Mathematics in England's Further Education colleges: who is teaching what, and why it matters.

Andrew Noyes , Diane Dalby, Yvonna Lavis

University of Nottingham

Professor Andrew Noyes (corresponding author)
Andrew.noyes@nottingham.ac.uk
University of Nottingham
School of Education
Jubilee Campus
Wollaton Road
Nottingham
NG8 1BB

Abstract

Improving mathematical skills is a priority in England and a series of policy levers and government change projects have focused on improving mathematics outcomes in further education (FE) in recent years. Yet little is known about the mathematics teacher workforce that supports these students on vocational and technical programmes. This paper addresses this knowledge gap by examining important features of the mathematics teacher workforce in colleges and the implications for recruitment, initial training and ongoing professional development. We report findings from a national survey targeted at all mathematics teachers in around one sixth (N=31) of England's general FE colleges. Teachers have transitioned into FE from three main areas: another career, curriculum area, or educational context. We discuss the varied assets and training needs of these three subgroups and argue that the mathematics teacher cohort in FE should be seen as distinct from that in either primary or secondary education. We highlight the bimodal distribution of mathematics qualifications amongst this workforce; those having level 2 mathematics qualifications being more likely to be teaching functional skills mathematics courses than GCSEs. The rapid expansion of the mathematics teacher workforce that followed the changes to the condition of funding in 2014 has come disproportionately from teachers who previously working in schools. This, together with a trend of funnelling increasing numbers of FE students into academic mathematics rather than functional skills courses, raises important questions about the nature of mathematical education for learners on vocational and technical programmes, and the teachers thereof.

Keywords

Mathematics, further education, teachers, recruitment, training, CPD

Introduction

Further education colleges in England offer a range of vocational and academic programmes for post-16 students and are the main providers of vocational pathways for 16–18-year-olds. The training routes and qualifications required for those who teach in further education have changed over time. There have been some controversial attempts at regulation (Lucas, 2007; Lucas, Nasta, & Rogers, 2012) but these ceased following the Lingfield Report (BIS, 2012). Similarly, there have been regular changes in the purpose and nature of vocational qualifications, and of mathematics qualifications for vocational learners (Dalby & Noyes, 2020, 2022). Such changes have impacted on the work of those teaching mathematics qualifications in the FE sector and this paper focuses on those teachers. Those qualifications currently encompasses some advanced level qualifications (e.g. A level, Core Maths) but are mainly lower level qualifications (e.g. GCSE, functional skills mathematics), although it should also be noted that mathematics is also taught in embedded forms by vocational and academic staff.

In 2014, the government introduced a new condition of funding (CoF) for England's further education (FE) sector, which required all 16–18-year-old students who have not achieved a 'good pass' (i.e. at least a grade 4) in GCSE Mathematics to continue studying the subject. Around one third of the annual cohort achieve such lower grades in GCSE at age 16 and typically progress to vocational education and training in the FE sector. The CoF resulted in a sharp increase in the number of FE students being required to retake GCSE mathematics (Noyes, Dalby, & Smith, 2020a). As well as producing increased demand for mathematics teachers, the policy also led to GCSE becoming the dominant qualification in FE colleges that the expanding workforce would need to teach. Against a backdrop of longstanding shortages in the supply of mathematics teachers generally, it is not surprising that the FE sector has continued to experience particular recruitment challenges (Greatbatch & Tate, 2018; Kyffin, Hodgen, & Tomei, 2013) and has had to make significant changes to the organisation of their mathematics provision as a result of the policy (Dalby & Noyes, 2016; Dalby & Noyes, 2018, 2020; Noyes & Dalby, 2020b).

Given that numeracy skills levels in England fall behind other nations (BIS, 2013; OECD, 2016) and that raising the level of skills has been a policy priority for some time (BEIS, 2017; Moser, 1999; Smith, 2004, 2017), it is imperative that the FE sector attracts a highly competent and well-qualified mathematics teaching workforce. Yet beyond estimates of the number of mathematics teachers in the FE sector in England, which vary considerably, little is known about the mathematics teacher workforce because of the lack of high-quality data. This point was well made in the Treasury-commissioned report on post-16 mathematics (Smith, 2017) with the following recommendation: "The Department for Education should improve the evidence base on the FE workforce teaching mathematics and quantitative skills in order to assess supply, teaching quality and the effectiveness of current recruitment measures.” (Recommendation 7)

Such improved understanding would help to ensure an adequate and ongoing supply of appropriately qualified mathematics teachers in England’s FE sector by informing strategies for recruitment, initial training and continuing professional development that are specifically applicable to the FE workforce (Noyes & Dalby, 2020b). To this end, key stakeholders need to understand not only numbers and training needs, but also important attributes of this workforce including their prior experiences and training, career trajectories, and their roles and responsibilities within institutions. It is also important to appreciate the ways in which this workforce differs from that in secondary schools and the distinctive nature of student learning in FE. For example, with GCSE retake being the dominant qualification, mathematics teachers are normally teaching those with weaker skills, who typically have negative experiences of mathematics learning from school and insecure foundations. Furthermore, the students’ main aim is typically a vocational career and so mathematics courses are an unwelcome addition. The ability to motivate, engage and support low-attaining young adults to move forward with mathematics is, therefore, an important attribute for FE mathematics teachers (Noyes & Dalby, 2020a).

The main source of data available on the FE workforce is the annual survey that forms the Staff Individualised Record (SIR). However, as reported in an earlier Gatsby-funded survey (Hayward & Homer, 2015), “The data are insufficiently granular to provide policy-makers with an evidence base on which they can anticipate and implement necessary interventions to ensure a future post-16 mathematics teaching workforce”. The Gatsby survey had low response rates (100 of 186 were from FE colleges) and these were scattered across 65 FE colleges which limited the generalisability and usefulness of the research. Earlier analysis by the Education and Training Foundation (ETF, 2014) which focused on teachers’ qualifications was based upon two surveys, one a Training Needs Analysis of those involved in GCSE Mathematics (157 respondents from FE colleges) and the other a Strategic Consultation Survey of mathematics and English teachers in the college sector (149 respondents). These too are relatively small and limited in scope. As we explain herein, the composition and training needs of the workforce has changed in any case so these studies need updating.

Hayward and Homer estimated (in 2015) that “the mathematics workforce in English FE colleges is…approximately 830 full-time and 720 part-time mathematics teachers, and 920 full-time and 850 part-time numeracy teachers” (p. 5). Later DfE-funded analysis in 2018 (Thornton, Hingley, Edwards-Hughes, Boniface, & Wilson, 2018) had very little to say about the nature of the mathematics workforce but estimated that there were 2240 teachers in the area of mathematics. The situation is far from clear, and who and what is being included is sometimes ambiguous.

The national survey that informs this paper presents the most recent representative data and analysis available on the FE mathematics teacher workforce in England. Furthermore, it goes beyond numbers, qualifications and training needs to try and understand the composition of the workforce, the impact of recent policy and what all of this means for vocationally-relevant mathematics education in FE. The survey was conducted as one strand of a larger Nuffield-funded project that explored 'Mathematics in Further Education Colleges'[1].

This paper analyses the flow of teachers into FE colleges from different backgrounds, considers how the 2014 condition of funding might have differentially changed these flows and what this means for the mathematics learning of vocational students. We examine the career histories and experiences of teachers who have entered the FE mathematics teacher workforce via different routes and investigate how these affect their employment and deployment within colleges. In particular we are interested whether different subgroups of the teacher workforce are teaching different kinds of qualifications (e.g. GCSE Mathematics vs Functional Skills mathematics). Understanding where these teachers come from, how colleges capitalise on their skills (including what they teach), and their future aspirations is important for recruitment, training, and retention strategies as well as for the mathematical education of vocational learners.

Beyond matters of workforce management, however, there is a qualitatively different issue that needs consideration and this has to do with the nature of the mathematics being taught and the needs of these vocational students (FitzSimons, 2002). So, following analysis of the survey findings we discuss what the compositional changes in the workforce mean for mathematics learning of vocational students in England's FE sector.

Methodology

Sampling

The sample of respondents for the survey consisted of all of the teachers of mathematics in 31 general Further Education providers (i.e. FE colleges or college groups) across England, who were teaching mathematics in the academic year 2017/18 on courses that led to a mathematics qualification (all age groups and levels). Sixth Form Colleges (SFCs) and other smaller and specialist Further Education providers were excluded, the former as these generally cater for a different category of student, i.e. those on academic programmes of study. At the beginning of the project (September 2017), there were 187 such general FE providers in England though this number changes regularly due to college merging and restructuring. The sample of providers included in the survey amounts to around one sixth of such colleges in England.

[1] The Mathematics in Further Education Colleges project - www.nottingham.ac.uk/research/groups/crme/projects/mifec/index.aspx

The survey design aimed to produce a stratified sample of colleges, and clustering of teachers, according to geographical region that also balanced a number of key criteria: size (number of 16-18-year-old students); type of provision (vocational only vs academic and vocational); location (e.g. *urban major* or *minor conurbation*); mathematics progress measure[2] and most recent Ofsted grade. The goal was for the sample to be broadly representative on characteristics that affect the operation of FE colleges and indicate effectiveness.

Managers in the participating colleges completed staff audit forms prior to the circulation of the survey. These provided high-level summary information about the approximate total number of mathematics teachers that should be engaged in the survey along with their type of employment. Due to the complexity and constantly changing workforce, and the period of a few months over which these forms were returned, the 'snapshot' data from these forms were not expected to remain fully accurate. However, they allowed the research team to estimate the response rate and undertake a qualitative assessment of the extent to which the survey responses represented the population of mathematics teachers in the sample colleges.

Survey design and distribution

The survey aimed to build understanding of the mathematics teacher workforce in FE colleges, in particular teachers' routes into the profession and their roles within colleges. To this end, it included items on general demographic information (e.g. age, gender), previous employment, current roles and responsibilities, job satisfaction, and expected employment plans. A pilot version of the survey was developed and distributed to a small number of staff in colleges who were not included in the main sample. The results of the pilot prompted some minor changes to enhance the clarity and readability of the survey, and some alterations to response categories. Although the survey was anonymous, participants were invited to include their initials so that we could cross-check responses against the similarly initialled teacher audit (see above) and estimate response rates and significant missingness (e.g. from part-time teachers). They were also invited to opt into any future linking of their survey response with any later involvement in the project (e.g. interviews as part of case study visits). The survey was expected to take around 10 minutes to complete.

Colleges were able to choose between an electronic or paper version of the survey. These two versions were effectively identical, except for the use of display logic in the online version to restrict the presentation of certain questions based on previous responses. Eight colleges requested the paper version and the remaining 23 completed the online version. In order to

[2] The Mathematics Progress Measure is the means by which the DfE analyses the cohort progress in mathematics. All qualifications have a score and the progress measure is the aggregation of all students in the college.

maximize response rates, managers were asked to set aside time in a meeting for teachers to complete the survey, and teachers were asked not to confer over their responses.

For colleges that opted for the paper version, the required number of (consecutively numbered) paper copies were sent to the college contact, along with individual envelopes for each survey, and a reply-paid, return-addressed envelope. To maintain respondent confidentiality, it was suggested that an independent staff member (i.e. not a manager) be nominated to administer and collect the completed surveys. Respondents were asked to seal their completed surveys into their individual envelope before handing it to the nominated staff member. The college contact was then tasked with securing and returning the completed surveys in return-addressed envelopes. For colleges that requested the online survey, an email with the survey link was sent to the college contact, who then forwarded it to eligible teachers.

There were 480 responses to the survey, which (based on the completed staff audit forms) constituted an estimated response rate of just over 60%. Comparison of the staff audit data and the survey data, in terms of the distribution of employment type, suggest that the final sample of respondents was broadly representative of the population of mathematics teachers in the 31 colleges.

Analysis

Routes into Teaching Mathematics

To understand the entry routes into teaching mathematics in these FE colleges, respondents were asked to identify their main occupation immediately prior to teaching mathematics in FE. The question was a single-response, multiple-choice question with nine possible options, including *Other*. The *Other* option was linked to a mandatory free-text box. Analysis of the free text responses for the category *Other* led to some redistribution of responses into existing categories, and two additional categories of interest were identified. These categories were 'Teaching another subject elsewhere' and 'Learning support'. Figure 1 shows the response pattern over the original and additional categories.

The wide distribution of respondents over a large number of categories reflects the heterogeneity of the workforce in further education. Only 10% of the FE mathematics teachers in the sample selected full time study as their main activity immediately prior to teaching. Compared to the school teacher workforce, for which the majority undertake full-time teacher training (and often an undergraduate degree) immediately prior to joining the profession, this number seems particularly low.

The majority of respondents began teaching mathematics following other careers. Two thirds of the respondents were spread fairly evenly across three main routes into the FE mathematics workforce. These are: careers outside of education (24%); teaching mathematics in school or elsewhere outside of FE (23%); and teaching other subjects in FE (19%). Teachers in these three groups are dissimilar in terms of their skills, experience and training needs, so some of the analysis below considers each characteristic in terms of these categories. For example, if teaching mathematics for vocational learners requires a mixture of general pedagogic skills, mathematics-specific pedagogic skills, and knowledge of vocational applications, these three groups can reasonably be assumed to start with broadly different 'assets' (and deficits) as new FE teachers.

Insert Figure 1 here

Length of service as an FE mathematics teacher

The flow of teachers into the FE workforce was examined by considering length of service. The survey did not include a question that asked directly about how long respondents had been teaching mathematics in FE. However, it did include two separate questions about how long they had been teaching in FE and how long they had been teaching maths. The time since entry into teaching maths in FE was taken to be whichever of these two time periods was the shortest.

Insert Figure 2 here

Figure 2 shows the time since entry for the entire sample. Although the data might appear normally distributed according to the five response categories provided, it is worth noting that the responses representing longer tenure in FE maths cover greater time periods. In 2018, over 20% of respondents had been teaching mathematics for less than 3 years, which reflects the recent influx into mathematics teaching and is consistent with the increase in demand for teachers following the introduction of the 2014 condition of funding.

Insert Figure 3 here

To compare the three main entry routes by length of service as teachers of maths in FE, the five time categories were collapsed into three: *less than 3 years*, *at least 3 but less than 10*, and *10 or more*. Figure 3 shows the distribution of respondents according to length of service for the three main entry routes. This indicates that those that came from teaching mathematics outside FE tended to have shorter service, with 35% of them having taught maths in FE for less than three years (compared to 22% and 17% for the groups from another subject in FE and from outside education, respectively). Those who came from outside of education had the longest service, overall, with 42% of them having taught maths in FE for at least 10 years (compared to 27% and 28% of the groups from another subject in FE and from maths outside of FE, respectively). This suggests that the recent expansion in the FE mathematics teaching workforce has been disproportionately made up of existing mathematics teachers from schools (and elsewhere). It is not inconceivable that these teachers, which if scaled up for the sector as a whole would number a few hundred, have come from the secondary school sector. This drift towards an increasing proportion of the workforce being career mathematics teachers reflects the changing place of mathematics in the post-16 FE curriculum, a point to which we will return in the discussion below.

Another way of looking at this data is to note that of those newcomers to mathematics teaching in the three years prior to the survey only around half are experienced teachers of mathematics; the other half are made up equally of experienced teachers from elsewhere in the FE sector and people from outside education altogether. So the expanded workforce resulting from recent policy moves comprises a significant number of inexperienced teachers of mathematics. Whatever the background of these newcomers there is an impact on supply elsewhere, or on the initial training and development needs of the teachers. It might be, however, that these different teacher groups are focused on different kinds of post-16 mathematics qualifications and we consider this below.

How teachers are deployed

To investigate how teachers of mathematics are deployed within colleges, respondents were asked about their employment contracts and the courses on which they had contact hours. Figure 4 shows the distribution of respondents across each of the nine employment contract categories. Nearly two thirds (63%) of respondents were teaching only maths. Most of the rest of the workforce consists of either vocational (or other subject) staff who were teaching mathematics as part of their workload (16%) or others who teach mainly mathematics but also another subject (10%).

Insert Figure 4 here

To investigate whether the type of teaching contract differed according to the entry route, main employment was collapsed into five categories: 1) only maths, 2) mainly maths, 3) vocational, 4) hourly/agency, and 5) managers. Figure 5 shows the distribution of participants across these categories. The vast majority (81%) of the teachers of mathematics in the sample that come from outside of FE are teaching only mathematics, with very small numbers distributed across the other categories. In contrast, only 43% of those from another subject in FE are teaching only maths. Another 37% of them are mainly teaching vocational or other subjects, but also teaching some mathematics. The patterns for those from outside of education resemble those for the mathematics teachers from outside of FE, with the majority of them (70%) teaching only mathematics. However, there are greater numbers distributed across the 'Mainly maths' and 'Vocational' categories.

Insert Figure 5 here

Respondents were asked to state the number of contact hours they spent on each of the six categories of mathematics provision: Functional Skills Mathematics, Core Maths, GCSE

Mathematics, AS/A Level Mathematics, Mathematics Workshops, and Other Mathematics. *Figure 6* shows the number of teachers who reported any contact hours for each of these six categories.

Insert Figure 6 here

Around two thirds of respondents reported teaching functional skills mathematics (65%) and/or GCSE Mathematics (63%), which reflects the focus on provision at Level 2 and below since the introduction of the condition of funding. Level 3 mathematics teaching is not common in this sample (4% Core Maths and 7% AS/A level, no doubt with some overlap between these).

Figure 7 shows the percentage of respondents teaching GCSE only, functional fkills only, both, or neither: 91.3% of respondents teach at least one of these two qualifications. When the sample is considered overall, teachers are roughly evenly split between GCSE only (28%), functional skills only (31%), or both (32%). [For a discussion of the positioning and history of functional skills mathematics see Dalby and Noyes (Dalby & Noyes, 2020)]

Insert Figure 7 here

However, a different picture emerges when teachers are considered according to their routes into FE maths teaching (see Figure 8). 83% percent of teachers with a background teaching mathematics outside of FE taught GCSE maths only, or both GCSE and functional skills, while only 10% taught functional skills only. In contrast, a slight majority of the teachers coming from another subject in FE (54%) taught functional skills only. Teachers coming from outside of education had a roughly even split, with 32% teaching functional skills only, 30% teaching GCSE only, and 35% teaching both. This reflects the patterns of the sample overall. This allocation of mathematics specialists and FE specialists to GCSE and functional skills respectively suggest different ways of thinking about these qualifications and the teaching needed for success. As colleges have drifted towards entering more of their learners with low prior GCSE grades (i.e. <4) for GCSE rather than functional skills (Noyes, Dalby, & Smith, 2020b) this suggests more of the teachers who would traditionally not have taught GCSE will now find themselves doing so. The survey found that many of those teaching mathematics only had formal mathematics qualifications to level 2. This is in contrast with the secondary teacher population in which 99% hold a degree or higher[3] (also see Figure 9).

Insert Figure 8 here

Insert Figure 9 here

[3] The DfE report that of 34681 mathematics teachers in state-funded secondary education, 78.3% hold “any relevant post A level qualification” and 21.7% do not

Gender

Finally, we consider some key demographic variables. Respondents were asked to indicate their gender by selecting one of four options: 'Male', 'Female', 'Neither of these' and 'Prefer not to answer'. There are more females (53%) than males (40%), which is consistent with existing data on the FE maths and numeracy workforce (Homer and Hayward, 2015; ETF, 2018).

Age

Respondents were asked to indicate their age by selecting one of ten age groups ranging from *Under 25* to *Over 65*. *Figure 10* shows the distribution of respondents across age groups. The graph shows that most of the FE maths teachers surveyed (48%) were between 45 and 59 years of age[4]. This skew towards the older end of the distribution is consistent with the finding that most of the sample came to FE via previous careers.

Insert Figure 10 here

Before investigating whether age differed according to the route into teaching mathematics in FE, the age data were collapsed into four bins. The purpose of this was to simplify analysis and interpretation. The tail ends of the distribution were collapsed into a younger group (below 35) and an older group (55 and over), and the middle of the distribution was split into two further groups (35 – 44 and 45 – 54).

Figure 11 shows the age distribution for the three main routes in. The data indicate that those with a previous career teaching mathematics outside of FE had the greatest proportion of the youngest people, and that those coming from outside of education had the greatest proportion of the oldest people. Those coming from teaching other subjects within FE tended to be clustered towards the middle, with relatively small numbers of young and old. These differences might suggest that those who initially teach mathematics elsewhere have transitioned reasonably quickly into FE, while those teaching outside education spend time retraining first.

Insert Figure 11 here

The mathematics teachers are also younger, but this is makes sense in terms of the length of tenure. 40% of those from outside of FE have been teaching maths in FE for more than 10 years, as well as having had a previous career. They have to be older.

Discussion

These findings raise a number of important issues that we discuss in turn.

---

[4] Less than a quarter of secondary classroom teachers (24.7%) are in the age range 45-59, considerably younger that this sample of FE teachers of mathematics.

A 3rd mathematics teacher workforce

The first key point is that the mathematics teacher workforce in FE should be understood as different from that in primary and secondary education, albeit with some overlap with the latter. This is a subtle but important point. It is well understood that the mathematics teaching workforce in generalist primary education and secondary education are distinctive, with different training and development needs. That distinction is smoothed to an extent by the continuity of the (national) curriculum between primary and secondary schools and a focus on traditional knowledge domains in both phases. The FE mathematics teacher workforce is different in composition, as we explore further below, but there are also significant secondary-FE discontinuities in the learning aims of vocational programmes of study and in the culture and general aims of further education. Recent policy on post-16 mathematics education (e.g. the condition of funding) appears to not only have omitted to consider the capacity of this workforce (i.e. teacher numbers) but also failed to take proper account of the composition, competencies and commitments of this group of teachers. A major government investment - Centres for Excellence in Mathematics (DfE, 2018) - is aiming to improve mathematics education practice for these students in FE but that change programme lacks a clear vision for workforce development. Such a vision needs to start with recognising the distinctiveness of the FE mathematics teacher workforce.

Diverse entry routes

The distinctiveness of the FE mathematics teacher workforce is produced in part by the diverse entry routes, each associated with their own profile of skills and experience. These profiles differ from those typically found in the secondary school mathematics workforce, who tend to enter teaching as a first career, with a mathematically-related degree and mathematics-specific pre-service teacher education. One of the reasons for those specific conditions in secondary teaching is that teachers focus on teaching one (national curriculum) subject, but there is also a heavy focus on content knowledge and very little cross-curricular learning or collaboration. Our analysis of teachers of mathematics in FE identifies three main routes into teaching:

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

Teachers on each of these pathways come with particular assets as well as training needs. Together they comprise a rich blend of knowledge, skills and expertise, well suited to the learning needs and employment goals of vocational students. However, this does need to be conceived of as mixed *assets*, rather than seeing those without the disciplinary and pedagogical training of typical secondary mathematics teachers as somehow in *deficit*. This blending of expertise and knowledge also relates to the purposes of mathematics education in vocational contexts which raises questions of curricular purpose that we return to below.

This blend of assets is important when one considers that vocational students in FE colleges follow a single study programme of their own choosing with the notable exception that many are now required to continue mathematics (and/or English), a subject that they failed to master through eleven years of schooling and which is arguably not well designed for their learning needs. These vocational students need to benefit from a) understanding of the kinds of vocational futures they face b) expertise on vocational education and the challenges facing many in the 'forgotten third' (ASCL, 2019) and c) knowledge of mathematics and mathematics pedagogy. Whilst we are not saying that there is a 1-1 correspondence between the teacher entry pathways and the contributions made, the key point is that this diversity is entirely appropriate for this cohort of students, if recognised and managed appropriately, and if the mathematics learning aims align with the more general learning aims of the vocational programme. Professional learning communities that are skilfully coordinated so as to cross-fertilise those varied expertise and knowledge are needed. In fact, the data above shows an uneven distribution of these skills between GCSE and Functional Skills mathematics, with the increasingly dominant GCSE pathways being predominantly taught by the group with the least understanding of FE and vocational curriculum and pedagogy.

Teachers' positions and transitions

The positioning of mathematics can be quite different in colleges from in schools; not 1 of 10 independent subjects but an addition, either integrated or bolted-on, to a major programme of vocational learning. Where colleges do try to integrate mathematical or quantitative skills learning into vocational programmes, the embedding and contextualising of mathematics is a marked departure from typical secondary mathematics education. Accordingly, the arrangements for teaching vary considerably by college as a result of particular contextual constraints and educational values, from a centralised approached (which does resemble secondary school departments) with teachers clustered in a specific place, to dispersed approaches with mathematics teachers being specialists in a vocational team (Noyes & Dalby, 2020b). Not only are varied training needs contingent upon teacher histories, but also on the different kinds of curricula arrangements that can be found in colleges.

Notwithstanding the different contexts into which the growing teacher workforce has been recruited, their different routes into teaching mathematics in FE calls for different emphases in their initial training and ongoing professional development. Even for those experienced teachers moving from secondary school, some form of 'transition training' would ensure successful conversion into this quite different context and concentration of low attaining students, and a better sense of pathways to employment and the skills needs to navigate that transition successfully. Subject knowledge enhancement programmes exist but bias the required learning need to mathematics alone, not vocational knowledge or skills in motivation and engagement of disenfranchised learners. Yet there is little clear guidance or regulation for colleges on supporting these transitions and identifying/meeting the training needs of new teachers. There is a need for better, sector wide training needs analysis tools. This is a surprising omission when there is a national push for FE colleges to take up the challenge of improving the quantitative skills base. Given the independence of colleges since 'incorporation' nearly 30 years ago, there is little commonality of approach.

Changing workforce composition

The patterns in the data suggest that with the greater demands on colleges to recruit more mathematics teachers in a time of shortage, coupled with increased teaching of GCSE resit classes, disproportionate numbers of mathematics 'specialists' have been appointed in recent years. The qualification levels of new teachers, and their deployment towards more GCSE than functional skills reflects another instance of academic drift (Dalby & Noyes, 2020), reinforcing the academic vocational divide which has plagued tertiary education in England for too long. This raises questions about how well aligned these specialists are with the vocational mission of the FE sector, and how effectively they are prepared to work alongside vocational specialists to contextualise and embed mathematics in study programmes. Interestingly, 40% of those teachers in the survey coming from teaching mathematics elsewhere (and who held maths degrees) thought that knowledge of vocational learning/programmes was of little or no relevance to their teaching of these vocational students.

Aims for mathematics learning in FE

This change in the balance of the workforce reflects the shifting place of mathematics in the post-16 curriculum. But what does this mean for the learning of mathematics in vocational programmes? Who should be teaching mathematics for vocational learners? Should mathematics learning be stand-alone or integrated? If the goal is merely increased passing of GCSE (at grade 4 and above) the approach seems acceptable, and presently this narrow education goal does seem to be holding sway. If, however, the goal is to improve young people's mathematical capabilities for life and work, a different kind of thinking might be needed, and it might be closer to the holistic, student-centred ideals of primary education than the knowledge-based curriculum championed by recent education ministers and that is maintained in the knowledge silos of secondary school curricula.

FitzSimons (2014) has explored this conundrum from an Australian perspective. For her, "vocational mathematics education encompasses preparation for, or continuing education in, mathematical facets of recognised skilled work, ranging from narrowly specified jobs to broader clusters of occupations to recognised professions" (p. 292). Framed by Bernstein's ideas, she continues:

> The question of who will teach vocational mathematics…has been debated over many years across the institutional spectrum. There are arguments for staff specialising in the vertical

> discourse of mathematics and mathematics education on the grounds that they are more suitably qualified in theoretical mathematics and have expertise in specific pedagogical aspects such as pedagogical content knowledge. However, there are likely to be problems if mathematics specialists have no relevant industrial experience nor make any serious effort to comprehend the specific contexts, applications, and problems that students may be confronted with during their studies or after graduation (i.e., the horizontal discourse). On the other hand, teaching staff with relevant trade or professional experience are likely to have extensive contextual experience but limited mathematics subject matter knowledge and pedagogical content knowledge. They may be unable to comprehend mathematical learning difficulties and be limited in their mathematical pedagogic repertoire (p. 299)

This reflects the earlier point about 3-fold assets in England's FE mathematics teacher workforce (workplace expertise; vocational education expertise; mathematics education expertise). This raises interesting policy questions about what mathematics teaching in FE is for and this debate needs to be had to inform the development of further education and skills policy. If what matters is repeating the 'gold standard' GCSE, whether it provides useful mathematical competence or not, the drift seems to be moving in the right direction. If, however, the aim of teaching mathematics on vocational programmes is to increase the capability of future workers to confidently apply mathematical ideas in vocationally-relevant contexts, the present drift seems to be going in the wrong direction, both in terms of the favoured GCSE qualification but also in how it is skewing the workforce. There could be merit in adopting more widely the framework of General Mathematical Competences[5] that has been embedded into the new T-level qualifications but this would need new qualification pathways and a significant workforce retraining programme.

Acknowledgements

The Mathematics in Further Education project was generously supported by the Nuffield Foundation, Grant reference number EDO/42854. The Nuffield Foundation is an independent charitable trust with a mission to advance social well-being. It funds research that informs social policy, primarily in Education, Welfare, and Justice. It also funds student programmes that provide opportunities for young people to develop skills in quantitative and scientific methods. The Nuffield Foundation is the founder and co-funder of the Nuffield Council on Bioethics and the Ada Lovelace Institute. Whilst the Foundation has funded this project, the views expressed are those of the authors and not necessarily the Foundation. Visit www.nuffieldfoundation.org

[5] https://royalsociety.org/~/media/policy/topics/education-skills/Maths/Mathematics%20for%20the%20T%20Level%20Qualifications%20-%20a%20rationale%20for%20GMCs.pdf

References

ASCL. (2019). *The Forgotten Third: final report of the commission of inquiry*. Retrieved from Oxford:

BEIS. (2017). *Industrial Strategy: building a Britain fit for the future*. London: HMSO

BIS. (2012). *Professionalism in Further Education*. Retrieved from London:

BIS. (2013). *The International Survey of Adult Skills 2012: Adult literacy, numeracy and problem solving skills in England*. London: BIS Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/246534/bis-13-1221-international-survey-of-adult-skills-2012.pdf

Dalby, D., & Noyes, A. (2016). Locating mathematics within post-16 vocational education in England. *Journal of Vocational Education & Training, 68*(1), 70-86.

Dalby, D., & Noyes, A. (2018). Mathematics education policy enactment in England's Further Education colleges. *Journal of Vocational Education & Training, 70*(4), 564-580. doi:10.1080/13636820.2018.1462245

Dalby, D., & Noyes, A. (2020). The waxing and waning of functional skills mathematics. *Journal of Vocational Education & Training*, 1-20. doi:10.1080/13636820.2020.1772856

Dalby, D., & Noyes, A. (2022). Mathematics curriculum waves within vocational education. *Oxford Review of Education, 48*(2), 166-183. doi:10.1080/03054985.2021.1940913

DfE. (2018). *Centres for Excellence Programme*. Londond Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/712441/Guidance_for_Centres_for_Excellence_Application_Process.pdf

ETF. (2014). *The Qualifications of English and maths teachers*. Retrieved from London: www.et-foundation.co.uk/wp-content/uploads/2014/09/RPT-Survey-v4.pdf

FitzSimons, G. (2002). *What counts as mathematics?: technologies of power in adult and vocational education*. Dordrecht: Kluwer Academic.

FitzSimons, G. (2014). Commentary on vocational mathematics education: where mathematics education confronts the realities of people's work. *Educational Studies in Mathematics, 86*(2), 291-305. doi:10.1007/s10649-014-9556-0

Greatbatch, D., & Tate, S. (2018). Teaching, leadership and governance in Further Education. In: Government Social Research.

Hayward, G., & Homer, M. S. (2015). *Profile of the mathematics teaching workforce in the college sector in England*. London: The Gatsby Charitable Foundation.

Kyffin, H., Hodgen, J., & Tomei, A. (2013). *The Supply of Mathematics Teachers in the Further Education Sector*. Retrieved from London:

Lucas, N. (2007). Rethinking Initial Teacher Education for Further Education Teachers: From a standards-led to a knowledge-based approach. *Teaching Education, 18*(2), 93-106.

Lucas, N., Nasta, T., & Rogers, L. (2012). From fragmentation to chaos? The regulation of initial teacher training in further education. *British Educational Research Journal, 38*(4), 677-695.

Moser, C. (1999). *Improving Literacy and Numeracy: A Fresh Start*. London: Department for Education and Employment.

Noyes, A., & Dalby, D. (2020a). *Mathematics in England's Further Education Colleges: an analysis of policy enactment and practice*. Retrieved from https://www.nottingham.ac.uk/research/groups/crme/documents/mifec/interim-report-2.pdf

Noyes, A., & Dalby, D. (2020b). *Mathematics in Further Education colleges: final report*. Retrieved from https://www.nottingham.ac.uk/research/groups/crme/documents/mifec/final-report.pdf

Noyes, A., Dalby, D., & Smith, R. (2020a). *Mathematics in further education: student progress over time*. Retrieved from https://www.nottingham.ac.uk/research/groups/crme/documents/mifec/interim-report-4.pdf

Noyes, A., Dalby, D., & Smith, R. (2020b). *Mathematics in further education: student progress over time* Retrieved from https://www.nottingham.ac.uk/research/groups/crme/documents/mifec/interim-report-4.pdf

OECD. (2016). *Skills Matter: further results from the survey of adult skills*.
Smith, A. (2004). *Making Mathematics Count*. Retrieved from London:
Smith, A. (2017). Report of Professor Sir Adrian Smith's review of post-16 mathematics. *London: DfE*.
Thornton, A., Hingley, S., Edwards-Hughes, E., Boniface, R., & Wilson, G. (2018). *College staff survey 2018: research report*. Retrieved from

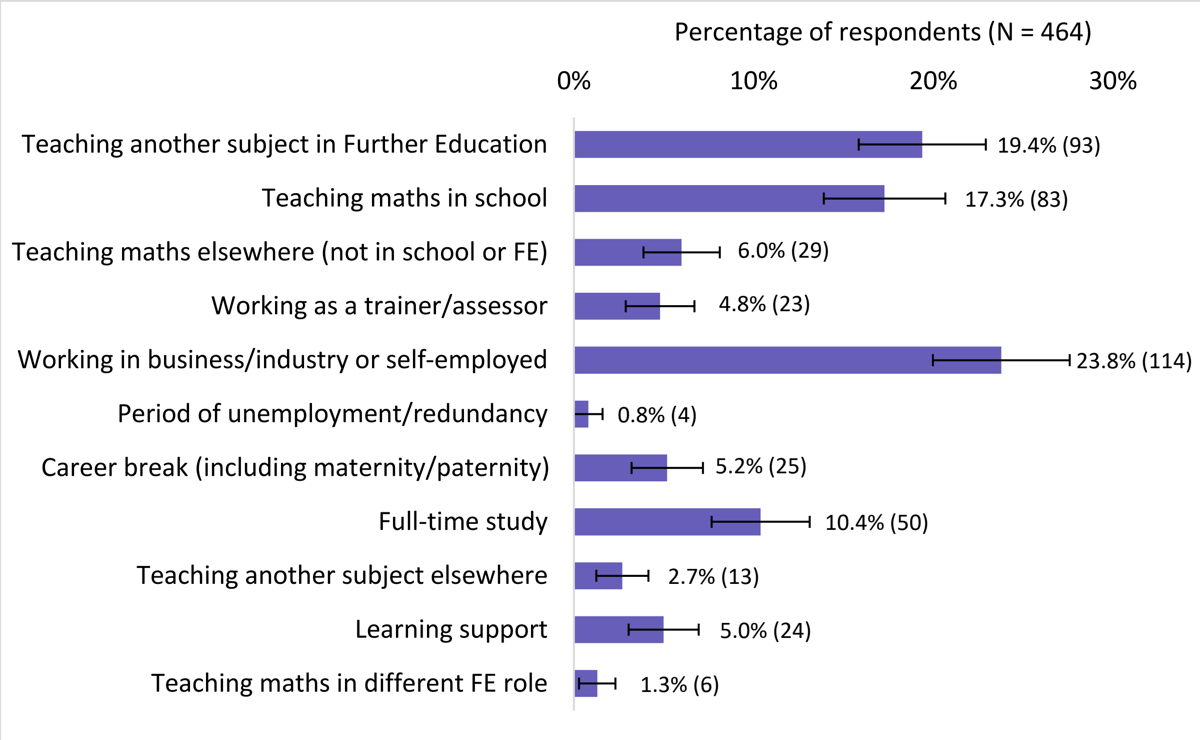

Figure 1: The percentage of respondents who fell into each previous employment category, either by self-selection, or by redistribution from the 'Other' category. Error bars show 95% confidence intervals for the percentages.

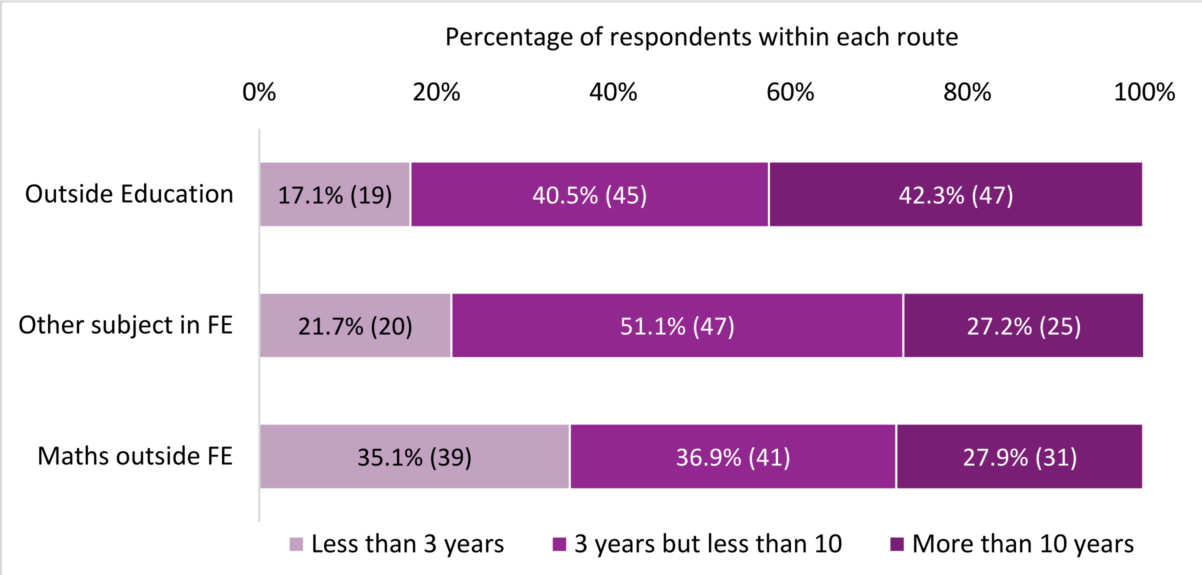

Figure 3: Time since entry into teaching maths in FE for each of the three routes in.

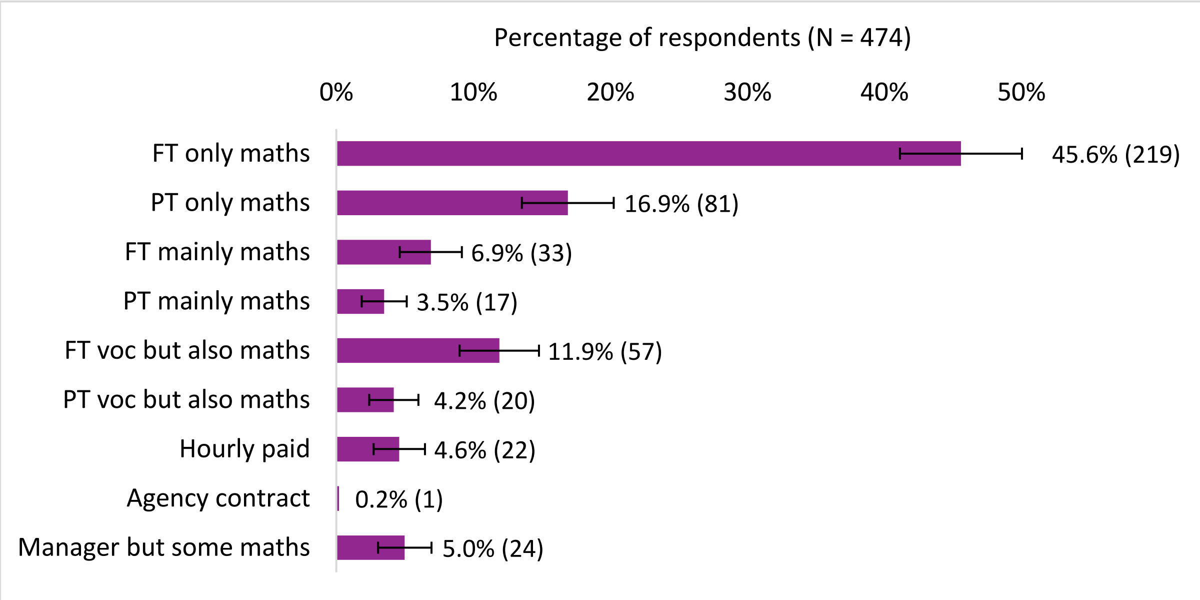

Figure 4: Percentage of respondents in each of the nine employment categories displayed in the survey. Error bars show the 95% confidence intervals of the percentages.

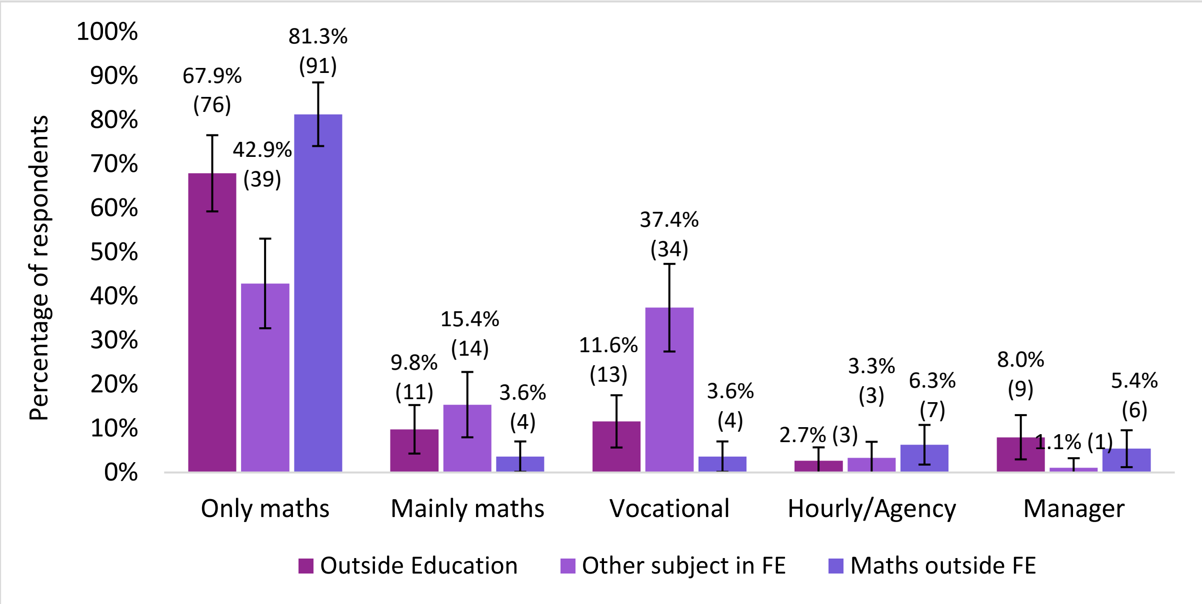

Figure 5: Distribution of respondents over the 5 binned employment categories within each of the three main routes into teaching maths in FE

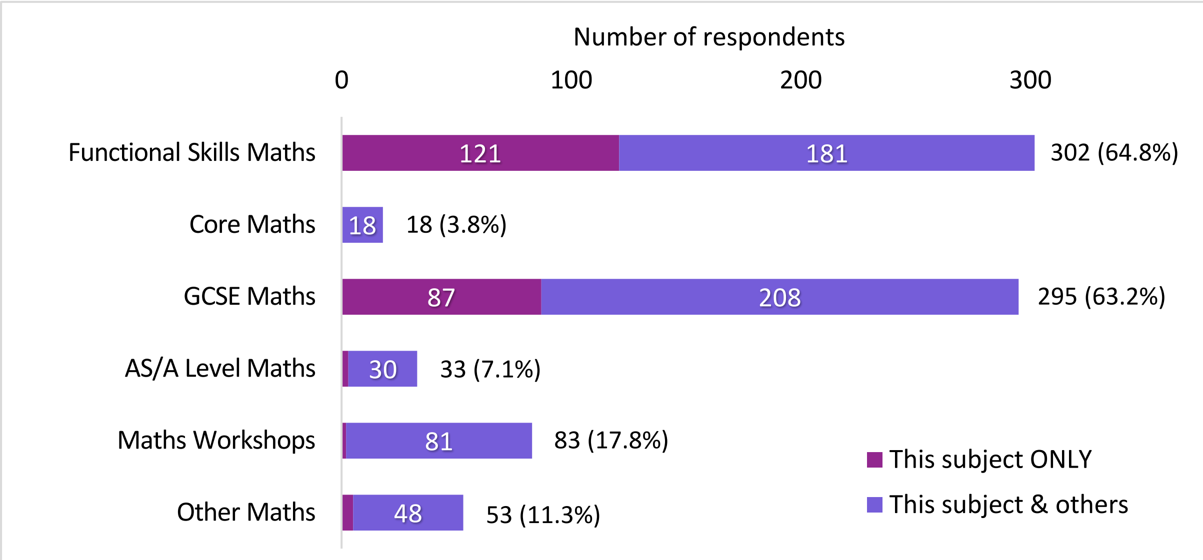

Figure 6: Number of respondents reporting any contact hours for each of the six categories of mathematics provision. For each category, this is divided into people who teach only that mathematics subject, and people who teach at least one of the other mathematics subjects as well as the subject stated. The numbers to the right of each bar show the total number and percentage of respondents teaching that subject.

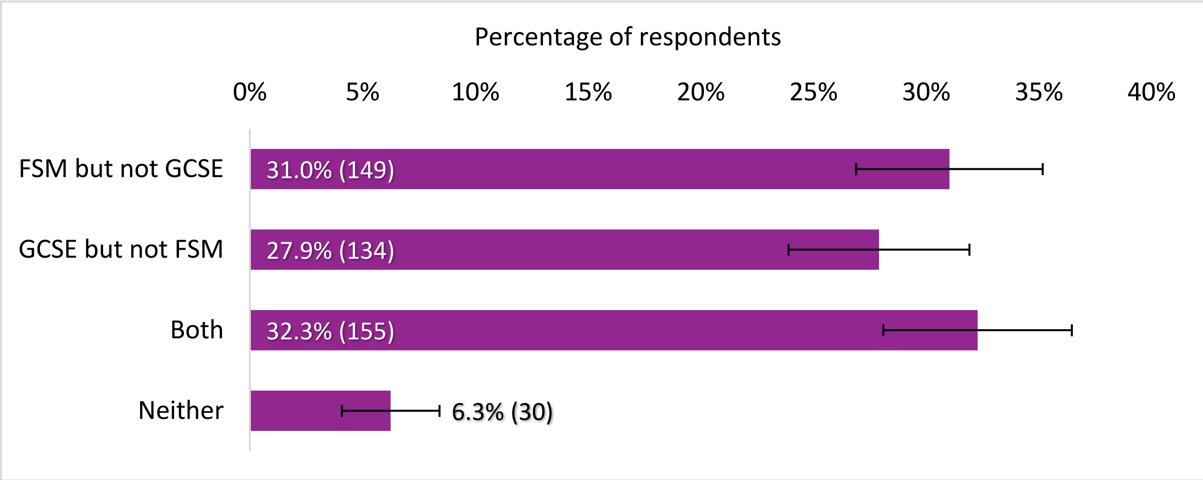

Figure 7: Percentage of respondents teaching FSM but not GCSE, GCSE but not FSM, both and neither

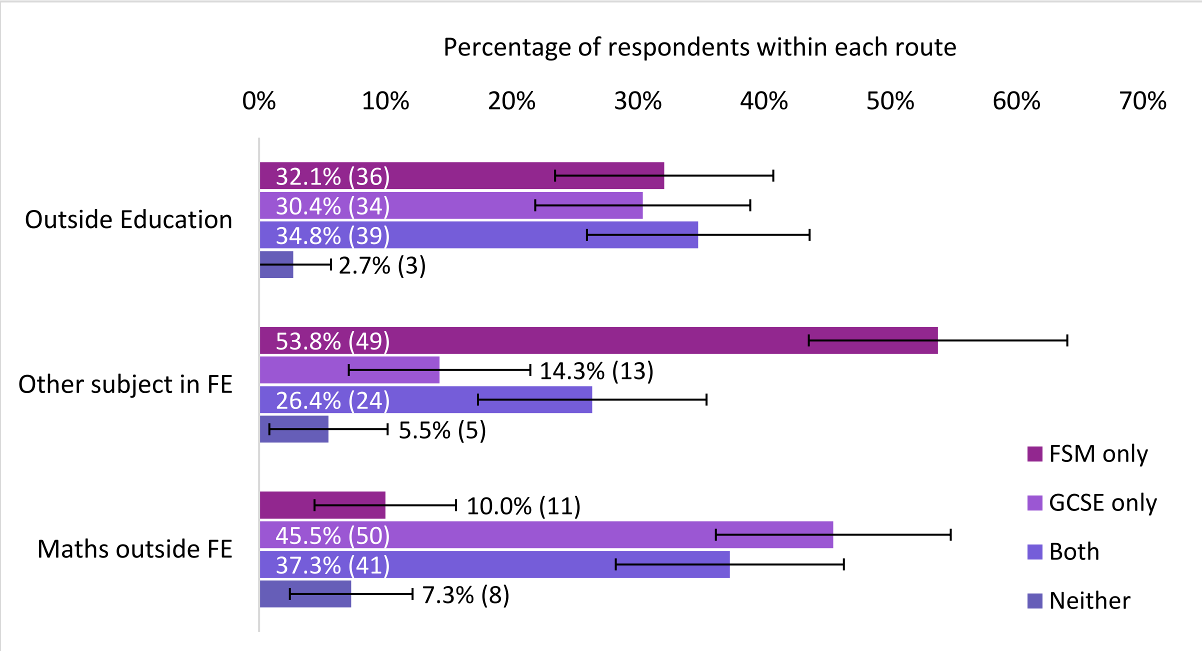

Figure 8: Percentage of respondents teaching FSM but not GCSE, GCSE but not FSM, both and neither within each of the three main routes in

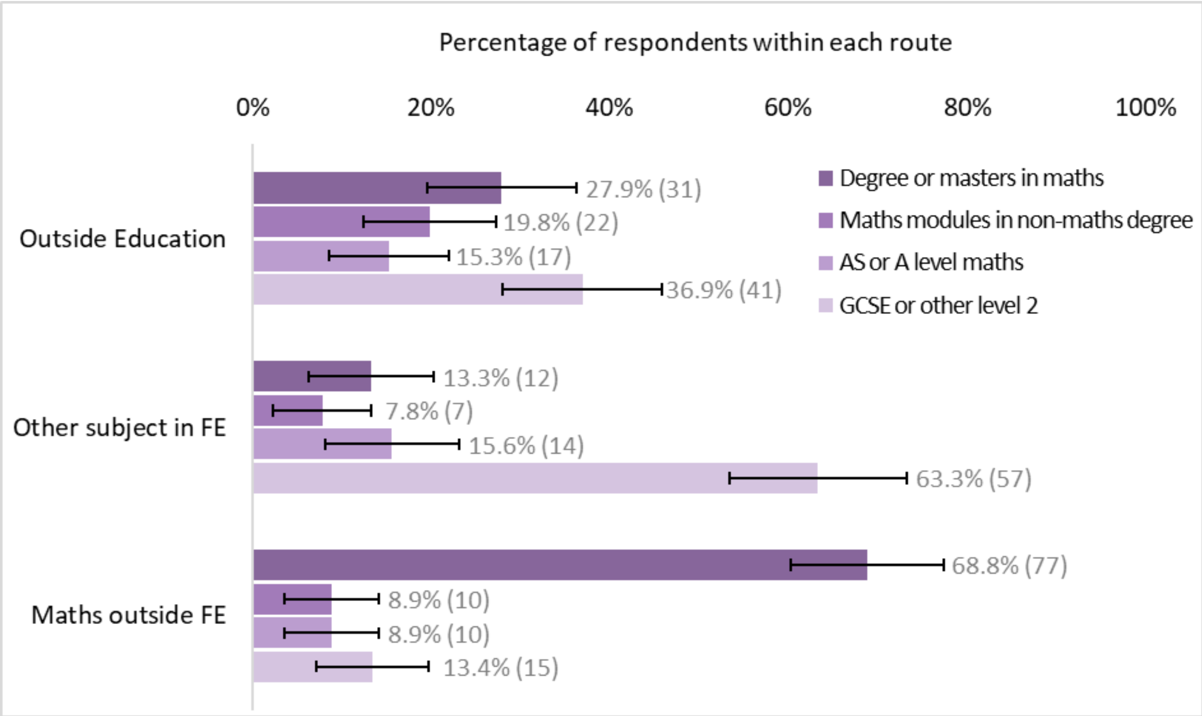

Figure 9: Distribution of highest mathematics qualification by each of the three entry routes

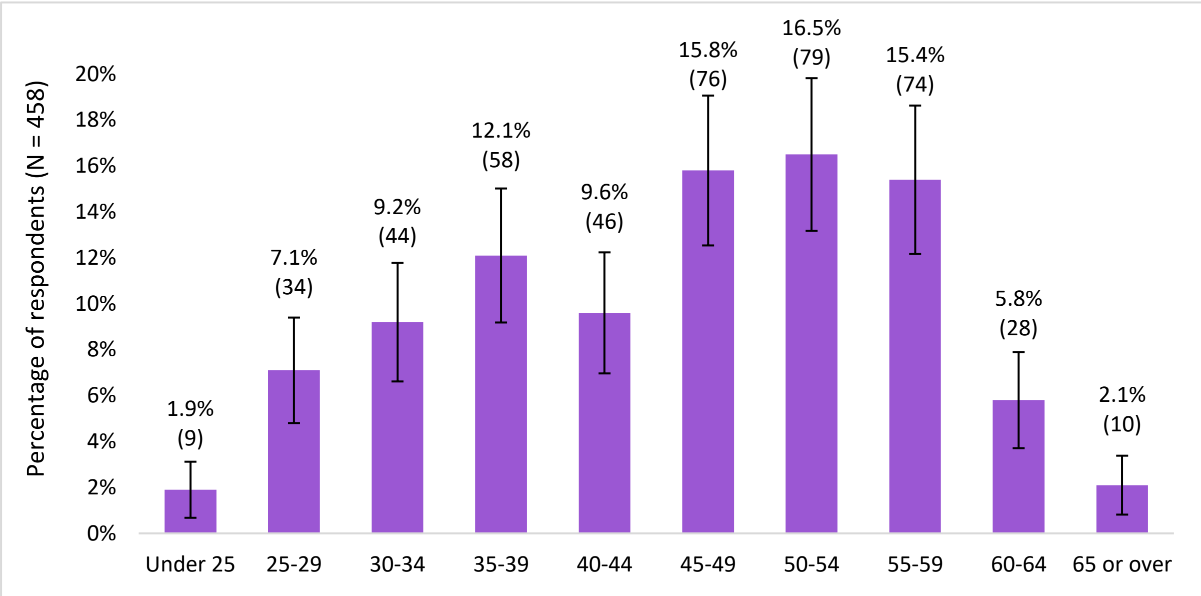

Figure 10: Percentage of respondents in each of the ten age groups displayed in the survey. Error bars indicate the 95% confidence intervals for the percentages.

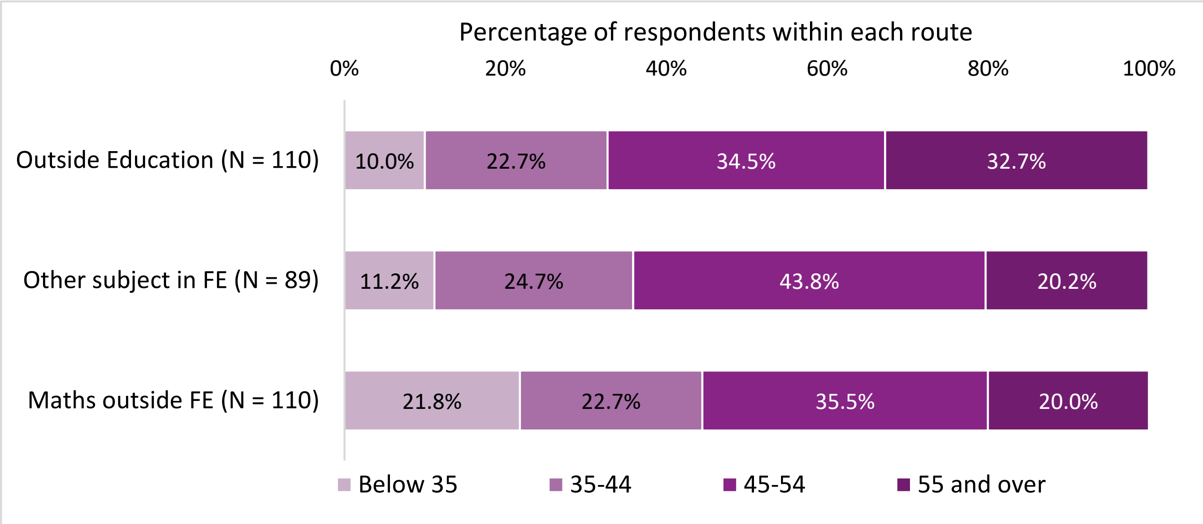

Figure 11: Distribution of respondents across the four binned age groups for each of the three routes into teaching maths in FE.