Discussion paper

Retaking GCSE mathematics: a discussion document on post-16 policy, practice and possible futures

Dr Jenny Smith and Dr Diane Dalby

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This paper was originally commissioned in February 2019 to inform a working group of the Royal Society's Advisory Committee on Mathematics Education's Post-16 Pathways Contact Group. References to previously unpublished work have subsequently been added for this published version (October 2021), with only minor revisions to the original paper. It should therefore be read in the context of what was known about GCSE mathematics in further education in April 2019.

Abstract

Current policies concerning the retaking of GCSE mathematics by students in post-16 education are causing concern due to the lack of measurable impact on student achievement or progress and large-scale problems for providers such as FE colleges who have to implement the policy. There is little robust evidence about the processes of policy enactment in FE colleges and therefore limited understanding of why current policy is not producing the intended outcomes. In this paper we draw on published work and unpublished interim findings from relevant research to map out the policy landscape and provide an overview of the current position. This includes a brief review of the historical development of mathematics in further education, an overview of the responses of General Further Education Colleges (GFECs) and the impact on students. We identify the positive and negative impact of current policy on student participation and outcomes, as well as the effects on the quality of teaching and the positioning of mathematics in GFECs. Problems in policy enactment for colleges arise from the rapid development of mathematics provision at level 2 and below, in order to cope with huge increases in demand at a time of teacher shortage. Tensions in policy development and enactment also arise from the different purposes mathematics is expected to fulfil from academic and vocational perspectives and from the use of financially related levers which cause conflicts between business decisions and a student-orientated focus. Finally, we draw the complex picture of policy enactment together in a system map to show the influences on post-16 mathematics and propose some of the considerations that need to be taken into account when considering future alternatives.

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Introduction

This paper was commissioned to inform the Royal Society, ACME (Advisory Committee for Mathematics Education) working group reviewing policy and practice concerning the retaking of GCSE mathematics by 16-18 years old students in English post-16 education. The ACME review is in response to concerns about the effectiveness of policy for post-16 GCSE retakes in mathematics, the curriculum and qualification offer for these students and their learning outcomes. This paper offers an overview of current policy and its implementation before presenting suggestions for a framework to guide the development of future scenarios and criteria for the evaluation of post-16 GCSE mathematics for discussion by the working group.

The focus of this paper is on GCSE retakes in General Further Education Colleges (GFECs), as this is where the majority of learners are most likely to complete their compulsory education who have not achieved a satisfactory pass (Grade 4 or above) in English and/or mathematics at the end of Key Stage (KS) 4 (age 16 years old). There are currently[1] 257 colleges in the FE sector in England, of which 174 are GFECs, 57 are sixth form colleges, 14 are land-based, 2 are specialist colleges in art, design and performing arts, and 10 are specialist designated colleges. Since the majority of GCSE retake students study in GFECs, the enactment of policy in these colleges forms the focus of this report. However, data and outcomes are sometimes reported in the literature using the term FE colleges without clear definition of whether this includes all colleges in the FE sector or only GFECs. We have attempted to make a distinction unless the term has been used indiscriminately in the literature.

The term 'retakes' is used rather than 'resits' as the former involves further study, i.e. retaking the course, rather than just 'resitting' the examination. The majority of these students are on vocational programmes, often starting their post-16 studies on level 1 or level 2 programmes.

[1] April 2019, based on most recent AoC data available.

This cohort are also more likely to be from a socio-economically disadvantaged background (DfE, 2019).

It is widely perceived that current policies concerning GCSE retakes in mathematics for 16-18 year olds are causing complex problems for providers and learners. Achievement rates for this student cohort have been consistently poor. For example, over 145,000 students aged 16-18 years were re-entered for GCSE mathematics in 2018 (DfE, 2019) but less than a fifth (18.7%) achieved the required grade 4 (DfE, 2019). There are some strong opinions that GCSE is not the most appropriate qualification for students following vocational programmes and one that focusses on application of mathematics might be more suitable for some (Noyes & Dalby, 2020a).

However, as discussed later in the paper, alternative qualifications to GCSE have historically failed to gain equal status and credibility. Policy levers, such as accountability measures are closely aligned to funding mechanisms and there is evidence to suggest that such approaches become divisive, sometimes leading to unintended outcomes (Dalby & Noyes, 2018).

Methodology

A system mapping approach has been used in an analysis of the relevant research literature available, to identify and consider the key influences of policy on local policy enactment, the curriculum offers and student attainment. A ‘system’ can be considered as a framework of concepts, objects and/or attributes and the relationships between them – a structured set of ‘things’, factors or variables, working together (Smith & Hamer, 2019). System mapping provides a way of capturing causal relationships, the interdependencies and interrelationships between factors and drivers, in a visual conceptualisation of a system.

The analysis has drawn on both published and unpublished[2] literature – the latter with permission from the authors to cite emerging outcomes from a current project, Mathematics in Further Education Colleges (MiFEC), funded by the Nuffield Foundation. The project aims to produce evidence-based advice for policymakers, college managers, curriculum leaders and practitioners on how to improve post-16 mathematics education in England's FE colleges. MiFEC explores the complex issues that affect students' progression with mathematics in FE, focusing particularly on the pathways of low-attaining 16-18 year olds. The project involves several relevant strands:

- A policy trajectory analysis of mathematics policy in FE colleges over the last 20 years.

- Case studies of a balanced sample of over 30 GFECs and cross-case analyses

- A survey of the mathematics GFEC workforce

The MiFEC project is due to report in November 2019[3]. We are grateful to be able to use emerging research outcomes from both the policy strand and the case studies since these offer an up-to-date narrative and analysis of the impact of GCSE Mathematics retake policy at a local level.

Structure for the rest of the paper

Included in this paper is a brief overview of the FE context and mathematics education policy changes for the 16 – 18 years old cohort since the widespread introduction of Key Skills (KS) qualifications (Key Skills, Application of Number) and new KS standards at the beginning of this century. This is followed by a description of the cohort retaking GCSE mathematics in GFECs, an overview of current policy for GCSE mathematics retakes, the key drivers of policy

[2] Revisions in October 2021 include references to reports from the MiFEC project that were unpublished in April 2019. All the final and interim published MiFEC reports are available at https://www.nottingham.ac.uk/research/groups/crme/projects/mifec/index.aspx
[3] The final report was published in 2020. All the MiFEC reports are now available (see link above).

at a local level and how colleges have responded in practice, drawing on the MiFEC research outcomes.

Other recent research and development studies have looked at issues relating to the position of GCSE mathematics for 16-18 year olds in colleges, and its teaching and learning. Some of these studies are still in progress. We make reference to these projects where they are relevant to the debate on policy for GCSE mathematics retakes for 16 – 18-year-old students. GCSE English retakes are discussed in relation to points of similarity or difference to GCSE mathematics, to highlight potential impact and areas where common solutions may be possible.

The paper concludes with a summary of the strengths and weaknesses of current policy and how practice is changing over time and suggests a framework for the evaluation of 16-18 years old GCSE Mathematics policy and provision. A draft map of the ‘post-16 GCSE retakes system’ is presented in the final section to support discussion and the policy decision-making process.

Background

In this section we consider the GFEC context for GCSE retakes and policy changes impacting on mathematics education for lower-attaining students over the last 20 years.

The General Further Education College context

Since the turn of the century there has been a series of policy changes that have impacted on the curriculum offer and teaching of mathematics for 16 – 18 year old students who have not reached the minimum level of mathematics considered appropriate (GCSE grade C, or currently grade 4 for the reformed qualification) by the end of KS4 at age 16. There have equally been concerns about the extent to which students who have gained at least this level of mathematics have the opportunity, or are encouraged, to continue their study of mathematics after KS4 (Smith, 2017) to enable them to gain the mathematical skills they will need for the future. This latter cohort however is not the focus for this paper.

Any discussion of mathematics education post-16 for students who have not gained the appropriate grade at GCSE needs to be made with an understanding of the GFEC context, where the majority of this student cohort, on leaving school at the end of KS4, continue their education, many of these on level 1 or level 2 vocational programmes.

GFECs left Local Education Authority (LEA) ownership and control in 1993 following the Further and Higher Education Act 1992. Colleges changed from being controlled by a locally elected body to autonomous and independent organisations, albeit heavily regulated. Funding was drawn from the Further Education Funding Council (FEFC), later the Learning and Skills Council (LSC), the Skills Funding Agency (SFA) and more recently the ESFA (Education and Skills Funding Agency). Policy enactment has been characterised by changes to funding mechanisms and the requirement to meet performance indicators for student recruitment, retention and achievement, and an inspection regime to monitor a market-focused sector (Kettley 2007; Coffield et al. 2007; Goodrham, 2008; Fletcher, Gravatt, & Sherlock, 2015). Funding mechanism and accountability measures continue to act as influencers and levers on current local policy enactment and decision-making.

The performance indicators and the data collection administrative role required created a gap between administrative functions and the teaching and learning focus within colleges. Targets were economically set, with funding directly linked to this and the threat of a ‘claw-back’ of funding if the targets were not met (Page, 1997). The importance of effective financial planning resulted in a cultural and structural shift within colleges, with new centralised business functions often having a more influential and powerful role within the college structure than vocational or academic heads of departments (Dalby & Noyes, 2018). Tensions between the business functions and the core activity of teaching and learning are still evident in colleges and can lead to unintended consequences when policy intentions and levers are not aligned.

The Labour government’s policy prior to the General Election in 2010, sought to remodel and reshape the sector. Two Skills White Papers published in 2005: ‘14-19 Education and Skills’, and ‘Skills: Getting on in Business, Getting on at Work’, outlined an employer-led ‘brokerage’ model for FE. Conventional education phases were blurred with a greater emphasis on partnership working to deliver qualifications with schools and higher education institutions (HEIs). The 'Further Education: Raising Skills, Improving Life Chances' (2006a) White Paper, built on recommendations from the Foster Report (2005). It identified an economic mission for FE with the delivery of skills and qualifications to meet the needs of employers, echoing a mission first identified in the 1890s and again in the 1944 Education Act (Kettley, 2007). The paper also made recommendations for extensive FE workforce reforms and a more self-regulatory approach for the sector. World Class Skills: implementing the Leitch Review of Skills in England (2006b) also reinforced the vocational training message. The more recent Industrial Strategy (BEIS, 2017) and Sainsbury Report (2007) again raise the profile of vocational pathways and the need to improve skills, with mathematics identified as a specific area for skills development.

The complex further education sector in England, 'the neglected middle child between universities and schools' (Foster, 2005), has continued to be reinvented as part of successive governments' agendas for improving economic prosperity and wider public sector reforms. The literature on reports frequent changes to curriculum, policy and funding mechanisms in FE (Green & Lucas 1999; Cripps 2002; Coffield 2006; Edward, Coffield, Steer & Gregson 2007; Dalby & Noyes, 2016; Dalby & Noyes, 2018). Such changes contribute to instability within the system and an environment of continuous change (City and Guilds, 2016, Norris & Adam, 2017) in which colleges are often expected to respond rapidly.

Prior to Incorporation, Gleeson and Mardle (1980) in their case study of education and training in FE, described the role of FE colleges as maintaining existing social relations for production for craft-based apprenticeships. Twenty-five years later, Goodrham (2008) reported that researchers and commentaries on FE continued to describe the FE role in terms of 'socialising' even after Incorporation:

> [a role] to socialise groups of often marginalised and/or economically and socially disadvantaged learners into a wide range of often low paid occupational identities and roles. (Goodrham, 2008:26)

Explanations of inequality in the UK education 'system' have drawn on a largely social perspective of education based on theories of cultural reproduction; for example, the neo-Marxist perspective of the work of Bowles and Gintis (1976) or Young (1971). From this perspective, research and debate on school or college-based curriculum and assessment is viewed in terms of the reproduction of external relations of power and economics. The impact of externally driven contexts on the effectiveness of education for a particular group of stakeholders is conceptualised in terms of the impact of economic relationships and subsequent power relations on and within policy enactment and classroom practice (Maton & Moore 2010; Young 2008). The divide between academic and vocational pathways and who should have access to them continues and is discussed further in the following sections. This distinction between academic and vocational pathways has a substantial influence on the type of mathematics curriculum believed to be most appropriate for post-16 learners. Mathematics is often strongly associated with the academic pathway but is experienced in practical applications with vocational training and the workplace. The relative power of academic and vocational voices in policy debates and in society generally is a factor worth considering for a subject like mathematics that has a different purpose in each domain.

Mathematics education policy changes in vocational education timeline

In this section, the key policy discourses for mathematics education within vocational education over the last 20 years are briefly summarised to identify the underpinning ideologies influencing the changing curriculum offer for students during this period. (Current policy is discussed in more detail below – see 'Current Policy and Practice')

Key influences on mathematical education discussed in this section include:

- Dearing Report (1996) – introduces the term key skills

- Moser Report (1999) – identified the lack of essential numeracy skills in the adult population

- Key Skills Standards (QCA, 2000)

- New Key Skills qualifications introduced (2001)
- Tomlinson Report (2004) – introduces the term functional skills
- Functional mathematics launched (2010)
- Condition of Funding (DfE, 2014) – makes GCSE the primary aim and prioritises GCSE retakes over other mathematics qualifications (DfE, 2015)

The status of mathematics education in GFECs in England has fluctuated over time. The extension of compulsory education to age 18 in 2015, and the recent high profile of mathematics in government policy make the implementation of effective college-level strategies for mathematics education a priority. However, the ongoing tension between vocational learning and subjects such as English and mathematics, which are more commonly perceived as based within academic disciplines, continues. The concept of generic modes of training with terms such as core skills, key skills or functional skills, transferable across subject areas, reflect a move away from discipline-based, academic knowledge discourses to the concept of 'trainability' and flexible, work-readiness (Beck & Young, 2005). What constitutes appropriate mathematical understanding and underpinning ways of thinking required for life, further study or work remains the subject of intense debate and stakeholder concern.

Changes to mathematics education for vocational students over the last 20 years, have their roots in the 1980s, when youth training schemes and pre-vocational courses specified 'numeracy' as one of several transferable core skills (Beck & Young 2005; Dalby & Noyes, 2016). The new BTEC specifications for vocational qualifications also identified similar skills requirements in 1983. The idea of a set of 'core skills' needed to underpin economic growth in the UK were identified by DES (1991) and these included mathematics (rather than numeracy). By 1992, after these early conceptualisations, application of number was specified in the new General National Vocational Qualifications (GNVQ) as a core skill (Dalby & Noyes, 2016).

The core skills approach within the GNVQ prioritised secure knowledge of fundamental mathematical procedures over skills in applying and using mathematics (Dalby & Noyes, 2017). The core skills units often lacked vocational relevance and the Dearing Report (1996) reconceptualised a mathematics curriculum for vocational students as ‘key skills’. The idea of key, transferable skills underpinned a political and ideological move towards the concept of 21st Century ‘learning and skills’ needed for employment, and a move away from a discipline-based ‘education’. Key skills were based in the premise that a set of transferable skills that cut across occupational sectors could be identified and applied within specific contexts.

The initial Key Skills Application of Number qualification required the collection of evidence to show that students could use the prescribed mathematical skills within their vocational context. This often resulted in large portfolios of evidence being collected and submitted but the lack of an external test of mathematical knowledge meant that the qualification failed to gain credibility (Dalby & Noyes, 2016).

The Moser Report (1999) highlighted the lack of basic mathematical skills in the UK adult population. In 2000, David Blunkett, the then Secretary of State for Education and Employment, issued a statement outlining the government’s Skills for Life response to Moser’s report and a series of actions including the development of an Adult Literacy and Numeracy strategy and curriculum. The core body of mathematical knowledge for key skills was revised and became aligned with the Skills for Life Adult Numeracy Curriculum. Following the introduction of Key Skills standards (QCA, 2000), a new curriculum for Key Skills Application of Number was introduced, which had a dual focus. Part A focused on a core body of mathematical knowledge and was assessed by means of an externally set and marked examination, identical to the Adult Numeracy test. Part B focused on application of core knowledge and was assessed by portfolio.

Achievement in key skills qualifications contributed to challenging local and national targets for Skills for Life attainment and encouraged some colleges to enter students for Key Skills level 2 qualifications who had a prior achievement of GCSE grade C or above in mathematics. These students could use their GCSE as a proxy for the Key Skills test and simply compile a portfolio to gain the Key Skills qualification (Dalby & Noyes, 2018). This often meant that new learning was minimal but the outcomes contributed to targets at low cost for the college (Dalby & Noyes, 2018).

The need for mathematics skills in life (Moser, 1999) and the workplace (Hoyles, 2002) was the start of a move towards an alternative vocational curriculum with suggestions of a 14-19 approach (DfES 2002; DfEE, 2003; Tomlinson 2004; DfE 2005) that led to a change in the curriculum offer. In addition, Smith (2004) identified the need for an overhaul of age 14+ mathematics and ACME (2006) advocated recognition of the dual importance of mathematics for both academic and vocational disciplines (ACME, 2006). The new hybrid qualification, the 14-19 Diploma, attempted to offer vocational and disciplinary knowledge. Mathematics knowledge and skills became 'functional' as suggested by Tomlinson (2004) rather than key. The intention was that functional skills would be a part of every post-14 pathway including academic, vocational and Foundation Learning (DfE, 2008) an intention that was never realised (Noyes, Drake, Wake & Murphy, 2010).

Functional skills in mathematics aimed at addressing the need for mathematics knowledge and skills for life, study and work. However, there was a change in emphasis towards the application of mathematical knowledge and skills across a range of contexts, including the unfamiliar (QCA, 2006). Problem-solving skills also appeared in functional mathematics specifications and although these could be applied to a particular vocational context, the emphasis was on developing transferable skills rather than limiting application to specific familiar contexts. The need for functional skills in mathematics continued to be advocated in a series of reports, highlighting for example, the needs in industry (CBI, 2010), the types of mathematics used in the workplace (Hodgen & Marks, 2013) and the impact of poor skills on economic growth (OECD, 2010).

Publications of results from the Skills for Life survey (BIS, 2011) showed little change in adult numeracy skills levels despite the 10-year initiative to address the skills deficit. International comparisons such as PIACC (Programme for the International Assessment of Adult Competencies) continued to show a need for improvement (BIS, 2013). The Wolf Report (2011) on vocational education proposed wide-reaching changes to the vocational education policy, including the emphasis on GCSE mathematics rather than alternative mathematics qualifications. More recent developments have seen a review of functional skills and new standards, leading to changes in the functional skills specifications from September 2019. The new Technical or T Level qualifications will include relevant embedded mathematics (The Royal Society, 2019). Meanwhile, GCSE mathematics remained firmly grounded in secondary education and relatively stable, with only minor changes to the curriculum compared to the radical shifts in possible alternatives such as the change from key skills to functional skills. Furthermore, promoted by Wolf (2011) and by the condition of funding, GCSE has moved into a central position in post-16 education.

Changes to policy continue in response to the debate by key stakeholders on what level 2 mathematical understanding is required by young people, and its education or training purpose. Tensions between an academic knowledge-based qualification and the value of skills in using and applying mathematics in vocational education remain. The following section offers a snapshot of current post-16 mathematics policy and its enactment and impact at a local level.

Retaking GCSE mathematics

Who is retaking GCSE mathematics?

In 2016/17 approximately 685,000 students aged 16-18 years studied in FE colleges (DfE, 2019). This figure includes students in sixth form colleges, land-based and specialist colleges as well as GFECs. Of these, 204,000 students were retaking English and/or mathematics and 163,000 were on A-level courses. These data show the high proportion of students retaking English and/or mathematics and the dominance of this provision compared to A-level programmes in FE.

These FE colleges provide education for a substantial section of the 16-18 student population. Analysis of 2016/17 data (AoC, 2018) shows that over a third (35%) of 16-18 year olds studied in FE colleges compared to less than a quarter (23%) in state-funded schools.

The profile of the student cohort in FE colleges has particular characteristics and differs from school in several ways. For example, 16% of 16-18 year olds in FE colleges had claimed free school meals at age 15, compared to 8% in maintained schools or academy sixth forms. 18% have a learning difficulty or disability. The progress made in post-16 education by disadvantaged students who did not achieve GCSE mathematics, grade 4 at the end of KS4 is lower than that made by non-disadvantaged students (DfE, 2019).

GCSE mathematics is stated as a requirement for entry to many level 3 study programmes in FE colleges, including vocational courses. This requirement may not always be strictly enforced especially when students are progressing from level 2 courses in college (Noyes & Dalby, 2020b), but the requirement does mean that students without GCSE mathematics are more likely to be studying on level 1 or level 2 study programmes in colleges. These students often have weaker general GCSE grade profiles than those on level 3 programmes, which may include a low grade in English. For example, over 80% of those required to take mathematics in post-16 education were also taking English in 2016/17 (DfE, 2019).

Student destinations from GFECs are also worth considering in discussions about the suitability of different mathematics qualifications. A quarter (25%) of students from FE colleges progress from level 3 courses to sustained employment, compared to only 18% from schools where there is a higher level of progression to HE. This can affect the motivation to achieve a GCSE qualification since it is often a requirement for progression to HE but not necessarily for employment.

Despite 79% of these FE colleges being judged as good or outstanding for overall effectiveness in their most recent inspections (AoC, 2018), achievement rates for mathematics (and English) are disappointingly low. The overall achievement rate for all qualifications in GFECs is 84.4% (2016/17) but for GCSE Mathematics the national average for high grades (grade 4 or above) was 22.1% in 2016/17 and declined to 18.2% in 2017/18. Students clearly find mathematics much more challenging than other parts of their study programme (AoC, 2019)

Current policy and practice

In the current FE sector, in the absence of a mediating organisation, senior leadership teams in GFECs act as mediators of policy as well as interpreters and translators (Ball et al, 2012; Dalby and Noyes, 2018). The independence of these colleges leads to variety in internal strategies and enactment, under the constraints of a range of policy levers such as inspections, targets or performance measures (Coffield et al. 2007; Fletcher, Gravatt & Sherlock 2015). Since GFECs operate as independent businesses, drivers with financial implications are of prime importance, especially in the current climate where the FE sector is under severe financial pressures (AoC, 2018). Variation and a sensitivity to financial effects are therefore to be expected in FE college policy enactment.

Evidence from the MiFEC project (Noyes & Dalby, 2020a) indicates that there are three specific aspects of government policy currently acting as strong levers and driving the agenda for GFECs with mathematics provision at level 2 and below:

1. ***The condition of funding for 16-19 year olds:***

Meeting the condition of funding is of prime importance since failure to comply leads to financial penalties which colleges can ill afford in the current climate. If students without GCSE Mathematics at grade 4 (previously grade C) fail to attend mathematics lessons the college is at risk of losing funding. There is a 5% margin of tolerance[4] but with many colleges facing financial challenges (AoC, 2018) the 50% reduction of study programme funding for students above this tolerance level is a risk many cannot afford to take.

2. ***Achievement rates (GCSE and functional skills mathematics):***

With the policy emphasis being on achieving GCSE Mathematics at grade 4 or above, the 'high grade' achievement (9-4, previously A*-C) is a key performance indicator for colleges although functional skills mathematics achievement is also a concern. With large numbers of students taking mathematics (and English) the achievement rate can also have an impact on overall college performance.

[4] We will apply funding reductions for non-compliance with the condition of funding to institutions where more than 5% of students without a GCSE grade 9 to 4 or A* to C in maths and/or English did not enrol on an approved qualification in these subjects. The funding reductions for these institutions will be applied at half the national funding rate above the tolerance. https://www.gov.uk/guidance/16-to-19-funding-maths-and-english-condition-of-funding#applying-a-tolerance-to-allocations

3. *Maths progress measures.*

Guidance on the condition of funding also states that colleges must be able to demonstrate progression by placing students on courses to aim for a qualification at a higher level than their previous achievement (DfE, 2017). A headline progress measure is used in performance tables to recognise the progress students make with mathematics (and English) at the college. This is a measure of the effectiveness of the mathematics provision offered by the college which focusses on evidence of improvement by grade (e.g. an improvement of one GCSE grade counts as +1) or by level of functional skills mathematics (see Appendix 1 for table). The equivalences used for functional skills mathematics compared to GCSE grades means transfer from GCSE to functional skills mathematics is often not counted as a positive gain. For example, the progress measure of a student with prior achievement of GCSE grade 2 who then achieves Functional Skills Mathematics at level 1 is -0.5. If instead they take GCSE and improve by one grade their progress measure is +1. Students who improve from Entry Level Functional Skills to level 1 however would be counted as +2.1.

In summary, the condition of funding has led to increased student numbers and therefore required an expansion of the mathematics teacher workforce in many colleges, revised management structures and extensive efforts to track, monitor and encourage student attendance, including obtaining support from other curriculum areas.

The importance of high-grade achievement rates to colleges has led to extensive efforts to increase the quality of teaching, to provide extra support for students outside lessons, to timetable mathematics classes in ways that encourage good attendance and to devise strategies to ensure students attend their examinations. Specific work to boost exam performance takes place in most colleges through revision classes, examination practice, the teaching of exam techniques and by adapting teaching to focus on topics that have the greatest impact on achieving a grade 4 (Noyes & Dalby, 2020a).

Maths progress measures have led to adjustments in the qualifications and mathematics progression routes offered to students. There has been a recent trend in colleges towards placing more students on GCSE retake courses, even though some with low grades have little hope of passing (Noyes, Dalby & Smith, 2020). The target for many students under this college strategy is achieving one grade higher than their previous performance.

Evidence from the MiFEC project indicates that the relative importance to a college of high-grade achievement compared to maths progress measure is highly influential on their internal strategies. There has been a recent shift in many colleges towards improving progress measures rather than high-grade achievement. A change in Ofsted inspections towards recognition of student progress rather than attainment[5] has also been instrumental in colleges re-assessing their priorities and making these strategic changes.

Overview of enacted policy in colleges and effects

Since the result of the condition of funding, colleges have made rapid adjustments in order to deliver mathematics to the increased numbers of students who are required to continue studying mathematics at level 2 or below. The increase in numbers has been substantial for many colleges, sometimes multiple times the number taking mathematics at this level before the policy change (Noyes & Dalby, 2020a).

Data from a sample of GFECs (MiFEC) shows that the number of GCSE entries for these colleges were substantially lower than for functional skills qualifications prior to the condition of funding in 2014/15. GCSE entries rose sharply in 2014/15, as a result of the condition of funding but then continued to increase for the following two years. The continuing rise is partly as result of the amendment to the condition of funding in 2015/16, which required students with grade D to take GCSE rather than functional skills. It was also affected by the need for students in their second or third year of post-16 education to continue retaking GCSE mathematics, after failing for a second or third time, in addition to the new school leavers. With achievement rates for GCSE retake being low, e.g. 2016/17 17.5%; 18.7% in 2017/18 (ESFA,

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[5] Learners without GCSE legacy grades A* to C (reformed grades 4 to 9) in either English or mathematics follow appropriately tailored courses in English and/or mathematics. The considerable majority make substantial and sustained progress towards legacy grade C (reformed grade 4) or above.https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/782172/Further_education_and_skills_inspection_handbook_181218_updated_for_1_March_2019_final.pdf

2019) this considerably adds to the numbers continuing with mathematics and needing to retake the qualification again in their second or third year of post-16 study.

In contrast, these data (MiFEC) show relative stability in the number of entrants for functional skills at Entry Level and a small overall decline in level 1 functional skills. Level 2 functional skills entries have declined steadily since 2014/15. The reasons for this are discussed in the following sub-section on the curriculum offer.

The rapid increase in mathematics provision within 16-18 study programmes has led to a greater college-wide emphasis on mathematics and an increasing acceptance amongst both students and vocational staff that this is an important core subject. This is a welcome change for those concerned with mathematics in colleges and few would question the benefits of this renewed focus (Noyes & Dalby, 2020a). Teachers and managers in the MiFEC study do however query the suitability of the current curriculum on offer to 16-18 year olds.

The curriculum offer

Interim findings from the MiFEC project (Noyes & Dalby, 2020a) indicate that most GFECs offer courses to 16-18 year olds in both GCSE and functional skills mathematics. The functional skills offer is becoming increasingly restricted with the prioritisation of GCSE for 16-18 year olds, although the qualifications remain widely used with adults.

The decline in entries for level 2 functional skills for 16-18 year olds (as mentioned in the previous section), has also been influenced by revisions of functional skills specifications in 2015/16. Evidence from the MiFEC project suggests three main curriculum-related reasons for the decrease in functional skills mathematics qualifications:

- Perceptions amongst teachers that level 2 functional skills mathematics is now more difficult for 16-18 years olds to pass than GCSE mathematics

- The length of written examination questions and the complexity of the language used. This presents a barrier for second language speakers and those with low levels of English as a first language.

- Teachers' beliefs that level 2 functional skills mathematics does not provide an appropriate 'stepping stone' to GCSE. This argument is largely based on differences in content (GCSE content being more extensive) and the use of calculators (which are allowed in functional skills examinations whilst GCSE includes a non-calculator paper). The qualification was however never designed to be a stepping stone to GCSE (The Research Base, 2014) and it is not surprising that it does not adequately fulfil this purpose.

These factors make level 2 functional skills mathematics a less attractive qualification for 16-18s, since it is perceived to be challenging but lacks a clear purpose within a progression pathway where retaking GCSE is the ultimate aim.

The credibility of level 2 functional skills as a 'gatekeeping' qualification is also surpassed by GCSE, and this seems likely to continue unless HE and employers give greater recognition to the qualification. Attempts to reform the qualification to give it greater mathematical substance seem unlikely to fulfil expectations, without coupling this reform with efforts to improve the currency value of the qualification (Dalby & Noyes, 2020).

Interim findings from the MiFEC project suggest an increased emphasis on mathematics progress rather than just achievement of GCSE grade 4 and this also contributes to a diminishing use of functional skills qualifications in students' mathematics progression routes (Noyes, Dalby & Smith, 2020). There are also indications that colleges are gaining better understanding of the measure and how entering students for different qualifications affects progress scores.

Minimisation of college offers of level 2 functional skills mathematics to 16-18 year olds can be traced to the combination of the increasing importance of being able to demonstrate progress, with an increased awareness of how to maximise mathematics progress scores and the weaknesses of the curriculum. Although some colleges still find value for level 2 functional skills mathematics within progression pathways, in many cases the qualification is only offered in exceptional circumstances.

The result of minimising the role of level 2 functional mathematics in progression pathways does mean that students with low grades (GCSE grade 2 or below), who might initially be placed on a functional skills course, are then allowed to progress directly from level 1 functional skills to GCSE. Data from the MiFEC project (Noyes & Dalby, 2020a) highlight a common view amongst teachers that the step between these two qualifications, of different type and level, involves a large amount of learning which is unrealistic within a one-year retake course. The pressure to make such progress in a single year is avoided by strategies that solely focus on repeating GCSE with the aim of improving a grade each year, rather than taking any functional skills qualifications. In contrast, some colleges advocate the value of functional skills courses as opportunities to deal with deficits in basic knowledge, develop better understanding of fundamental concepts and build confidence before retaking GCSE course, which is fundamentally a short revision course.

The latest change in the condition of funding (ESFA, 2019) however removes colleges from the obligation of progressing a student who passes level 2 functional skills to GCSE and thereby gives greater recognition to level 2 functional skills. This indication of more equitable status is useful but may not be sufficient to halt the decline in level 2 functional mathematics without dealing with the associated issues already discussed (Dalby & Noyes, 2020). The new specifications for functional skills mathematics appear to widen the gap between Entry 3 and level 1 qualifications, which may mean functional skills mathematics becomes a more effective stepping stone to GCSE and confidence in the qualification returns. At this point, without further details and analysis of the intended assessment material it is too early to predict the impact.

Increases in the importance of student progress measures have also led to other changes in college policies concerning student progression (Noyes & Dalby, 2020a). For example, in some colleges all students are placed on GCSE courses in preference to functional skills mathematics, except those at very low prior levels of achievement (Entry 1 or 2). The aim is then to help students improve at least one grade in a year, which attracts a maths progress score of +1. Despite the likelihood of a negative impact on GCSE high-grade achievement, this should lead to improvements in college maths progress scores. These college approaches are however likely to result in a decline in GCSE high-grade achievement rates.

The above approach is also justified by college staff on the grounds of GCSE being the 'gold standard' and therefore warranting prioritisation as Wolf (2011) suggests. Others express beliefs that the continuity of studying for the same qualification is better than moving to functional skills and returning to GCSE later. This is a contentious issue in colleges with strong arguments for and against a 'GCSE for all' strategy.

College structures and staffing

Some colleges were in the position of offering very little GCSE Mathematics before the condition of funding and therefore had none of the management and infrastructure needed to deliver GCSE Mathematics at the scale required. Most colleges have seen large increases in numbers and the challenge of managing the expansion has resulted in the development of new management structures, strategic plans, implementation plans for mathematics (and English) and an expansion of existing teaching teams (Noyes & Dalby, 2020a).

Evidence from the MiFEC project indicates that large increases in students have typically led to actions such as:

- A college restructuring to make mathematics (often with English) into a separate centralised department

- Appointments of additional managers to provide strategic and curriculum leadership for mathematics

- Strenuous efforts to recruit sufficient mathematics teachers. Since there is a national shortage this has been difficult.

- A shift away from employing agency or temporary mathematics teachers, since permanent substantive posts are likely to attract better teachers.

- Appointments of additional administrators to support managers with tasks such as attendance monitoring.

- Greater recognition across colleges, including other curriculum/vocational areas, that mathematics constitutes an important part of the study programme.

- Greater involvement of other curriculum/vocational staff in operational aspects of mathematics provision (e.g. monitoring attendance) and college-wide prioritisation (e.g. mathematics being timetabled first and vocational areas having to work around mathematics).

Colleges report that recruiting and retaining sufficient mathematics teachers of the quality they would like is an on-going problem (Noyes & Dalby, 2020a) and probably the most severe problem that they face. A national shortage, highlighted as a problem in earlier reports (The Research Base, 2014; Kyffin, Hodgen and Tomei, 2013), has frustrated attempts to recruit sufficient specialist mathematics teachers in GFECs. In some GFECs, strong local competition for mathematics teachers from schools or other FE providers has resulted in mathematics specialists being offered higher salaries in order to recruit and retain them (Noyes & Dalby, 2020a). Furthermore, the MiFEC study indicates that many colleges now offer enhanced salaries or other college-funded incentives and that most colleges have had to develop new strategies to increase and retain an adequate workforce. The approaches used often include a range of strategies and schemes in combination, in order to ensure there is an adequate workforce.

Strategies used by GFECs in the MiFEC study to recruit and retain mathematics teachers include ‘grow your own’ schemes to retrain teachers from other curriculum areas. These might include the use of bursary schemes (e.g. ones offered by ETF) to attract new teachers but generally involve one or more of the following approaches:

- Retraining vocational staff or teachers of other subjects to teach functional skills and/or GCSE Mathematics. In most cases this has been offered as a choice and these teachers have opted into mathematics teaching. However, decreases in adult funding and changes in the popularity of some vocational courses have influenced decisions.

- Upskilling functional skills mathematics teachers to teach GCSE. The way in which teachers have been upskilled seems to vary between colleges but many have accessed recognised courses provided by organisations such as ETF and NCETM.

- Identifying learning support staff or those in administrative roles within the college who may be interested in a career in mathematics teaching. In the best cases these teachers have undertaken a scaffolded pathway into classroom teaching with a clear structure involving taking relevant teaching qualifications.

Finding managers for this area of provision can also be difficult and this affects both operational a strategic processes (Noyes & Dalby, 2020a). Recruitment processes and retention strategies both incur high costs and a place a heavy burden on the human resources needed to deal with this continuing crisis.

In addition, colleges employ a range of strategies to monitor and improve the quality of teaching and learning. Most colleges in the MiFEC study used a system of formal lesson observations that may lead to identification of areas for improvement and individual action plans for teachers, although these do not necessarily involve subject-specific pedagogies. ‘Walk through’ observations were also used by many MiFEC colleges to identify weaknesses or strengths in classroom practice (Noyes & Dalby 2020a), which sometimes led to individual coaching or sharing of ‘good’ practice between teachers. Peer observations were often encouraged but are not always logistically feasible.

Colleges have provided professional development over the last few years to improve the general quality of provision. This includes training to:

- improve or extend the skills of existing staff

- retrain vocational teachers, or teachers of other subjects to teach mathematics

- upskill functional skills teachers to teach GCSE Mathematics
- prepare teachers of mathematics for adults to teach 16-18 year olds
- improve the mathematics skills of vocational teachers and their skills in embedding mathematics in vocational learning.

This professional development has largely been funded by the colleges themselves and varies widely between colleges, with some mathematics teachers having very few subject-specific professional development opportunities (Noyes, Dalby & Lavis, 2018).

Impact on students

Students who are required to retake mathematics in post-16 education would typically attend mathematics lessons for around 3 hours a week as part of their study programme, in addition to the time spent on their vocational academic studies (Noyes & Dalby, 2020a). There is an expectation that they will retake the GCSE Mathematics examination, or an alternative ‘stepping stone’ qualification within a year. Those who also need to retake English would spend an additional 3 hours a week in English lessons. For the 2017/18 cohort, 83.4% of those required to retake mathematics were also entered for an approved English qualification. For these students, mathematics and English lessons constitute a substantial part of their weekly timetables.

Large increases in the number of students who now have to take mathematics at level 2 or below have led to changes in the responses of these learners to mathematics. Teachers report that the attitudes, engagement and motivation of the student cohort towards mathematics have deteriorated since the subject has become compulsory (Noyes & Dalby, 2020a). This is not totally unexpected, since students are now required to study the subject who may previously have opted out due to a lack of interest or motivation. Student focus groups also provide evidence of resentment at mathematics being compulsory and reluctance to engage with learning the subject even from some students who need the qualification to progress (Noyes & Dalby, 2020b).

Evidence from the MiFEC project shows how motivation to study mathematics is often linked to students' perceptions of a need to improve their skills or gain a qualification (Noyes & Dalby, 2020b). Although some 16-18 year old students aim to progress to further studies for which GCSE Mathematics is a 'gate-keeper', or they need the qualification for progression within college, others see less need. There is an acceptance amongst students that better mathematics skills or a higher grade in GCSE Mathematics may help them gain employment (MiFEC), but this is often too distant in their futures thinking to have an impact. For students, the need to improve their actual skills in mathematics is more motivating when they understand the relevance to their vocational studies or personal lives. Teachers report the difficulties of achieving this with the limited timescale for delivery, particularly with some of the content of GCSE Mathematics (Noyes & Dalby, 2020a).

Although there are students who recognise the need to gain GCSE Mathematics at grade 4 for progression to another course in college or further study or training, many still lack sufficient motivation to engage fully in mathematics lessons. This makes teaching difficult since effort has to be made by teachers to engage students as well as teach the mathematics.

Disaffection with mathematics is a common problem, even in schools (Brown, Brown & Bibby, 2008; Nardi and Steward, 2003) but is strongly evidenced in post-16 low-attaining students who are expected to continue studying mathematics (Dalby, 2014; MiFEC, 2019). Achieving a GCSE result at age 16 that is deemed unsatisfactory reinforces any existing perceptions of being a failure at learning mathematics, often leading to increased disaffection and demotivation. There is some evidence that further failures to gain a grade 4 in subsequent post-16 retakes of GCSE Mathematics are increasingly demotivating (Noyes & Dalby 2020a).

Students who are required to study mathematics as a condition of funding are studying the subject regardless of whether they have any motivation to improve their mathematics skills or interest in the subject. Negative experiences in the past and low attainment often lead to perceptions of 'failure', a lack of motivation and reluctance to re-engage with mathematics in college (Higton et al. 2017, The Research Base, 2014). A number of recent studies (see below) highlight the poor engagement of students with low-attainment in post-16 education, attributing this to:

- Negative prior experiences of learning mathematics (The Research Base, 2014)

- A lack of confidence with mathematics (The Research Base, 2014)

- Anxiety about mathematics or about taking a mathematics examination (Higton et al., 2017)

- Exposure to negative cultural attitudes to mathematics in society (Smith, 2017)

- Peer pressure (The Research Base, 2014)

A low level of engagement with mathematics may be evidenced by poor attendance at mathematics lessons, or avoidance behaviours (even when present in lessons) and a lack of effort to learn mathematics (Dalby, 2014). Ultimately, these behaviours have a negative impact on the progress a student makes with the subject.

The low levels of achievement when retaking GCSE Mathematics indicate that although more students are studying the subject, the majority do not achieve a grade 4 or above by the end of their two or three years in college (Noyes, Dalby & Smith, 2020). For those that do succeed, current policy has provided an opportunity that they might not have chosen voluntarily but has been of benefit. Concerns amongst college staff tend to focus on the negative effects of repeated failure, which is the experience of the majority.

A comparison of GCSE mathematics retakes and English provision

The logistical problems involved in organising large numbers of students based in different curriculum areas of large FE colleges are similar for mathematics and English. Many colleges have one senior manager responsible for mathematics and English and use similar organisational systems for both subjects.

The organisational demands and management responsibilities may be similar at this level but a distinction is usually made at a lower management level where subject specific curriculum leads take responsibility for subject teaching, learning and assessment (Noyes & Dalby, 2020a).

The numbers of post-16 students 'in scope' and required to retake mathematics is higher than for English. For example, 145,448 students were 'in scope' for the mathematics progress measure in 2017/18 and 115,115 for English (ESFA, 2019). Achievement rates for English have consistently exceeded those for mathematics over the last few years but both are low with 2017/18 data showing 18.7% achievement (at grade 4 or above) for mathematics and 23.5% for English (ESFA, 2019)

Trends in the achievement rates of students resitting the GCSE examination do not follow the same patterns for mathematics and English. There is evidence from some colleges in the MiFEC study that students taking GCSE Mathematics have decreasing chances of passing with successive attempts whilst those taking GCSE English have increased chances. This has been attributed by some teachers to declining motivation (Noyes & Dalby 2020a) but may also be affected by the way students learn these two subjects.

There is some evidence that affective responses to mathematics and English (e.g. attitudes, emotions, motivation) are not the same. Disaffection is less evident with English (Higton et al, 2017). Mathematics anxiety for example is a common subject specific response that is not replicated with English and beliefs about an innate ability to either comprehend the subject or not are also common (Furinghetti, 1993). As Smith (2017) reports, cultural attitudes to mathematics in England are predominantly negative and it is acceptable in society to be poor at mathematics. The subject is often viewed as a remote inaccessible academic subject that is the domain of a select minority (Volmink, 1994). Colleges report that students find it easier to see the relevance of English than mathematics (Noyes & Dalby, 2020a), which may be due to the more obvious 'use-value' of English.

The concept of 'functionality' applies across English and mathematics in functional skills qualifications, which provide an alternative to GCSE. The interpretation of functionality and how it affects both the specifications and assessment of these qualifications is not the same and these may well lead to different experiences of a functional curriculum in English and mathematics.

Recent research and development studies

In this section, key messages are considered that have come from recent studies looking at issues related to the teaching and learning of GCSE Mathematics and functional skills in post-16 education.

An overall message from recent studies of post-16 mathematics suggest a need to utilise contrasts afforded by post-16 vocational learning contexts to make mathematics learning a different experience for young people to compared to school (Higton et al., 2017; Dalby & Noyes, 2015; Research Base, 2014). Students overall enjoy college and embrace the culture and values of their vocational education and training (Dalby & Noyes, 2015). The teaching and learning of mathematics within the vocational context is seen as more relevant and of interest to students (Dalby, 2014).

A lack of student motivation as a result of negative experiences of mathematics in school and a sense of failure following GCSE examination outcomes, often pervade students' attitudes to post-16 mathematics learning in GFECs. The Research Base (2014) suggests students need to identify themselves with being competent and successful with mathematics:

> Disengaged learners, particularly those who have had negative learning experiences in the past, may need to be supported to develop an identity through which they can view themselves as being competent to deal with real-life situations, such as money, employment and the law (2014:5).

The literature suggests a strong need for teachers to identify students' learning needs and what they need to understand in order to meet the required level and breadth of mathematical understanding for an appropriate qualification pass (Higton et al., 2017: Research Base, 2014). A recurring theme is the need for differentiated teaching and learning, with appropriate support structures that recognise the range of backgrounds and the learning and development needs of a diverse GFEC student cohort (Higton et al., 2017, Research Base, 2014). Internationally, jurisdictions where teachers have greater autonomy to shape the curriculum to meet individual student needs tend have greater success in mathematic outcomes (Research Base, 2014). Where the curriculum is decided nationally, teachers have more control over their teaching approaches than the content of their lessons (Research Base, 2014).

There are teaching approaches that have been successful internationally, which include approaches to problem solving and 'real life' activity-based learning.

> […] contextualised learning of maths improves both learners' overall understanding and the extent to which they retain the information they have learned. Piecemeal contextualisation, however, can be limiting for learners; ensuring that contexts are planned and aligned to the broader curriculum, and that contextualised mathematical tools are applied across several areas, can help to avoid this. (Research Base, 2014:5).

Dalby (2014) also suggests caution is required when teaching mathematics within a vocational context. Following her observations of functional skills classrooms and focus group discussions, she concluded that:

> For these students, the context acted as a potential source of interest that linked the classroom to their lives. A relevant context motivated students to engage with the task and facilitated understanding, but contexts could also confuse, and the connections to their lives were often fragile (Dalby, 2014:76).

The management structure and place of mathematics within the college can influence the teaching approaches used. For example, the centralisation of mathematics teachers or dispersion into vocational departments can affect how strongly teaching is connected to vocational learning. In general, pedagogic approaches that reflect vocational values and make connections to vocational learning are more effective than teaching mathematics as an academic discipline (Dalby & Noyes, 2014).

The Education Endowment Foundation (EEF) are funding intervention programmes that look at the teaching of specific areas of mathematics that have historically proved challenging for GCSE students. This followed a literature review (Maughan et al. 2014) that looked at successful strategies for the teaching of mathematics that might be transferable to the 16 – 18 GCSE retakes context. One programme, Maths for Life, is based in the work of Swan (2006) who looked at the role of dialogic approaches to the teaching of algebra with 16 – 18 year olds retaking GCSE Mathematics across 44 FE sector colleges.

> resources encourage and support the implementation of collaborative, discussion-based approaches to learning algebra. As these are used by teachers, even for the first time, there is evidence here to suggest that learning is enhanced, particularly when they are used in student-centred ways. In particular, this means that students' existing knowledge and misunderstandings are brought to the surface and discussed in the lessons.
>
> (Swan, 2006:240)

Learning is enhanced by using the activities in this study. These ideas reiterate the importance of teaching approach, the pedagogy, as discussed above to the understanding of key mathematical concepts such as algebra.

Summary of strengths and weaknesses of current policy and practice

The main strengths and weaknesses of current policy are summarised in four sections:

- Participation
- Student outcomes
- The positioning of mathematics in the curriculum
- Teaching and learning

Participation data for 16-18 year old students with mathematics have greatly increased as a direct result of the condition of funding. The GCSE retake policy ensures that many students now receive teaching to improve their mathematics who may not have chosen to retake the subject under previous policies. The weakness is that much participation is nominal and involves little active participation in learning mathematics, even for those who attend the lessons.

Student outcomes may be evidenced by measures of achievement and progress, or through skills improvement or other personal gains. GCSE achievement rates (grade 4 or above) and maths progress measures are both disappointing, showing that only a minority of the student cohort who were without a GCSE Mathematics grade 4 at the end of KS4 achieve this by age 19 years. This seems a poor return for the cost and effort involved by colleges to implement the policy and suggests the policy is ineffective. There is also little or no improvement in maths progress measures for many students, although the scoring system does not reward gains in different skills at an equivalent level or capture smaller steps of progress within a grade (Noyes, Dalby & Smith, 2020).

The emphasis on GCSE, which is a knowledge-based qualification, does not necessarily help students develop the particular mathematical skills commonly needed in the workplace. Employers still state that basic mathematical skills are often lacking.

Other outcomes for students also suggest weaknesses in the current policy. Although some students do make progress, achieve qualifications and gain confidence, the policy subjects many unwilling students to additional unsuccessful attempts to achieve a GCSE grade 4 in mathematics (Noyes & Dalby, 2020c). This often has a negative effect on attitude and motivation (Noyes & Dalby, 2020a), leaving students even less willing to try to improve or use mathematics in the workplace.

The condition of funding has led to an increased emphasis on mathematics in post-16 study, raising the profile within colleges and leading to a *positioning of mathematics* more centrally in the study programmes of many students. There is wider acceptance that mathematics skills are important amongst staff and students, which encourages some students to aim for a better qualification. In order to achieve this, colleges have had to make substantial internal changes and face on-going problems, especially with student attendance, engagement and staffing (Noyes & Dalby, 2020a). This has been costly to colleges, in terms of the resources, structures and change management needed.

Implementing strategies to ensure compliance with the condition of funding, in conjunction with attempts to improve measures of achievement and progress with mathematics, is demanding for colleges. The relative importance of achievement and progress, in a situation where colleges are their own mediators and interpreters of policy, leads to variation in the curriculum offer or progression pathways for students between colleges (Noyes & Dalby, 2020c). Some variation or flexibility may allow for colleges to meet different students' needs but it can also be the result of business-related decisions that may not be in the interests of students, particularly when the policy levers are related to funding.

There is also a weakness in the way current policy has not taken account of the impact on staffing, which in turn affects the quality of *teaching and learning*. Introducing a policy that required a large increase in the mathematics teaching workforce at a time of a national shortage, without adequate planning of how the workforce could be increased, has inevitably led to difficulties in recruiting and retaining good teachers. Although the emphasis on GCSE mathematics has caused colleges to seek more mathematics specialist teachers, these have been difficult to find. This has an effect on the quality and stability of a college teaching team. A lack of stability hinders the effectiveness of planned professional development strategies and makes it difficult to achieve a sustainable improvement in teaching and learning within a college. The Centres for Excellence in Mathematics will bring opportunities to develop evidence-based approaches but without a solution to the staffing shortage these may not have a sustained effect on the quality of teaching and learning.

Conclusions

Limitations of the current research literature and data

We have been fortunate to be able to draw on data and analysis from the MiFEC project but this is an ongoing project with emerging research outcomes, so there needs to be certain caveats attached to its use[6]. There is limited evidence or understanding, as yet, of how the revised GCSEs have impacted on GCSE retakes or how the new functional skills qualifications will affect curriculum decision making and students' progression pathways for mathematics in colleges from September 2019.

The existing literature reviewed for this paper is sometime inconsistent in its use of the term further education colleges (or FE colleges). This sometimes includes sixth form colleges, land-based and specialist colleges as well as GFECs but more often does not. Care has been needed when authors have not been clear in their use of the term. The distinctive issues presented here are mainly based on evidence from GFECs, but these are the largest providers of post-16 GCSE mathematics retakes and warrant closer focus than the small numbers in other colleges within the FE sector.

There are other very small-scale research studies, which we have not included here since their size substantially limits any possible generalisability of the findings.

[6] The MiFEC project was completed in 2020. Revisions in October 2021 include references to published MiFEC reports but do not include revisions to the actual content of this discussion paper.

Developing a framework for considering post-16 GCSE retake policy

The concept map (Figure 1) summarises the key influences on post-16 mathematics policy at a local level: the curriculum offer and student progress and attainment identified in the literature. The orange coloured boxes in the map identify the 'system-engine', the central dynamic of the system map. They make explicit the interrelations at play between policy decision, policy enactment and outcomes for the post-16 students who left school without a GCSE Mathematics qualification at grade 4 or above.

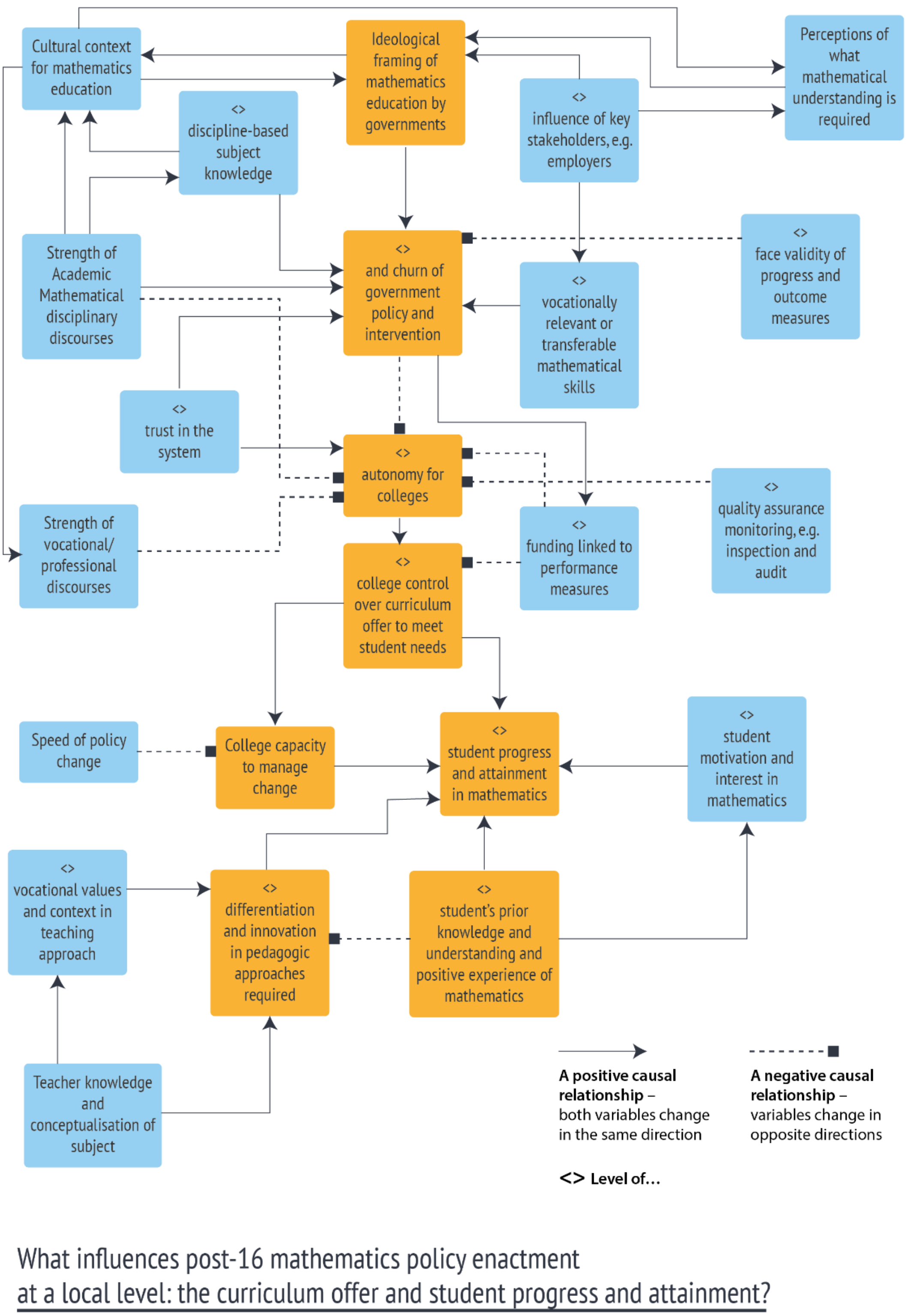

Figure 1: **What influences post-16 mathematics policy enactment at a local level?**

Within a system map causal relationships are visualised as positive or negative, using a series of arrows. A positive causal relationship is seen as one where both variables, or factors, increase or decrease in the same direction, i.e. an increase to variable **a** means an increase in variable **b**. A negative causal relationship is identified when the variables or factors change in different directions, i.e. an increase to variable **a** results in a decrease in variable **b**. The factor at the tail of the arrow has a causal effect on the factor at the point of the arrow (Smith & Hamer, 2019).

A positive causal relationship is visualised with a solid arrow ⟶

A negative causal relationship is visualised with a --------■ series of dashes and a square arrow head

Feedback loops are a characteristic of system maps. Reinforcing loops drive change, while balancing loops maintain the equilibrium within a system. While national policy and interventions may be intended to drive changes, for example, to enable, an increased number of students retaking GCSE to gain a grade 4. Funding regimes linked to progression targets may, as suggested in the literature, create a greater focus on students being entered for the GCSE examination to evidence a single grade progression, rather than focusing on attaining the grade 4 or above. The funding regime may therefore balance the system, with little or no change seen in GCSE attainment rather than driving through change.

Within the 'system' of post-16 mathematics, as seen at the top of the map, mathematics education is influenced by perceptions of what post-16 mathematics education is attempting to achieve, especially for the low-attaining students who do not achieve GCSE grade 4 in mathematics at age 16. There are several key stakeholders with interests in post-16 FE mathematics education but different fundamental values and visions of what the intending qualification aims and learning outcomes should be. Similarly, the curriculum offer is shaped by different conceptualisations, academic, vocational or hybrid, of what students are learning mathematics for.

Unless there is more agreement about the aim of low-attaining post-16 students learning mathematics, a post-16 mathematics policy needs to fulfil several purposes, some of which may be conflicting and not easily reconciled. For example, since the Wolf report (2011) GCSE mathematics has been seen as the 'gold standard' and is a 'gate-keeper' for many higher education courses and career pathways. The value of GCSE for gaining employment is also widely believed to be important, although not essential for employment in some skilled trades and services. The concerns of employers however tend to focus on the ability to use and apply basic mathematics.

Our analysis of the current situation in colleges shows however that the actual pathways and qualifications taken by students in FE colleges are not consistent across the sector and influenced by the relative importance to colleges of: the condition of funding, achievement rates and maths progress measures.

In summary, the following influences need consideration in any future policy development:

- The intention of the policy, in view of the differing values and visions for mathematics education held by stakeholders and the ideological framing of mathematics education and its purpose

- The type of curriculum that will best equip students for future educational and employment pathways and the workplace, and the form of assessment used

- The mathematics needs or deficits highlighted by different stakeholder groups

- The expectations of those with gate-keeping roles

- The level of autonomy afforded colleges to determine the curriculum offer for their students

- The mechanisms, such as the level of funding linked to performance measure that will affect how colleges respond to policy, including what curriculum and progression pathways are offered

- The level of trust in the system, including the face validity of assessments, which influences the level of government intervention in the system

- The speed of any policy change and colleges' capacity to manage change

- The diverse nature of the student cohort and their specific learning needs

- What is known about effective approaches and pedagogy to motivate students to engage with and value their mathematics learning

Four proposals were suggested in the 'Proposal for a task and finish project' for the ACME working group. An additional factor emerges from our analysis, which concerns the mechanisms used to drive the implementation of policy in colleges. The current situation in colleges is driven by the details within the condition of funding but also influenced by the importance of achievement rates and maths progress measures to colleges. Adjustments to any of these three elements may result in changes in the provision offered to students and progression pathways for mathematics. Changing the maths progress measure, or the relative importance of achievement and progress, could affect implementation of any of the first these alternatives. Appropriate levers need to be considered in conjunction with the intended policy

From our analysis, any alternative curriculum offered would also need to:

- be recognised and valued by both academic and vocational stakeholders

- achieve similar status to GCSE, including acceptance by key stakeholders such as employers and HE

- meet progression requirements but also act as a preparation for life and work

- have relevance and interest for students in order to overcome any previous negative experience of mathematics education.

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Appendix 1: maths progress measures

Points awarded	Grade achieved					
	Reformed GCSEs (9-1)	Legacy GCSEs (A*-G)	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				
1.7				L1 (D)		
1.5					L1 (pass)	
1	1	G				G
0.8				L1 (E)		
0.4			Entry Level	Entry Level	Entry Level	
0	Fail	Fail	Fail	Fail	Fail	Fail