Individuals rarely have a long-term personal development plan. As noted earlier (see *Workforce*) individuals have very different needs for initial training and CPD due to their varied backgrounds, skills and prior qualifications. It therefore seems important that colleges develop a long-term plan to develop these individuals into skilled all-round professionals rather than only addressing the most obvious pedagogic weaknesses.

Professional development that is specifically for mathematics teachers in the sample colleges is often planned by managers of mathematics provision, with limited evidence of links to college-wide strategic plans for improving teaching and learning. In some colleges connections are made by having mathematics-specialist members of a cross-college teaching and learning team or carrying out paired observations with a member of a cross-college teaching and learning team and a mathematics curriculum lead or manager working together. More commonly, opportunities to use generic and mathematics specific expertise in a connected approach seem to be missed.

The transience of the workforce in the case studies, as evidenced in this and the survey report, is a challenge to long-term professional development planning since retraining of new staff is continually needed. Colleges with stable staffing would appear to be in an advantageous position concerning long-term professional development, although it is worth noting that some of the colleges attribute their record on good teacher retention to investment in the development of individuals.

Initial teacher training and CPD to support new mathematics teachers needs to be more closely aligned to sector-specific needs.

The distinctive roles of FE mathematics teachers and the personal qualities required have already been discussed (see *Workforce*) and the need identified for a transition period of additional training and adjustment. There is agreement from FE mathematics teachers in the sample, including those who have worked in both schools and FE, that different skills are required and that much of the teacher training available for mathematics teachers (e.g. PGCE) does not adequately address their sector-specific needs.

The main areas of need for professional development identified by mathematics teachers or managers are:

1. Ways of engaging students who do not want to learn mathematics. (This was the most frequently mentioned CPD need).
2. Managing student classroom behaviour, including building rapport with a student group.
3. Differentiation and other approaches to meet individual student needs.
4. Feedback to students.
5. Updating subject knowledge when teaching a different qualification or a new specification, (e.g. teaching GCSE for the first time or the change to 9-1).
6. Revision techniques.
7. Dealing with emotional issues.
8. Planning for students with specific educational needs.
9. Ways of identifying why students do not understand, i.e. a diagnostic approach.
10. Different ways of teaching the same topic to suit different student groups.

There is a clear connection to certain aspects of the situational context:

- Students who are disaffected with mathematics (1,2,7)
- Students who have had difficulty learning mathematics (3,6,8,9,10)
- An examined retake course (6)
- A changing curriculum (5)

This emphasis on context-related aspects of teaching mathematics from those working in the colleges reinforces the need for sector-related training and CPD for new mathematics teachers that prepares and supports them specifically for FE teaching.

5.7.2 Professional development models

Professional development for mathematics teachers in colleges could be enhanced by making better use of the expertise that already exists within the college community.

Within the wide variety of types of CPD offered, FE mathematics teachers in the sample colleges report that they find informal sharing of practice with colleagues the most helpful, due to the situational relevance and close connection to practice. Opportunities for sharing practice occur naturally and informally when teachers are working in close proximity, for example as a site-based or centralised team with a shared physical space (usually a staff room). In more dispersed arrangements, staff identify benefits in having regular meetings to exchange ideas, share materials or develop resources collaboratively but find it practically challenging, especially when dispersion is across multiple sites. Examples of 'in-house' sessions that teachers have found useful include meetings in which an individual teacher shares an idea identified as 'good practice' with the team or colleagues work together to develop resources or lesson plans.

There is evidence from staff in the case studies of increasing transparency of practice in colleges, with a change towards a more open culture and encouragement to undertake peer observations. Although practical difficulties with observing colleagues limit these opportunities and some colleges have encountered resistance to more open classrooms, visits from colleagues take place regularly in many colleges in the form of 'walk through' or peer observations. The way in which some mathematics teams are working, with transparency of practice, collaboration and a common aim, suggest they are beginning to form subject-focussed professional learning communities which some would see as an effective model for teacher development[39,40].

The diversity in teachers' backgrounds, skills and knowledge within the workforce means that a typical mathematics team in these case studies has much latent CPD potential. Developing a professional learning community in a college requires good leadership so that interaction, sharing and mutual support become a priority and practical barriers are overcome. The case studies did not provide any evidence of training in the development and leadership of a professional learning community in the sample colleges but indicate that there is scope for further development in the effectiveness of these communities of practice, drawing on the best knowledge and research to inform improvement.

There is potential for more effective college-based development of teaching with further training on appropriate evaluative methods.

Several teachers refer to learning most from reflection on their own trials of different approaches and resources or other experiences in the classroom. This experimental approach is more common in colleges when teachers are encouraged to take risks and try out ideas than in those where resources and lesson plans are tightly controlled. Teachers' descriptions of their practice indicate that there is however heavy reliance on a simple 'try it and see' approach rather than a more rigorous evaluation that seeks to understand why an approach works in a certain classroom and whether it might be transferable. There is the potential for this experimentation to be developed into more rigorous action research but teachers seem unaware of how to conduct a more effective investigation and evaluation. This is a key area of training that could be explored more widely and bring benefits to the sector.

Teachers in the colleges talk about continually experimenting but there is little evidence that they are building up a sound evidence base of 'what works' in their own context. Their descriptions of CPD for mathematics suggest that this often reflects the latest new idea in the sector, or what seems to work in another college, without consideration of differences in student cohorts that might affect the transferability and impact.

[39] Matos, J.F., Powell, A., Sztajn, P., Ejersbø, L., Hovermill, J. & Matos, J.F., 2009. Mathematics teachers' professional development: Processes of learning in and from practice. *In* R. Even & D.L. Ball (eds.) *The professional education and development of teachers of mathematics.* US: Springer, 167-183.
[40] Ermeling, B.A., 2010. Tracing the effects of teacher inquiry on classroom practice. *Teaching and Teacher Education,* 26**,** 377-388.

5.7.3 CPD for vocational teachers

The initial training of vocational teachers need to include opportunities to develop personal confidence with mathematics so they can communicate positively and demonstrate meaningful connections between mathematics and vocational learning.

Colleges in the sample report that the greatest barrier to widespread support for mathematics across colleges is that many vocational teachers lack confidence with mathematics. Evidence from interviews with vocational teachers show that they can identify how they use mathematical processes with their occupational practices but comments such as "I don't feel comfortable in talking about percentages in my class" suggest a need for greater confidence with their mathematics. There are exceptions since some areas (e.g. Engineering, Business) have more naturally occurring mathematics and vocational managers explain how staff in these areas often have better mathematics skills.

As noted earlier (see *Students*), vocational teachers can communicate, implicitly or explicitly, that low mathematical confidence and poor skills are acceptable in their vocational area. Several vocational teachers state that the mathematics they use within their trade or occupation is unconnected to the mathematics they learned in school which leads to personal doubts about the relevance of GCSE mathematics for their students. Such beliefs are easily communicated unintentionally or otherwise to students. Inconsistencies in the messages students receive about mathematics have already been noted (see *Students*) and CPD for vocational teachers that attempts to minimise this would help achieve a more consistent college approach.

A lack of mathematical competence and confidence amongst vocational teachers is also perceived as a hindrance to wider use of embedded approaches to developing students' mathematics skills. Colleges in the study that are addressing weaknesses in vocational teachers' mathematics skills are more confident that embedding mathematics learning in the vocational areas is having a positive effect, but the concept of embedding is often misunderstood[41] and expectations of vocational teachers can be unrealistic[42].

Vocational teachers readily talk about naturally-occurring applications of mathematics in their areas but some acknowledge that this is often in a highly procedural way due to limitations in their own conceptual understanding. Expectations that vocational teachers will not only have the requisite subject knowledge but also the confidence to go beyond explaining familiar naturally occurring mathematics in their areas are considered unrealistic in some colleges but are still promoted as a desirable goal in others. Further development would seem to require a culture in which every vocational teacher also became a teacher of mathematics, an intention that has already been refuted as inappropriate when last prominent in college agendas[43]. The potential benefit to students of vocational teachers having greater confidence with mathematics is however clear and some colleges are working hard to achieve this.

There is no common approach to upskilling vocational teachers and improving their confidence. Practices vary between colleges but the main focus is on helping vocational teachers develop their subject knowledge, whilst a few also provide support to help them

[41] Eldred, J. 2005. Developing embedded literacy, language and numeracy: supporting achievement. London: NRDC.
[42] 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.
[43] Ibid

understand different approaches to teaching the mathematics relevant to their vocational programme. Open workshops or optional courses are sometimes provided or teachers may be identified who need to achieve a Level 2 qualification in mathematics. The sample colleges. There is some resistance to this upskilling but those who undertake training report that it is valuable, especially for understanding the challenges that their students face and the mathematics they are expected to understand.

Colleges provide support for vocational teachers to develop embedded teaching of mathematics in a variety of ways:

- Compulsory or optional CPD sessions on embedding mathematics into vocational programmes;
- Bespoke CPD sessions for vocational areas on embedding;
- Drop-in support sessions for vocational staff to access help with any mathematics they are teaching;
- A designated member of the mathematics team to work with each vocational area;
- Projects to develop more confidence, skills and effective embedding with a specific vocational team;
- Observation training for non-mathematics specialists to identify good practice with mathematics.

Data from the case studies suggests that, whilst the upskilling of vocational teachers is welcome, it often comes too late and the need only becomes apparent after commencing a teaching career. More attention to mathematics in general FE teacher training would provide better foundations in terms of subject knowledge, confidence and the skills base to embed mathematics appropriately, thereby reducing the burden on colleges to provide their own CPD to meet these needs.

5.7.4 Summary and implications

Wide variation in the formal and informal professional development opportunities available to mathematics teachers in different colleges suggests that better CPD strategies are needed. All colleges would benefit from support in the form of designated funding for mathematics CPD and an agreed entitlement for teachers. Guidance for managers on the development of training plans for individual staff, the construction and leadership of college-based professional learning communities, and evaluative methods for practitioner-led research would help to realise the potential for professional learning within colleges.

There is a need for more sector-specific training and CPD, including on teaching approaches for which there is evidence of a positive effect in the FE context. The low mathematical confidence of some vocational staff could be more effectively addressed, for example during training and with better guidance on strategies and available resources.

5.8 Change in FE

The frequency of change in FE is well documented[44,45]. Here we focus primarily on recent changes in policy, performance measures and curriculum and their impact on post-16 mathematics from the perspective of staff in the case studies. Evidence from the studies indicates that events involving external bodies (e.g. Ofsted) can prompt significant internal changes whilst major college decisions, such mergers, which have been common since the Local Area Reviews, can generate considerable disruption to established working practices during the transition period. The impact of such events and decisions are mediated by senior leadership in quite different ways within the sample colleges, demonstrating highly variable levels of institutional resilience. Finally, the extent and impact of internally generated change is considered. Internal changes are frequent occurrences in the sample colleges which tend to add to instability rather than providing long-term strategic direction. The main areas identified where decisions trigger significant change are summarised in *Table 10*.

External sources	Internal sources
Policy (including drivers)	College strategies for implementation
Ofsted	Operational processes
Curriculum	Staffing
College mergers	Structural re-organisation

Table 10: The main external and internal sources where decision trigger change in colleges.

5.8.1 Responding to change

Policy-making for mathematics in FE needs to take into account that implementation takes place in a climate of frequent change, in which providers need time to respond to multiple concurrent or overlapping demands.

Senior leaders in the colleges highlight the impact of externally-prompted changes in policy, performance measures and curriculum but staff at all levels raise issues about the frequency of internal changes. Policy implementation in FE colleges is reliant on senior leaders and managers carrying out the functions of policy interpreters and translators[46]. The frequency of policy changes leads to a climate in which senior leaders find they are continually needing to re-assess priorities and revise internal strategies in order to integrate ways of implementing new policies or responding to overlapping initiatives. Whilst still trying to develop their response to one policy, college managers explain how they often face new demands concerning policy, performance measures or curriculum that require further adaptations. During this project, for example, in a space of just over two years, colleges highlight a number of changes with a direct or indirect impact on mathematics provision:

[44] City and Guilds. 2016. *Sense and Instability*. London: City and Guilds
[45] Norris, E. and Adam, R. 2017. All Change: why Britain is so prone to policy reinvention, and what can be done about it. London, Institute for Government.
[46] Dalby, D. & Noyes, A. 2018. Mathematics education policy enactment in England's Further Education colleges. *Journal of Vocational Education & Training* 70 (4):564-80.

1. A change in GCSE specifications, assessment and grading
2. Changes in functional skills specifications and assessments
3. Changes in performance measures (e.g. maths progress measure)
4. Adjustments to the condition of funding (e.g. Progression to GCSE no longer being mandatory after achieving Level 2 Functional Skills)
5. Changes in the focus of Ofsted inspections
6. Recommendations concerning mergers from Local Area Reviews.

Change permeates every level of FE and staff within the sample colleges explain that they have come to expect frequent change, but often with insufficient time to establish new practices before they are superseded by different ideas. As one manager explains, the process can be likened to planting seeds and digging them up before they have time to grow.

The development of long-term strategies for improvement in mathematics within colleges is dependent on clearer *communication, support and lead-in time between the introduction and implementation of new policies.*

Several college leaders and managers in the study raise concerns that communication about new policies is not always sufficiently informative, that processes are unclear and "decisions come out in peculiar ways". They find external advice about effective approaches to implementation is often not readily available and, in the absence of precedents to indicate how implementation might be approached, they resort to seeking advice on policy implementation in an ad hoc way from various events and networks. The sample colleges feel they often need more time to examine and work through possible approaches than timescales for implementation allow.

5.8.2 The GCSE retake policy

There is strong agreement amongst college managers and senior leaders that the most far-reaching and significant changes to mathematics provision in FE colleges in recent years have been prompted by the Condition of Funding, otherwise known as the GCSE retake policy. They feel this has had a "massive impact" on how colleges think about mathematics and organise provision, especially when dealing with a huge increase in student numbers on mathematics courses at level 2 and below. For example, one sample college with 30-40 GCSE mathematics entries a year previously is now handling nearly 500. Comparisons between colleges indicate that the transition has been more demanding for some colleges than others, depending on how extensive their mathematics provision was before the policy change.

The Condition of Funding has raised the status of mathematics in FE colleges and responsibility is more widely shared across the whole college.

It is widely agreed amongst college staff in the case studies that mathematics has become a much more prominent part of study programmes for 16-18 year olds since the Condition of Funding. It generally recognised as an important subject for students and mathematics lessons are the first priority in timetabling across most of the sample colleges, with vocational areas having to fit around these. Vocational staff are expected to share responsibility for mathematics in ways such as following up on student absence or behaviour issues in mathematics lessons. College leaders refer to frequently discussing mathematics and/or being actively involved in plans for improvement. Mathematics staff view this heightened status positively, even though much of the attention focuses on underperformance, but some vocational managers have concerns that mathematics and English now take up too much time. For example, a student who has to retake both mathematics and English can spend up to 6 hours a week on these (without counting any additional workshops or revision sessions). This constrains the time available for vocational content, which some vocational staff claim can be de-motivating for students.

A greater focus on mathematics has also had a positive effect on the mathematics teaching workforce. Additional permanent posts and/or enhanced salaries are offered by some colleges, which can place mathematics teachers in more secure and well-paid positions than their vocational counterparts.

The Condition of Funding has been demanding and costly for colleges since extensive re-organisation, recruitment and development has been required.

Colleges in the sample explain how they have needed to put in place new staffing and management structures to cope with the size of their rapidly expanded mathematics provision. This has included appointing additional managers to provide strategic and curriculum leadership where expertise was not already present in the college. Much effort and financial investment has also gone into the recruitment of mathematics teachers to meet the increased demand, including the development of creative schemes to attract and retain teachers and the upskilling of existing teachers for new roles.

The operational management of this expanded provision has presented major challenges for colleges that affect both managers and vocational staff. Timetabling, organisation, tracking and monitoring are large complex administrative tasks, for which some colleges have needed to appoint additional administrative or curriculum support staff.

An unintended consequence of the Condition of Funding is a deterioration in student behaviour, attitudes and confidence, which is time-consuming for colleges to address and change the focus of classroom teaching.

The issues around students' attitudes and motivation have already been discussed (see *Students*) but teachers report a deterioration since the Condition of Funding. Although making mathematics compulsory increases opportunities for some students, teachers explain how it also results in those without motivation, who might previously have opted out, being compelled to attend lessons. Unmotivated students are less likely to engage with learning and improve their skills, which has a direct negative effect on cohort achievement, whilst also causing disruption to learning for other students.

5.8.3 Externally prompted changes

The impact of other external processes on mathematics provision is contingent upon the change management strategies and resilience of the organisation.

From the case studies, two other externally-prompted processes can be identified that have an impact on mathematics provision: Ofsted inspections and mergers. There is evidence of *Ofsted* affecting the sample colleges in three main ways:

1. Anticipation of an inspection or re-inspection involves additional activity and pressure for managers and teachers, which usually affects mathematics teachers since achievement rates (at least for GCSE mathematics) are low across most colleges. Changes are sometimes made to comply with what the college perceives Ofsted want to see rather than retaining an existing strategy or teaching approach for mathematics.
2. Underperformance in an Ofsted inspection can demotivate staff but can also prompts colleges into new thinking, new strategies and reorganisation. Depending on the extent of change and management of the process, such changes can have positive or negative effects.
3. Changes in emphasis from Ofsted affect college approaches. A shift towards ungraded lesson observations and student progress rather than achievement and has prompted some colleges to abandon lesson grading and change their strategies to focus more closely on producing evidence of progression with mathematics rather than GCSE passes.

Mergers of colleges have become regular occurrences in FE during the study. Some have happened as a direct consequence of the Local Area Reviews, but colleges in the sample have sometimes made their own decisions about mergers in the light of the financial pressures facing the sector. Economies of scale, spreading of risk and institutional stability are potentially easier in a larger organisation. Two different collaborative arrangements are considered here:

- a full merger of two colleges into one with standardisation across all sites;
- a collaborative arrangement between a group of colleges in which some central services are shared but each site/college retains some independence and the aim is to achieve useful coordination and 'harmonisation' rather than full standardisation.

Evidence from the sample shows how a full merger can occupy considerable management time and typically involves a transition period of uncertainty for staff. Examples from the study demonstrate how changes in staffing and structures impact on mathematics teachers who work across the organisation, even if their own positions are not affected since personal connections are easily lost and communication with vocational areas disrupted. Uncertainty about roles, contracts and established working practices also lead to some mathematics teachers seeking alternative employment, particularly when one college is treated as the weaker partner and staff feel 'taken over'.

The formation of collaborative groups, within which each college has equal status, is an alternative arrangement in which good practice can be shared. The evidence suggests that this balance is difficult to achieve and mathematics provision sometimes remains weaker in one college because they retain sufficient independence to decide what ideas to accept or reject from others in the group. The collaborative group arrangement is therefore unlikely to bring little more benefit to mathematics provision than might be gained from being a network of independent colleges, unless agreement is reached on a level of standardisation to be achieved.

5.8.4 Internally generated changes

Pressure on colleges to produce measurable improvement leads to frequent internal reviews and changes of strategy.

In the sample colleges, managers and senior leaders typically review the effectiveness of their mathematics provision on at least an annual basis. These reviews seem to provide useful monitoring processes but decision-making under pressure for measurable improvement often appears to be reactive and lacks long-term strategic direction (see *Leadership and Management*). This results in frequent changes to structures, systems and teaching approaches for mathematics in the search for elusive solutions to low achievement, including large mid-year changes in some colleges. Revisions to structures, systems and teaching approaches require changes to working practices from teachers and these take time to develop and embed into work routines.

Changes to mathematics provision are also prompted by other internal management decisions that may not be specifically about mathematics including:

- whole college reorganisation (e.g. changing the vocational curriculum offer on a college site;
- changes of emphasis (e.g. in college observations and appraisals);
- operational changes (e.g. mid-year changes to timetables).

Staffing changes or long-term staff absence can also lead to small mid-year timetable changes for mathematics teachers but a change of manager signals widespread change since new ideas and preferences are likely to be brought into the organisation. As one senior leader explains, “A Head of School and a Curriculum Manager changing … you might as well start from scratch”. The speed at which established approaches are abandoned in favour of new ideas contributes to the sense of instability that pervades the colleges and increases expectations of continuing change. In a sector already struggling with policy churn and change, greater stability is difficult to achieve when managers themselves are under such pressure that they initiate frequent changes with hopes of almost immediate effects.

5.8.5 Summary and implications

The FE sector works within a climate of frequent change but the lead-in time and support needed to implement new policies is widely perceived by the managers and teachers in this study to be insufficient. The Condition of Funding has raised the status and importance of mathematics in colleges. This is laudable, but it has been costly to implement and the colleges have had to develop their own approaches to implementation, some aspects of which are still causing problems. An unintended consequence of the Condition of Funding reported in the colleges in this study has been a deterioration in student attitudes and behaviour. Some of the approaches taken by the senior leaders has moderated the impact of external catalysts such as Ofsted inspections and college mergers but pressure to raise attainment leads to frequent internal reviews and changes. Greater policy and institutional stability would help colleges make more sustainable, incremental changes within a long-term plan for improvement.

5.9 Policy

The section complements the previous one where the ways in which policy produces positive and destabilizing change were considered. Here we discuss the views of college managers and teachers on current mathematics policy. Although there is agreement that mathematics is important, staff express doubts about the suitability of GCSE grade 4 as the goal for so many students. Some staff believe that a requirement for all students to study mathematics to age 18 would be fairer than just focusing on low-attaining students but many question how such a policy could ever succeed without a suite of qualifications suitable for vocational students' needs. Others see this as inappropriate for the needs of many vocational students and potentially demotivating.

The problem of needing more suitable mathematics qualifications for students on different post-16 pathways is raised repeatedly but opinions are divided on what these qualifications should be. Some support the current policy, agreeing that GCSE should be the ultimate aim whilst many, including most of the vocational teachers interviewed, think an alternative skills-based mathematics curriculum would be more appropriate.

5.9.1 Current policy

There is widespread agreement amongst managers, mathematics teachers and vocational staff that the GCSE retake policy is flawed and needs to be reviewed.

The majority of managers and teachers interviewed (189 out of 238) stated that they do not support the current policy for mathematics in FE, though there is agreement with the broader intentions of improving mathematics skills. Their reasons include that:

- the policy is too prescriptive;
- implementation of the policy is problematic due to unpredicted obstacles;
- learning outcomes are not meeting policy aims;
- there are undesirable effects and outcomes for too many students.

There is agreement that changes are needed since only a minority achieve a better qualification in mathematics under current policy. Teachers note that some students are now retaking mathematics who may not have done so under previous policies but too many are unable to achieve the GCSE grade 4 goal. The policy is felt to be counter-productive for these students since there are detrimental effects on mathematical attitudes, confidence and mental health.

There are strong opinions amongst the teachers that the GCSE retake policy is actually an attempt to address the failure of primary and secondary education which leads to students at age 16 unable to reach an acceptable standard of mathematics. FE staff feel they are taking the blame for poor levels of mathematics in 16-18-year-olds when the problem is due to issues within education at an earlier stage. Better foundations in school would mean less students entering FE with such low levels of mathematics.

Teachers and managers consider that achieving GCSE grade 4 is not an appropriate or realistic goal for all.

Teachers believe that there are some students who will not achieve GCSE grade 4 during their 2/3 years in college because their starting point is too low or they have no motivation. Those who start from a low level and do engage often reach a 'plateau' after several attempts and fail to make further progress. There is also evidence of students achieving lower grades over time rather than improving, since repeated re-sitting of GCSE and experiences of 'serial' failure can be de-motivating.

A policy that allows students at age 19 to stop learning mathematics is also a concern amongst college staff since it suggests that mathematics is no longer important after this age. Consequently, colleges report that some students who study mathematics for 2/3 years in college take the attitude that they are just waiting until they can drop the subject. These students leave without a better qualification and with little intention of engaging with mathematics for the rest of their lives. In these cases, compulsory mathematics has resulted in no measurable improvement but has led to a deterioration in attitude and confidence.

Better understanding of the student cohort by policymakers is needed to ensure mathematics policies are appropriate for FE students' needs.

Managers in the study express concerns that there is insufficient understanding of FE contexts and the nature of student cohorts from government. They explain that students who have studied mathematics in school for eleven years to reach, at best, GCSE grade 3 standard may take time to reach grade 4. Furthermore, expectations that those with lower grades will achieve GCSE grade 4 within one year in a further education college, or even make measurable progress, are unrealistic. The sector is expected to make mathematics enjoyable and relevant so that students engage and improve their skills but making mathematics compulsory and expecting measurable improvement within less than a year does not help teachers achieve this.

Colleges highlight a mismatch between policy and students' interests. As one teacher explains, "What we expect and what the government expects is completely different to what the student needs sometimes". There is a lack of confidence in policymakers to understand students or develop policies that will address their needs in an appropriate way. As one teacher explains, "You trust that the policy makers have made the right decision although they haven't to a large extent".

Managers of vocational study programmes where students have alternative aspirations to university find the current policy climate, in which progression to HE dominates, unhelpful. This reinforces perceptions that policymakers do not understand FE students and that they make inappropriate assumptions about progression routes from vocational education to the workplace.

5.9.2 Future policy

Managers and teachers have reservations about the idea that all students should continue to study mathematics to age 18 years but there would be more support if suitable curricula and/or qualifications were available for all students.

Some teachers and managers in the case studies have strong views that maths-for-all-to-18 is unnecessary since there is no point in some students continuing with mathematics if they have already achieved the qualification they need. The change would be a 'step too far' at present for colleges and would require "a lot of selling and a big culture change".

There is however some support for the idea of encouraging students who have already obtained a GCSE grade 4 or 5 to aim for a higher grade, if this is likely to improve their opportunities beyond college. Teachers of Core Maths would like to see this qualification used more widely, although there are reservations from some respondents about whether it would be appropriate for all students with GCSE grade 4 as it seems more suited to those with higher grades. Exactly what mathematics would suit different groups of students was not easy for teachers to describe, although some common themes are that it should be relevant for those on vocational pathways, of practical use and interest, and not an academic knowledge-based qualification.

Future mathematics qualifications policy for FE students should have more realistic goals and a flexible suite of programmes that can meet individual needs without limiting access to GCSE or other high value qualifications.

There is general agreement that it is appropriate for students who are close to the grade 4 borderline to 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. Several teachers were of the opinion that a two-year programme for GCSE would be more appropriate because it often takes students this long to improve by one grade. It was also suggested that some students would benefit from a year way from mathematics rather than being forced into taking a subject for which they have no motivation and no intention of learning.

Greater emphasis on developing students' mathematics skills and more attention to the embedded mathematics within other parts of the study programme is considered preferable to the current focus on achieving discrete mathematics qualifications. For students at the lower levels (e.g. Entry level) some teachers question whether it is appropriate to take examinations at all.

Colleges would like to see more flexibility in the policy and an alternative qualification for students with low grades (below grade 3) or those without a need for a GCSE in their intended pathway. Greater opportunity for choice between different options would be welcomed but progression routes also need to be coherent.

Teachers find it difficult to define exactly what an alternative qualification should look like. Some would like it to be more relevant to vocational studies, with a focus on developing functionality but do not see Functional Skills mathematics fulfilling this purpose. A new qualification involving applications and functionality would be welcomed which would include more 'vocational' rather than an 'academic' mathematics and sit somewhere between GCSE and Functional Skills. Qualifications that students have a chance of passing, or a set of stepping-stone qualifications, would help students develop confidence with mathematics. However, the wide recognition and acceptance of GCSE by employers and HE is a barrier to developing alternatives, since other qualifications struggle to gain the same status or 'exchange value'. Acceptance of any alternatives by HE and employers is considered essential to their success.

5.9.3 Summary and implications

There is widespread agreement amongst college staff in this study that the GCSE retake policy is flawed and needs to be reviewed. Setting a goal of GCSE grade 4 for all students is considered by many teachers and managers to be unrealistic and achievement rates remain low. Moreover, if one of the goals of the skills policy is to produce more positive attitudes to (the application of) mathematics, an adjustment to policy might be considered.

College staff have concerns that policy-makers do not understand the FE student cohort and that better understanding is needed to inform more appropriate policies. Participants think that future policy needs to include more suitable mathematics curriculum and/or qualifications for post-16 vocational pathways and enough flexibility to ensure the needs of different student groups are met. Close liaison with the sector is needed in order to develop and support appropriate future policies and their implementation. The differences between colleges evidenced in this report suggests that this should include those able to provide broader perspectives.

6. Conclusions

The comprehensive analysis set out in the Main Findings above highlights the considerable complexity of providing mathematics qualifications for 16-18-year-olds in England's General Further Education Colleges. We have deliberately reported the findings in detail as we are keen to avoid the error of thinking that improvements can be simply achieved, or that a successful intervention in one area of the system (e.g. classrooms) can me made independently of considering other aspects of that interconnected system (e.g. operational strategy).

This complexity of FE mathematics provision is the product of the different scales, both spatial and temporal, of the educational system interacting with the varied local and regional needs of learners, communities and society. Understanding this multi-scale complexity, both societal and educational, is a prerequisite for considering how actors with different positions, roles and influence in this system might work to improve outcomes, whether individual, organisational or societal. Our analysis also points to places where there might be scope to invest resources to achieve worthwhile improvement.

6.1 Summary of Findings

We conclude the report below with a summary of the findings and implications from the nine themes.

College Context

FE colleges offer different ranges of vocational and academic qualifications to suit local needs. The scale of mathematics provision, as well as the nature of the cohort studying mathematics can therefore vary considerably. For example, student cohorts can have quite different levels of skills and motivations. The challenges faced by colleges in raising student attainment in mathematics are therefore not the same and in order to gain a more realistic view of college performance these contextual factors need to be taken into account.

Performance measures influence college management decisions in different ways but can lead to a narrow focus on examination success rather than a broader focus on the development of vocationally relevant mathematical skills. Such progress models (e.g. the performance measure) encode values and priorities and are intended to drive behaviours. It would be worth considering whether the right behaviours and outcomes are being achieved for learners with the current measures.

Variations in the student cohort studying mathematics affect the teaching skills and professional development needed. College strategies need to be context-specific, tailored to address student needs. The dominance of GCSE mathematics (retake) in colleges means this should be priority area for training and professional development. Questions about the suitability of Core Maths for vocational students and its place in vocational education need to be further investigated.

Management and leadership

The management of mathematics provision in FE colleges is complex due to the size, dispersion and shared responsibility involved. Colleges identify a need to develop a culture in which mathematics is seen as a whole college responsibility with full support from senior leadership and vocational staff. Collaboration and prioritization are key elements of this approach as might be seen in multi-level consultation by senior leadership and the prioritization of mathematics (and English) in timetabling.

Cross-college management of mathematics typically involves a team of staff at different levels working together but a key role is taken by the cross-college manager. This distinctive management role needs to be better understood and these managers need support and training. There would be merits in developing a national training programme, based on detailed examination of the functions and skills required for these roles.

Organisational strategies

The management and organisation of mathematics provision is complex and time-consuming. The geographical layout of the college and other cross-college processes (e.g. enrolment and induction) present a range of challenges. Systems and processes need to be developed in ways that align to the unique contextual constraints of a college and managers need more support to evaluate the likely impact of alternative systems within their own context.

Colleges commit much time and resource to dealing with poor student attendance and this remains a major issue with a significant impact on student learning. Operational decisions that take student preferences into account can have a positive effect but remedial strategies such as extra support are rarely accessed by those disengaged students with the greatest needs. Colleges need additional resources and new college-wide strategies to improve attendance.

Local communities and family backgrounds influence students' general aspirations and their motivation to study mathematics but colleges can influence attitudes to mathematics by highlighting the requirements of employers and Higher Education providers, as well as the value of mathematics in vocational employment. These messages need to be consistent and sound to motivate students, especially from vocational staff. There needs to be an emphasis on the 'use-value' of mathematics as well as its possible 'exchange-value' since this is more convincing for many students.

Teaching and learning

Mathematics teaching in FE is dominated by the need to address negative attitudes, increase motivation and engage students who often have insecure basic knowledge of mathematics and poor study skills. This requires specific competences that need greater emphasis in training and professional development. An unintended consequence of the Condition of Funding is the negative effect of compulsory mathematics on students who are already disaffected. Enforced attendance can intensify negative emotional responses and lead to a deterioration in classroom behaviour. Resources and specialist skills are needed to deal with these increasing problems.

Much of the teaching that mathematics teachers find effective in FE is centred on adaptations to meet the needs of different student groups or individuals. Teachers need a large toolkit of different approaches, methods and resources to develop such adaptive pedagogies. These includes tools to address different attitudinal issues, personal interests, prior knowledge and vocational links. A greater focus in training and professional development on equipping teachers to adapt their classroom pedagogy would be of benefit to the sector.

College strategies and national policies result in a framework of priorities which affect the teaching approaches used. Tensions between the needs of the system, the college and the students need to be recognised and balanced. There is a need for better FE-specific evaluation of the impact of teaching approaches such as interactive, collaborative methods; out-of-class independent learning; and, the use of technology. The practice of embedding mathematics in vocational learning is inconsistent and poorly understood. This needs better definition, with realistic expectations of vocational teachers and a thorough assessment of the impact on student understanding to inform future practice.

Workforce

The recruitment and retention of mathematics teachers in FE has been particularly challenging since the introduction of the Condition of Funding. Workforce stability is important to avoid pressures on other staff and sustain an improvement trajectory. Colleges have used creative and often costly methods to attract and retain teachers but there is an outstanding need for a better national strategy to attract and retain mathematics teachers suited to working in the sector.

Specialisms, conditions of service and workloads vary between colleges, with many teachers taking on additional responsibilities voluntarily. This lack of parity adds to the difficulty of retaining staff in a competitive market. There needs to be wider recognition that teachers who transfer from other learning environments or subjects need a transition period to undertake training and adjust pedagogy.

A more holistic view of the systemic issues that affect student outcomes and less attribution of blame to mathematics teachers may increase job satisfaction and contribute to better teacher retention. The diversity of knowledge and experience in the mathematics teacher workforce is a valuable resource for professional learning which could be better utilized in colleges.

Professional development

Wide variation in the formal and informal professional development opportunities available to mathematics teachers in different colleges suggests that better CPD strategies are needed. Colleges would benefit from support in the form of designated funding for mathematics CPD and an agreed entitlement for teachers. Guidance for managers on the development of training plans for individual staff, the construction and leadership of college-based professional learning communities, and evaluative methods for practitioner-led research would help to realise the potential for professional learning within colleges.

There is a need for more sector-specific training and CPD, including on teaching approaches for which there is evidence of a positive effect in the FE context. The low mathematical confidence of some vocational staff could also be more effectively addressed, for example during training and with better guidance on strategies and available resources.

Change

The FE sector works within a climate of frequent change but the lead-in time and support needed to implement new policies is widely perceived by managers and teachers to be insufficient. The Condition of Funding has raised the status and importance of mathematics in colleges but it has been costly to implement and colleges have had to develop their own approaches to implementation, some aspects of which continue to cause difficulties. An unintended consequence of the Condition of Funding has been a deterioration in student attitudes and behaviour regarding mathematics.

The approach taken by senior leaders can moderate the impact of external catalysts such as Ofsted inspections and college mergers but pressure to raise attainment leads to frequent internal reviews and changes. Greater policy and institutional stability would help colleges make more sustainable, incremental changes within longer-term plans for improvement.

Policy

There is widespread agreement amongst college staff that the GCSE retake policy is flawed and needs to be reviewed. Setting a goal of GCSE grade 4 for all students is not considered realistic and achievement rates remain low. An adjustment to policy needs to be considered seriously in response to this strength of evidence from the sector.

College staff have concerns that policymakers do not understand the FE student cohort sufficiently well and that better understanding is needed to inform more appropriate policies. Respondents think that future policy needs to include more suitable mathematics curriculum and/or qualifications for post-16 vocational pathways and sufficient flexibility to ensure the needs of different student groups are met. Close liaison with the sector is needed in order to develop those future policies and associated implementation strategies.

Finally

This report presents a comprehensive analysis of mathematics education policy enactment and practice across General Further Education Colleges in England. It focuses in particular on the case study strand of the MiFEC project. Whilst we cannot claim statistical generalisability, the research design and scale of the study means we can confidently make some analytic generalisations. We have been careful throughout to remind the reader that the findings are a) generated from a large sample of FE colleges and not the whole population, and b) based on reported evidence from a range of actors, rather than observations of practice.

We have not made clear recommendations at this stage, though some areas for attention are evident in the report. The forthcoming MiFEC Final Report (due summer 2020) will synthesise findings from the four strands of the study and make high-level recommendations for policymakers, FE sector leaders and other stakeholders aimed at improving the provision of mathematics in England's FE colleges. In the meantime, we welcome questions or comments on anything raised in the report[47].

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7. Appendices

Appendix 1: Main case study selection criteria.

Appendix 2: Coding framework showing themes and sub-themes

Appendix 3: Mathematics Progress Measure (2017-19) table

Appendix 1: Main case study selection criteria.

	Criteria	Area of interest	Measurement used	Source
1	Size	Number of full-time (FT) 16-18s	*Number of FT students at end of 16-18 study	Measure available on Find and compare schools in England
2	Location	Type of location	Urban city and town Urban major conurbation Urban minor conurbation Rural town and fringe Rural hamlet and isolated dwellings	Measures available on Get Information on schools service
3	Academic provision	Nature of 16-18 provision: vocational or includes A level programme	Number of students at end of 16-18 study with one or more A or AS entry.	As above
4	Participation rates for mathematics	Number of 16-18s on mathematics courses; success rate for 16-18 mathematics.	Number of students in scope (= number with GCSE below Grade C, or equivalent). Value-added measure for mathematics attainment.	As above
5	College performance with mathematics	Indicator of 'success' with mathematics	Maths progress measure	Measure available at gov.uk
6	Recent or pending merger		Recent mergers.	AoC list of colleges
7	Ofsted rating	Most recent grade.	**Overall (most recent) grade.	Measure available on Find and compare schools in England

*Data from Find and compare schools in England is for 2015/16. Where mergers have taken place data from merging colleges has been combined.

**For mergers, the Ofsted grade is generally taken from the latest report for the larger of the merged colleges. Where several mergers and/or name changes have taken place since the last inspection this was not always possible and the grade stated may represent only a small part of the existing merged organisation.

Appendix 2: Coding framework showing themes and sub-themes

Main themes	Sub-themes	Descriptions
Change	National	Changes nationally
	Internal decisions	Changes made internally, how and why.
	Merger	Changes as a result of college mergers.
Curriculum, qualifications and assessment	College curriculum	College curriculum offer (general)
	Mathematics curriculum	Mathematics curriculum offered
	GCSE & FS	Descriptions and comparisons: GCSE and FS mathematics
	Alternatives	Suggestions of alternative mathematics for vocational students
	Vocational	Mathematics that occurs within vocational programmes
	Embedding	Meaning of embedding of mathematics and examples
	Assessment	Assessment and examinations, methods and issues
Policy	Condition of funding	Views for or against the policy and why
	Maths to 18	Views for and against the policy and why
	Alternatives	Suggestions of alternative policies
	Other	Comments on other policies or suggestions
Professional development	CPD models	Approaches to CPD, models in use and staff perceptions of their value
	Mathematics CPD	CPD provided in colleges for mathematics staff (all forms)
	Mathematics staff needs	Areas of CPD need for mathematics teachers identified by teachers and managers
	Vocational CPD	CPD provided for vocational teachers (all forms)
	Vocational staff needs	Areas of CPD need for vocational teachers identified by teachers or managers.
Operational strategies	Level 2 provision	Level 2 mathematics provision and progression routes
	Level 3 provision	Level 3 mathematics provision and progression routes
	Adult provision	Mathematics provision for students aged 19+
	Timetabling	Approaches to timetabling and issues
	Groups	Ways in which student groups are structured for mathematics
	Session time	Time allocated for mathematics
	Attendance	Attendance and behaviour issues; monitoring and action
	Initial processes	Advice, guidance and enrolment on to mathematics courses; initial assessment
	Support systems	Ways in which progress is monitored and support is provided in addition to timetabled classes.
	Senior managers	Senior management roles and responsibilities wrt mathematics.
	Mathematics managers	Roles and responsibilities of middle managers with direct responsibility for mathematics

Structures, roles and responsibilities	Location	Type of staffing structure and location of mathematics staff
	Mathematics teachers	Responsibilities of mathematics teachers
	College provision	Range of college provision and distribution across sites
	Vocational departments	Responsibilities of vocational departments wrt mathematics
Students	Prior learning	Prior learning experiences and attainment in mathematics
	Backgrounds	Social and economic factors
	Motivation	Levels of motivation, sources of motivations and other priorities
	Attitudes	Students' views of mathematics, attitudes and behaviour
	Influences	Influences from parents and employers in student views of mathematics
	Attendance	Levels of attendance and reasons why
Teaching approaches	Motivating	Motivation and engaging students
	Differentiation	Differentiation between classes, groups and individuals
	Contextualisation	Ways in which contexts are used in learning
	Planning and resources	Approaches to planning as a team or individual and selection of resources.
	Changing attitudes	Approaches to changing student attitudes and overcoming barriers
	Exam preparation	Approaches to exam preparation and influence on teaching
	Coverage	Ways of 'covering' the GCSE specification and issues
	Embedding	Ways in which vocational staff embed mathematics and understand embedding
	Interactive	Ways of using interactive and active approaches
	Relationships	Ways of developing and using relationships and social structures in classroom teaching
	Variety and contrast	Need for variety, adaptability and difference compared to school
	Technology	Use of IT in teaching and learning
	Peer learning	Use of peer learning opportunities including collaborative group or paired work
	Basics	Need for and teaching of basic mathematics
	Other	Approaches and comments outside existing categories
	Homework	Extent of homework and types used.
	Independence	References to developing student independence and ownership of own learning.
	Understanding	References to understanding, conceptual understanding and mastery.
Workforce characteristics	Recruitment	Approaches to recruitment and retention of mathematics teachers and issues.
	Pathways	Teachers' narratives about how they became mathematics teachers in FE.
	Reasons	Reasons given for wanting to teach mathematics in FE.
	Workload	Weekly teaching hours, responsibilities and tasks carried out by mathematics teachers in FE.
	Qualities	What qualities and qualifications colleges or individuals believe are important for teaching mathematics.
	Vocational	Vocational staff and their relationship with mathematics.

Appendix 3: Mathematics Progress Measure (2017-19) table as published by the DfE at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/819734/16-18_Accountability_Measures_Technical_Guide_July_2019.pdf

Current points: 2017, 2018 and 2019 tables

Points awarded	Grade achieved					
	9-1 GCSEs	Legacy GCSEs	Functional Skills	Free Standing maths	ESOL	AQA use of maths
8	9	A*				
7.7	8					
7	7	A				
6.3	6					
6		B				
5.7	5					
5	4	C				
4	3	D	L2	L2 (all grades)	L2 (all grades)	A*/A/B/C
3	2	E				
2.5			L1	L1 (A-C)	L1 (D/M)	D/E
2		F				F
1.7				L1 (D)		
1.5					L1 (pass)	
1	1	G				G
0.8				L1 (E)		
0.4			Entry level		Entry level	

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