

# Wider school effects of engaging with the Further Mathematics Support Programme to introduce Further Mathematics: Final Report

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# Wider school effects of engaging with the Further Mathematics Support Programme to introduce Further Mathematics: Final report

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## Summary of Findings

Case studies were conducted in four 11-18 schools where Further Mathematics (FM) A-level has recently been introduced with some input from the Further Mathematics Support Programme (FMSP). The aim was to probe teachers' accounts of the range of effects of that introduction beyond the targeted FM students, so as to inform policy makers, other schools and teachers, potential students and their parents. Interviews with Heads of Departments and A-level teachers investigated any reported impact on teachers, structures, pedagogy and students at four points as the new course(s) developed. Intervening lesson observations served to elucidate and challenge the researchers' understanding.

The mechanics of introducing FM, and the range of support negotiated with the FMSP, varied between schools, as did the range and depth of the benefits and challenges/inhibitors that teachers identified. However, teacher talk about the introduction was largely positive and was categorised in six areas:

- *Headline benefits:* These are claims to benefits gained by introducing FM, usually framed as justifications to the school of investing staff resources in the change. We used this category to note effects that teachers framed as expected and planned-for outcomes, and that were so powerfully accepted in the school community as 'good' that they did not necessarily need further explanation or critique. Amongst these, teachers cite retention of more academic students, support of a variety of aspirational pathways, knock-on effects on A-level Mathematics participation and attainment, teacher retention and development.
- *Teacher Identity:* Teachers claim emotional and intellectual satisfaction or renewal from engaging with new teaching, including from seeing students engage with 'some wonderful maths' and behave and think more mathematically. They claim FMSP-provided CPD has improved not only pedagogical and subject knowledge, but has impacted on confidence and teachers' perceptions of their role, and hence on their job satisfaction.
- *Whole department issues:* Introduction of FM has usually involved creative use of structures and opportunities (a 'solution-focused' approach) and adoption of additional and different courses/teaching in KS3/4. Support by SLT for the additional teaching and CPD appears critical, and introduction of FM is then seen to enhance the profile of the department in the school.
- *Pedagogy:* In at least 3 of the schools, changes in pedagogy catalysed by the introduction of FM and associated FMSP PD were seen to have spread to other teachers or beyond the target classes. Teachers reported most changes in pedagogy for A-level classes and top sets preparing for A-level, with some knock-on effects on KS3 teaching. Changes have focused on teaching for deeper understanding and link-making, for reasoning and for challenge.
- *Sources of change:* These included a variety of professional interactions with colleagues in their own or other schools. In all four schools, interactions with FMSP, including with FMSP-provided resources at different levels and with Area Coordinators (ACs), played an important role in supporting high quality teaching and maintaining teacher development. For some, access to FMSP is claimed to be the only professional network, or live external CPD opportunity, they have, and that is greatly valued. The role of FMSP in supporting change was seen as fundamental in at least 3 schools, and included relief at having a non-judgemental expert at the

end of a phone to answer strategic, administrative and mathematical questions when they arose.

- *Benefits to students*: Initial motivation for the introduction of FM is often to enable access to particular aspirational pathways, but teachers suggest wider benefits to students arise from each of the above. Benefits are especially connected with deeper and more challenging teaching, emphasis on reasoning and fluency, availability of more knowledgeable and confident teachers for mathematical enquiries, working within a 'successful' and dynamic department, and support for a *range* of aspirational and to some extent personalised pathways.

Additionally, we observed how leadership of the change, and the nature of the departments as professional communities, appeared to interact with the claimed effects. Departments with strong leadership, whether single or distributed, and with a strong professional learning community[1], appeared well placed to embed and sustain the introduction of FM.

Below, we summarise school contexts and obvious effects of FM introduction, and then report each case study in more detail under the emergent themes 'department development', 'teacher identity' and 'pedagogy'.

## Key Messages

These studies suggest that the flexibility of type, depth and duration of support from FMSP, and the diversity of implementation models available, have been critical in enabling departments from a variety of contexts to engage with the challenges of introducing Further Mathematics. This introduction can bring with it a range of indirect benefits - to students, teachers and the quality of mathematics teaching in the school. If the department functions as a professional learning community then the wider benefits accruing from the associated development of professional practice and approach can be substantial and pervasive.

*However*, it is also clear that in harder-to-reach schools, such as these, FM provision can remain fragile for some years, and that embedding and sustaining it requires support from school leadership and from external sources, as well as committed leadership of the change at department level.

[1] Vescio, Ross and Adams (2008) define a 'teacher professional learning community' as one with shared values and which works collaboratively and with distributed leadership to sustain professional learning through sharing of (often external) expertise and practice, with a focus on improving student learning.

Vescio, V., Ross, D., & Adams, A. (2008). A review of research on the impact of professional learning communities on teaching practice and student learning. Teaching and Teacher Education, 24(1), 80–91.

## The study

Nationally there is a consensus that Further Mathematics is a valuable subject that should be available, and indeed promoted, to every interested student. At a school level, however, establishing teaching of Further Mathematics requires investment in extra teaching, often for a relatively small number of students. Further, the nature of the material means that not all mathematics departments have the knowledge, skills or teaching capacity to introduce it unaided. As a consequence, the DfE has funded the Further Mathematics Support Programme (FMSP) to facilitate introduction and embedding of the course. Evaluations of the FMSP[2] have suggested that introducing Further Mathematics A-level has impact beyond the FM students and their teachers, contributing to a raised profile and success in mathematics throughout the school. This study therefore asked ***'What are the wider school effects of introducing Further Mathematics with the support of the FMSP?'***

Our approach was a purposive set of longitudinal studies of four 11-18 mathematics departments who have recently (where 'recently' deliberately varies between one and three years before September 2014) introduced the teaching of FM at AS and/or A Level with the support of the FMSP. Our intention was to explore and document the effects of that innovation beyond the introduction of an additional subject into the curriculum, with the purpose of informing schools, the wider mathematics education community, and policy makers about possible wider benefits, affordances and constraints of such a move, including the challenges associated with embedding it. Potential schools were identified from FMSP records and selected for variation of FM experience, geographic setting and size, with enough stability in FM provision to suggest retention through the study. Six were approached in total, two of whom declined to participate so that similar replacements were found.

We used a sequence of semi-structured interviews with key players (the Head of Department, the Head of KS5 mathematics and at least one other teacher of A Level Mathematics/FM) to explore their perspectives on the effects of incorporating and promoting Further Mathematics. Interviews were developed iteratively as issues arose across and within case studies, and over time as teachers' experiences developed and a subsequent year's teaching had to be planned. They were triangulated by classroom observations which focused on identified effects, but were also sensitive to other hitherto unidentified issues. We also noted serendipitous data. Case studies were conducted with four stages of data collection over 15 months, as summarised in Table 1. We report our analysis of that data, relating to the period Sept 2014 to Nov 2015.

For each case study the core question 'What are the wider effects of the introduction of Further Mathematics in your school?' drove the research, with interviewers sensitised to probe the benefits, costs and challenges of any changes claimed to be catalysed by the introduction. To assist in reflection, teachers were asked:

[2] Searle, J. (2010). Saving Further Mathematics? In M. Joubert & P. Andrews (Eds.), *British Congress for Mathematics Education* (pp. 207–214). BSRLM.

- What changes have resulted for 16-18 students, whether participants in FM or not?
- Have there been effects on individual teachers or on the department, and if so, what?
- Has it affected the approaches to teaching (pedagogy), and if so, how?
- Have there been any other benefits or challenges associated with the introduction of FM?

***Table 1 Data collection (* Stages 1 and 2 were combined in school 4)***

| | |
|---|---|
| Stage 1: Winter 2014 | Group interview of at least 3 teachers: Head of Department, plus teachers A, B. In one case, replaced by 3 individual interviews. |
| | Observation of teacher A, with subsequent short interview |
| Stage 2: Spring 2015* | Observation of teacher B, with subsequent short interview |
| | Email or telephone contact with teacher A and Head of Department |
| Stage 3: Summer 2015 | Email or telephone contact with school participants |
| Autumn 2015 | Group interview targeting same 3 teachers (Schools 1 and 3 had new HoDs and another participant in school 3 had left the school). |
| | Lesson Observations in schools 3 and 4. |

Initial interviews also established the background to the introduction of FM, how that had been operationalised to date, and historic and continuing interactions with FMSP. Two teachers of higher level mathematics (FM or Mathematics at AS or AL) in each school agreed to offer a lesson observation that demonstrated some of the classroom-level changes claimed, followed by a short interview with a focus on both the identified area and other relevant areas emerging from the observation. Distance contacts with teachers in Spring and Summer 2015 were designed iteratively to probe emergent data, and served to update individual accounts of impact. Summer interviews had a dialogic purpose of getting feedback on our initial analysis. For example, as differences in department interactions surfaced, later interviews probed this theme through request for a 'teachers' pedagogic interactions' diagram indicating which teachers discussed planning and approach in FM, A-level Mathematics or other shared teaching.

Group discussions were chosen to gain several perspectives on the same topic and to gain insights into emerging shared meanings. In each case we set out to conduct a 50-minute semi-structured group interview, although once this was replaced by several individual interviews. Later individual contacts allowed for a variety of meanings to emerge, complemented by a final group interview. Data was collected in the form of field notes, transcriptions of interviews, and field notes of informal interactions and observations.

Teacher accounts were analysed under six emergent themes: 'headline benefits', teacher identity, department issues, pedagogy, benefits to students, and sources of change. Greater interpretive rigour was introduced into analysis through the use of reciprocal coding of data (between two researchers), together with discussion and challenge from an external expert in educational change. Impacts identified were largely positive, though not exclusively: for example, teachers in schools 2

and 3 talked about tensions arising in allocation of staffing given the additional teaching needed for FM but high-stakes nature of examination outcomes at 16. There was also recognition that the introduction of FM, often involving material new to teachers, cost them substantial non-allocated time for teaching, support – and their own learning.

The outcomes from these four departments are not claimed to be representative, but they do form a set of comparatively in-depth studies of the early years of adoption of Further Mathematics in contrasting settings. The research design relies heavily on teachers' accounts, and this is purposeful in that what teachers believe is happening both reflects and influences what happens in schools. As explained above, the longitudinal design and classroom observations provided some opportunities to test the robustness of teacher claims for their stability, spread and instantiation. In writing the case studies below we have firstly sought to communicate the important themes from teachers' accounts and, secondly and where possible, to add our own commentary on their robustness. We start with an overview of all four cases, considering how and whether the introduction of FM had the effects originally expected, and then consider each case separately.

## The Case Study Schools

Case study schools varied in their use of the FMSP, as summarised in Table 2. All schools had initially delivered FM in a flexible[3] and to some extent, individualised way, sometimes with teaching delivered by FMSP; usually, they moved over the course of a few years to having FM as a part of the 'mainstream' 16-18 timetable, with most teaching done in-house. All had altered their 14-16 curriculum to incorporate additional courses that were intended to better prepare students for the demands of A-level Mathematics and FM. Three of the schools had teachers who had engaged in professional development courses recommended by the FMSP area co-ordinators (ACs), either TAM[4] or TFM[5], whereas school 1 had an already-knowledgeable department at this level, the only one of our case studies where that was true.

***Table 2 The case study schools***

| School | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Approx no of 11-18 students 2015-16 | 1500 | 1000 | 1500 | 900 |
| Approx no of post-16 students 2015-16 | 270 | 180 | 230 | 330 |
| No of teachers of mathematics | 10 | 8 | 10 | 9 |
| FM AS cohort size 2014-15 | 15 | 14 | 4 | 4 |

[3] Creative scheduling of teaching time and/or participation in optional Mathematics modules and/or use of one or more forms of FMSP teaching

[4] Teaching Advanced Mathematics, funded by DfE to develop subject knowledge and pedagogy for A Level Mathematics

[5] Teaching Further Mathematics, a similar course focused on Further Mathematics A-level

| | | | | |
|---|---|---|---|---|
| FM AS cohort size 2015-16 | 12 | 0 | 0 | 1 |
| Flexible AS/AL FM | √ | √ | √ | √ |
| TAM + TFM participants in department 2013-15 | 0+0 | 2+1 | 1+0 | 2+1 |
| FMSP tuition of FM modules | No | No | 2013-14 only | 2010-2014 |
| Significant boost to A-level Mathematics participation/achievement reported | √/√ | √/√ | √/√ | √/√ |
| Curriculum change for 14-16 year olds | √ | √ | √ | √ |
| SLT support (funding+KS4 deployment) | √ | Limited | Some | √ |

## Intended Effects of Introducing FM with the support of the FMSP

When introducing Further Mathematics to the curriculum, the four mathematics departments in our study had each made a case to their senior leadership for the likely beneficial effects of this change. This justification was in all cases informed by advice from the FMSP, given during attendance at Access to Further Mathematics events and visits to the schools by Area Co-ordinators. In some cases, influential teachers had previously taught FM elsewhere and promoted it in their current school. It is reasonable to say that there are accepted, shared messages about the intended effects of introducing FM and we expected these to be at the forefront of teachers' accounts. This underpinned our decision to identify where the teacher accounts claimed 'headline benefits'.

Similarly, school leaders enact changes within a policy environment, so that at any one time there are certain goals and practices that frame what change can be prioritised, how it is justified or even thought about. In identifying 'headline' effects we have been influenced by Ball's analysis of such organising narratives[6] and how they become powerful in education as unexceptionable ways to understand actions and values (Ball, 1993). Examples are: improving standards, raising aspirations, personalising the curriculum. Typically, any significant educational change has to be related to powerful contemporary narratives in order to be considered worthwhile and so we expected to find them amongst justifications of introducing FM; conversely once such a link has been accepted there may be a less critical eye on the detail of what is happening. So we identified where claims evoke 'headline benefits' for two reasons : firstly because we would expect justification of a school-based

[6] Ball calls these 'master discourses', that is, ensembles of language and organisation that structure the ways individuals and institutions work, and their associated values, so that these seem unexceptionable and beneficial. 'Mastery' has other, contested, meanings in mathematics, so we have avoided it here. See Maguire, M., Ball, S., & Braun, A. (2010). Behaviour, classroom management and student "control": enacting policy in the English secondary school. International Studies in Sociology of Education, 20(2), 153–170.

change to reinforce the policy 'goods' they evoke; and also because they would normally serve as a complete justification so in pushing for further critique or explanation the research itself is changing the nature of participants' reflections.

The following 'headline benefits' were identified as being common to all cases, and providing unexceptionable support for teachers' accounts of positive change. The narrative slogans they evoke are powerful in schools so, although we have argued that we expect them to feature in justifications for change, it is also important to examine how they make that case. Each is thus outlined with the more specific claims that teachers made about the wider effects of introducing Further Mathematics

### Personalisation and Promotion of Equality of Opportunity

The main justification for offering FM in these schools was the opportunity it gave to individual students to succeed to the best of their ability and to follow the university course of their choice. This is a strong message from the FMSP literature and it resonated with the mission statements of these schools, which were all serving areas of social disadvantage, and with the values espoused by teachers to provide as good an education as any other school. All schools had offered FM for 2+ years at the beginning of the study and cohort size varied from 1 to 15 over that time. Where cohorts were small, teachers had stories of individual students who had been enabled to achieve high grades and apply to prestigious mathematics or computing degrees because they engaged with the content of FM. These stories were offered as desirable examples of personalising the curriculum for the range of students, including the very able. The availability and flexibility of FMSP support was cited as critical for personalisation by working round small classes and reduced timetables, although in school 2 this was not enough to secure continued FM provision.

### Retention of Able Students

All case schools felt that they were in direct competition with local post-16 providers, often larger and able to offer FM on timetable. Teachers responded to this by branding their school as offering better knowledge of individuals, pastoral care and personalised provision (as above). There was some concern that despite this they lost a bigger proportion of the more able students and this affected classroom atmosphere and results. In some cases the mathematics department had been prompted to introduce FM in order to retain a few known students in the school, who themselves influenced peers to remain. The value teachers attributed to this targeted retention was significant, extending to other subject areas and to parental involvement. Teachers reported agreement by senior managers that this wider effect justified the use of resources on small numbers of students.

In addition, all four schools followed FMSP advice and introduced extra content and qualifications to the year 11 curriculum for higher sets in order to challenge able students and prepare them for A-level. There was usually some student choice and teacher guidance in who would fully commit to these 'extra' courses and this was seen as an opportunity to promote mathematics and FM within the school environment. Although no teacher said so, we note there is little incentive to promote FM to year 11 students when that choice would result in them leaving the school.

### Improved Participation and Attainment in Mathematics AL

All cases claimed an increase in A-level Mathematics participation as a result of the introduction of FM. They were aware of the national growth of A-level numbers in the same period, but explained the specific effect of FM on growth either through retention of individual students or as a result of greater pupil engagement and confidence in the mathematics department. Further mathematics students were reported to study independently, to ask questions and to bring greater fluency and connections to A-level classes. In most cases, AL teachers – supported by professional development and resources – were then able to promote expectations for challenge, discussion and problem-solving that benefitted the class as a whole. This combination of influences was claimed to result in improved attainment for a range of A-level Mathematics students, but particularly those also studying Further Mathematics.

### Teacher Retention

In this study, and our other study concerning teaching A Level Mathematics in early career, we have noted the repetition as a 'truth' that those teachers who are relatively able mathematicians will be motivated by teaching advanced mathematics , and may become disenchanted with teaching and leave the school or profession if not given this opportunity. Being allocated FM and Mathematics AL teaching is thus associated with recognition of status, and all of these teachers reported pleasure in this professional achievement. Two schools experienced usual teacher turnover between years, while two had none. In all four schools, the introduction of FM modules and subsequent growth of A-level was part of the career growth of one or more teachers. The initiators of FM were promoted, two within the same school. In three schools, the opportunity to develop further within one's AL teaching was claimed as a factor to stay at the school longer-term; in the fourth, where recruitment was a particular concern, the relative stability of AL teaching was seen as a useful stress-reducer for teachers and the change enabled this to be spread across a core of teachers in the department.

### Teacher Development

Teacher development was cited as a significant effect across the study. Within A-level teaching there are opportunities to develop by extending the range of modules one can teach into more complex pure mathematics or different applications, and these are the ones most obviously supported by the introduction of FM. Typically these small schools had only one or two teachers who were eager to make that progression and they did so individually. The wider aspect of teacher development was seen as the potential to learn new strategies for engaging students with advanced mathematics from the combination of professional development courses, manageable new experiences of AL teaching and reflection as a departmental. All HoDs cited placing teachers on FMSP PD courses as a way of intentionally growing capacity in their department. In three cases they also deployed this external support to advocate for their mathematics teachers and reward their commitment, building a sense of agency.

## Case Study School 1: Embedding and sustaining Further Mathematics

Case Study 1 is a large mixed 11-18 school on the fringe of London. It has had a 'new build' in recent years and some ten years ago began post-16 provision: its recent Ofsted report says it is 'good' on all counts. The school is multi-cultural; there is an above-average proportion receiving free school meals and well above average proportion with English as an additional language. The sixth-form is growing and now of a sustainable size, though there is competition from a number of other post-16 providers within easy travelling distance. FM was introduced in 2011-12, just over four years before the study, but the teacher driving that, and teaching most of it, left in Summer 2014. The question asked by this department, then, was 'can we sustain and build on what is in place, with new teachers of FM and new post-16 leadership?' By 2014-15 Mathematics A-level recruited four year 12 A-level groups, up from only one in 2011. These groups studied different Applied options, and FM students studied S1, M1 and D1 in year 12 through judicious use of both year 12 and year 13 lessons. From 2015 they were timetabled as a separate group, and received a full (school) allocation of 20 hours' mathematics teaching a fortnight. Department turnover is very low; a senior leader also teaches mathematics. Value-added progression in the department has become very good, with ALPs scores[7] of 1, 2, 3 common.

The FMSP Area Coordinator (AC) was originally drawn on for 'ad hoc' organisational and pedagogical ideas, but teaching has always been in-house. MEI's Integral online resources for FM are used heavily, being described as '*easy to use and quite powerful*', cutting down on preparation and being '*flexible enough to use reactively in class*'. Interactions with the FMSP now consist of one or more teachers regularly attending the AC's termly area meetings, and making use of student revision days.

There are ten full time teachers in the department. Data was collected from two group interviews with the HoD, the new (2015) Head of KS5 mathematics, A, and another teacher of FM, B, observations with follow-up interviews of each of teachers A and B, and one additional short interview with each of those. Interviews (and previous interactions with the department) show there is a high level of mathematics and mathematics pedagogy knowledge between them.

### Department Development

Leadership within the department is clearly distributed, at each Key Stage. While teacher A leads provision at KS5, both the HoD and teacher B have significant input to discussion, and other teachers in the department contribute ideas and materials, which are organised centrally. In 2014-15 teaching of A-level Mathematics and Further Mathematics was re-organised so that teachers taught to particular areas of strength. The HoD explains this as a purposeful new strategy to produce more detailed schemes of work and resources that will enable the spread of A-level teaching to less knowledgeable teachers, and so *'develop and challenge them as teachers and give the department flexibility'*. Day-to-day discussion in the department was observed and reported to be rich and often

[7] ALPs scores, ranging from 1 (high) to 9 (low), are commonly used to measure value added in level 3 performance

subject- or pedagogy- focused, and teachers are well supported if they request external CPD or additional department targeted development time.

Further Mathematics was originally introduced with the aim of retaining more able students, particularly scientists, who were at the time going elsewhere post-16. It has been successful in doing so, and teachers claim this has impacted very positively on both participation and attainment in Mathematics A-level, that is beyond the immediate FM target group. The department is unusual locally in not requiring at least an A grade at GCSE for entry to Mathematics AS, though in 2015-16 a requirement for a 'good B' was made. They have nevertheless been very successful at A-level, with all 2015 FM A-level candidates gaining an A*. Students are encouraged to develop independent working habits, to take the initiative in approaching teachers outside lessons (which they were seen to do frequently), and to use peers as a first resort. Teachers say peer support has resulted in the benefits of FM spreading, since FM students have considerably more mathematical experience, and often a more nuanced understanding, than most A-level Mathematics students. Teachers claim the high level of participation and success in the department gives it a 'buzz' that all students in the school respond to, and that adds to teachers' own sense of wellbeing and professional satisfaction.

On the advice of the AC, the school introduced level 2 FM[8] for some students in year 11, delivered partly in class time and partly twilight. This is said to have enriched teaching beyond the year 11 target group of students, as well as raising expectations of algebraic fluency. For 2015-16, teaching time for all in KS4 mathematics was increased to allow for the new, more demanding GCSE specification. Pressures on GCSE results also mean many students are involved in twilight classes for other subjects, and so the level 2 FM course has been dropped. However, the HoD says *'the benefits remain and have influenced what we do with the new GCSE'*. No negative impacts of the introduction of FM were reported.

### Teacher Identity

The process of reorganising Mathematics A-level teaching is connected by teachers to how they feel about themselves: they explicitly report that they have enjoyed developing their teaching for Further Mathematics and Mathematics A-level. It has refreshed them intellectually, for example, through tackling rich problems at FMSP area meetings and communicating them to colleagues. They also feel an emotional satisfaction from taking such ideas into the classroom and seeing the benefit for students in engagement and learning to think mathematically. Teachers talk about the support available from the FMSP in ways that express their confidence, taken as a feeling of gaining control over the sometimes '*draining*' routines of teaching.

The process of departmental development is itself linked to changing teachers' views of themselves as taking part in valued professional activities (sharing ideas, critical mathematical discussion of practice, developing consistency , upskilling planned career progressions in A-level teaching). Teachers (and especially the HoD) feel a boost to their morale in belonging to a dynamic and successful department which is popular with students and gives them opportunities to excel through FM and other level 2 opportunities. They feel supported by SLT and trusted to be autonomous in

[8] AQA Level 2 certificate in Further Mathematics. This is unrelated to A-level Further Mathematics, except by coincidence of title. Nevertheless some teachers in all schools treated them as similar extension courses, perhaps unsurprisingly as level 2 FM had been introduced in all four schools on advice from FMSP ACs.

many department decisions; they commented this is probably helped by the presence of a senior member of staff in the department.

### Pedagogy

Teachers in the school agree pedagogy at A-level has changed through processes of experiment, reflection, and discussion (rather than a planned direction). Lesson observations show an emphasis on justifying reasoning and discussion with peers, both to support basics and to stretch. Teachers identify this as consistent with both their beliefs and the expectations of the new KS3/4 curriculum, and report they are now able to think about a continuum of experience from year 7 to year 13. Tasks to build depth of understanding are valued and trialled, typically first with the after-school A-level support class, and then refined through application in other A-level and in main school teaching. Student 'activity' is not valued per se, but teaching is managed so that students can think for themselves and differentiated tasks used to keep this possible in KS4. There is now more emphasis on algebra and functions as preparation for A-level. Strategies and structures learned from area FMSP meetings and Integral resources have spread beyond the A-level group to KS4, and occasionally even to KS3. This is reported as part of good teacher practice rather than a marked change in approach, and teachers feel affirmed in this by the increase in A-level popularity.

### Sources of change

The introduction of FM was comparatively well developed in this department at the beginning of the study, with their focus on embedding and sustaining opportunities for departmental growth. Teachers remembered good initial bespoke support from the AC, though they were not confident of the detail of that. Across the department they evidenced considerable subject and professional knowledge and claimed their deep mutual trust and collaboration provided support and confidence for developing practice. It is noticeable, though, how much they appreciated FMSP area meetings as a source of fresh ideas and 'recharging' from both the AC and other teachers, and also the use of Integral resources as support for a higher quality of learning. Teachers additionally said they regularly drew on the AC as a source of knowledge and strategy in a fluid school and policy context.

*In conclusion,* this department was observed to have developed an unusually productive professional learning community, with the claimed shared aims, values and distributed leadership consistent with what we observed. Developing teaching and teachers for A-level and FM is claimed to have been a vector for strengthening productive teacher relationships. Their good professional knowledge and relationships, and previous 'success', appear to give them confidence to take on new initiatives and find ways of making them work, and underpin the embedding and sustaining of FM provision they now enjoy.

## Case Study School 2: Competing school priorities

Case Study 2 is an average size 11-18 converter academy in outer London. It is an old school in a socially and culturally mixed area, with a transient population. Its most recent Ofsted report grades are outstanding. Almost two-thirds of students speak English as an additional language, and there is an above-average proportion receiving free school meals. The sixth-form is growing but remains barely viable, though some provision is shared with other local schools and colleges. The main priority for the school is said to be cultivation of 'key performance data', so that leadership scrutinises very carefully any request for additional development time. A considerable pressure on budget is also reported, so that small teaching groups at A-level are not viable and resources are felt to be severely limited.

The school introduced FM two years before the start of the study as the initiative of a new HoD who aimed to retain able GCSE students and compete with "buzzy" sixth form provision elsewhere. Teachers reported some success in doing this, with 8 students in 2013, 14 students in 2014 and a parallel increase in A-level numbers and attainment. For 2015-16, though, eight year 11 students initially expressed an interest in FM but this was not considered sufficient by SLT to justify the expense. FM was withdrawn by SLT for 2015-16 and the HoD (HoD1) left. He was replaced by another member of the department, HoD2.

Initially HoD1 had drawn heavily on ideas from the FMSP 'Access to FM' course about aspiration to competitive university courses and sought to convince students that FM gave them an academic 'group to identify with' inside the school. The increase in A-level numbers was seen as iterative, with more engaged students having the confidence to be seen to work on mathematics with peers and teachers, focusing on maths-rich careers, and making it 'OK to get stuck'. Higher performance and participation inspired year 11s, allowing a second group, more choice, and more teacher development. At the same time, HoD1 also introduced Level 2 FM to top set year 11s. By 2014, A-level teaching was in two groups studying different Applied modules, and FM students took both of these each year. FM Pure provision was initially delivered by the AC; during the study it was taught within the department by teacher A in its first (and for the moment, last) school-led iteration. Observations and interviews indicate this teaching is still a 'work in progress', with teaching of both Mathematics A-level and FM ripe for further development. Teachers' accounts of the changes largely focused on the effects of FMSP advice and professional development on their teaching and professional wellbeing, and on the effect of introducing demanding work in KS4.

Teacher retention is a high focus in this school, with the (large) size of the SLT reported to be in response to this challenge: retention appears to be a particular issue in mathematics. Opportunities for professional development are limited by funds and SLT permission, though several of the long-standing mathematics teachers are non-specialists. Access to free and twilight FMSP provision has been a rare opportunity for them to benefit from outside mathematical input on teaching, allowing HoD1 to 'look after' his staff. Teachers clearly appreciate this, and agree it has required sustained negotiation with SLT. Two teachers have recently completed TAM courses, and one continued with TFM. Some use is made of revision and other FMSP opportunities for students, although

management is parsimonious with permission for students to be out of school and keen that attainment in other subjects is not threatened by absence.

There are eight teachers in the department, of whom six are full-time. Data was collected from three interviews and an observation with HoD1, two interviews and two observations with teacher A, two interviews with teacher B, an observation with teacher C, and interviews with teacher D and HoD2.

### Department Development

Teacher deployment and shared values have been the greatest issues for this department, requiring intense negotiations with SLT to agree investment in improving A-level teaching, despite there being very limited appropriate subject knowledge in the department. Teachers interviewed said they valued the support from FMSP in arguing for subject-specific development, and the experience of teaching mathematics courses that allow students the same access to A-level or university as in other schools. Having now experienced it, they see opportunities to learn and experiment as key to their job satisfaction. They reported frustration that these values are not obviously supported or at least acknowledged as good by some in school leadership.

Teachers report the benefits to students as encouraging a culture of persistence with mathematics throughout the school, accessing fascinating ideas, and challenging low expectations and faulty careers information. This is facilitated in part by the teachers' awareness of what students can and should be aiming for, and in part because successful, aspirational students stay in the school and act as 'pace-setters' for others.

There remain tensions around the deployment of staff, eg whether teaching A-level or boosting GCSE attainment should take priority. HoD2 espouses values more aligned with apparent whole-school priorities, and feels the department now has sufficient A-level expertise and so needs to prioritise GCSE attainment.

### Teacher Identity

For teacher A, the introduction of FM and associated CPD has been *'life changing: I enjoyed teaching before but this has made me teach in much more depth and with much more challenge, and that has spread to all my classes: I feel like a really professional teacher. And I have learnt so much new mathematics, and now that I'm teaching FP2 and FP3 I feel like I've really arrived, this is what teaching is about. And the students are achieving so well, it makes me feel great that they're turning into mathematicians and they wouldn't be without FM'.*

The process of developing Mathematics A-level teaching is reported by TAM teachers as their opportunity to improve, with a major impact on self-image: e.g. teacher B separately reported *'I became a maths teacher, not a Physicist masquerading as a maths teacher. So it was life-changing.'* The teachers claimed the training courses combine intellectual and emotional refreshment, encouraging them to take risks in challenging the students, to evaluate the outcomes critically, persist and then enjoy seeing the benefit for students of engagement, independence and learning to think mathematically. Teachers talked about the support gained from FMSP in ways that expressed their confidence, taken as a feeling of assurance that their own understanding is sound enough to debate mathematical questions and familiarity with doing so.

HoD1 and some teachers articulated a sense of increased subject professionalism as a result of FMSP interactions, claiming that they are now teaching students in a way that prepares them for mathematics in life and university. This was opposed to experiencing pressures to teach for performance measures. Workload was cited as a problem that teachers have little control of. TAM and TFM courses had required teachers to invest personally (and financially) to teach and study on top of usual timetables but they felt rewarded by being positioned by themselves and students as an ambitious, 'can-do' department in the school. HoD2 was more pragmatic in her assessment: *'it's helped some teachers but our core aim is to get the good results at GCSE and A-level and we need to use the development these teachers have had to concentrate on that.'*

### Pedagogy

FMSP interventions were reported to encourage an increased emphasis on preparing students for A-level during KS4, including more emphasis on algebraic fluency, abandoning early entry GCSE and introducing a level 2 FM course as enrichment for top sets. There was considerable agreement that pedagogy should focus on developing multiple strategies and representations of mathematical problems, and discussion of effective strategies with peers and the teacher. This approach was reflected to some extent in lesson observations and there are ongoing, though occasional, discussions about how to focus on mathematical reasoning. Pedagogical development has spread beyond the A-level target group. FM is felt to support independent study for deep understanding, and Mechanics requires synoptic understanding; teachers of these courses report that they incorporate these goals in their KS4 classes. Teachers agree that the range of effects of interactions with FMSP currently go beyond A-level classes to the whole department profile. Younger students now reproduce the questioning attitudes and effort they see in A-level students (visible perhaps when A-level students seek help in the department or through peer contacts). Teachers also use their analysis of A-level content to teach and assess with greater depth, and to build up mathematical competence, skills and positivity through the school.

### Sources of change

It is clear that with competing priorities in this school, teachers feel FMSP support and development opportunities have been key not only to the introduction of FM, but to their own professional development and identity. The introduction and teaching of Further Mathematics A-level itself has catalysed some of these developments, but substantial benefits have accrued through support for and introduction of level 2 FM, and the experience of participating in TAM and TFM courses. Teachers in this department report feeling time and space pressures that constrain within-department interactions, so that reflective contact with other teachers afforded by FMSP courses was particularly highly valued.

*In conclusion*, the embedding of FM in this school appears to have been challenged by competing school priorities, including budgetary constraints and maintaining performance indicators. Introduction was very much the initiative of HoD1 in a department where deep professional collaboration is claimed to be limited by physical location and other priorities. However, teachers say they experienced wider effects, including reported increased teacher knowledge and an enriched KS4 curriculum, which they hope will survive; some further say they hope a FM group will be re-introduced in the future. We observed that the claimed changes in pedagogy often seemed to need further development and embedding, and no claims were made about changes spreading

beyond the teachers directly involved in FMSP courses. After the September 2015 withdrawal of FM, the number of students starting A-level Mathematics was lower than for several years, with a number of high-achieving students transferring elsewhere. Experiences in this school suggest that embedding of Further Mathematics as an A-Level was fragile because it depended crucially on the initiative and goodwill of a few teachers. Tensions in securing a unique permission for teacher development appear to have led teachers into strong claims about wider effects on themselves and students, partly borne out in outcomes. The main challenge to embedding both FM and its wider effects in this school has been the unusually demanding criteria used by senior decision makers to commit resources to its support.

## Case Study School 3: Teachers developing independently

Case Study 3 is a large 11-18 school in a small coastal town. It is a new school on an old site, sponsored by a national academy chain, and its recent Ofsted report praises outstanding teaching and management across all key stages. Most families are from White British backgrounds and there is an average proportion receiving free school meals. The sixth-form is growing but remains small, competing with large sixth-form colleges within easy reach.

Mathematics A-level recruits two year 12 A-level groups. FM was introduced one year before the study, and since then four students have studied for AS-level and two are continuing to AL. None started in 2015-16: the subject remains on offer but, disappointingly, the potential candidates left the school. Staffing resource is tight and this leads to unusual timetabling. The core pure mathematics is taught in year groups while Statistics (S1), Mechanics (M1) and Decision Mathematics (D1) are each scheduled as joint year 12 and 13 classes in after-school slots. This offers students the choice of applied modules, and supports module resits, while allowing FM students to attend all three Applied options.

For the first year the department drew heavily on FMSP online live interactive lectures and the local FMSP AC for delivery pathways, resources and advice. FM students were timetabled with the Key Stage 5 Maths Lead (KS5ML) in an after-school session: they watched a webinar together, discussed ideas and then completed follow up questions set and supervised by the teacher. In subsequent years the same teacher had responsibility for teaching all three FM pure modules plus M2, while another started teaching D2. An early–career teacher attended the TAM course in her first year of teaching A-level, but left the school part-way through the study, as did the original Head of Department (HoD1) who did not teach A-level.

There are ten full time teachers in the department. Data was collected from an interview with HoD1, three interviews with the KS5ML (who became HoD2 during the study) plus three other A-level teachers, and four lesson observations with HoD2, the TAM teacher and two other teachers.

### Department Development

Both HoDs argued that Further Mathematics is critical to the school's educative role because it guarantees that the school can prepare students for any university degree. The school publicises a message of aspiration for everyone, and FM has gained SLT support because it instantiates this message for able mathematicians. Teachers claim several individuals have stayed at the school who would otherwise have left, and the school notices a ripple effect among friendship groups. Supporting FM is therefore seen as having a wider effect on retention in the A-level cohort than its numbers suggest, particularly among science students.

HoD2 also reported that FM has changed the atmosphere in his A-level class. FM students themselves improved through greater experience, developing a confidence to tackle problems independently and gaining good results. They act as an example to other A-level students and sometimes take on an informal teaching role for friends. Having more successful A-level students

raises the department's status in the school, and in turn benefits recruitment. The appointment of HoD2, who had led the introduction of FM, suggests some SLT appreciation of the initiative.

Although these benefits are noted, both HoDs noted that the department feels it must prioritise KS4 attainment. The development of A-level is secondary to KS4 teaching and they see it as sometimes in competition. Primarily this is because A-level takes experienced teachers away from teaching in years 7-11. Although it has a core of established staff, the school experiences recurrent difficulty in recruiting a full complement of well-qualified mathematics teachers. Any growth in A-level, however welcome, is said to potentially exacerbate the problem.

This KS4 priority is reflected in the work practices of the department. Issues of teaching KS4 are discussed at departmental level and between colleagues. In contrast teaching of A-level is deliberately separated into modules and teachers develop independently. HoD2 recognised that there are risks if one teacher leaves, but the arrangement is time-efficient and gives teachers autonomy and authority in their specialism. HoD2 cites FMSP support as influential in this teaching structure. Teachers, including himself, do not have the confidence to develop their own A-level questions, as they would at GCSE, and they find textbooks do not focus enough on the aspects that students initially find difficult. Teachers use the MEI Integral online mathematics resources and summaries to support their pedagogic knowledge and provide good tasks, and FMSP online lectures as a model of exposition. Thus the development framework for A-level was set, and to some extent replaced, by the external support from FMSP, while the department concentrated on securing KS4.

### Teacher Identity

Most teachers in this school have been largely unaffected by the introduction of FM, and even A-level teachers reported only minor effects to their professional practice. The exceptions are HoD2 (where the impact comes from teaching new, demanding modules), the D2 teacher and an early-career teacher who was brought into A-level teaching as a result of increased numbers. She was encouraged by HoD1 to lead a level 2 FM group for top set year 11 and was keen to take the TAM course while teaching year 12. This teacher found the TAM discussions provoked her to consider '*my own sense of what type of teacher do I want to be when I'm an A-level teacher'* and that her reflections on the need to develop resilience and minimise teacher talk were *'having a knock-on effect lower down the school.'* These wider effects were in evidence as aspirations for her own teaching, and matched HoD2's concerns about 'spoon-fed' students, but were not observed in changed practice before she left the school.

### Pedagogy

The move to introduce FM accompanied a minor initiative to change pedagogy at A-level. HoD1 had articulated two goals in this, that were not necessarily consistent: she spoke both of wanting teachers to avoid lacklustre teaching and of their need to develop expertise in teaching exam preparation techniques. HoD2 reported that his practice was changed by FM teaching to give more conceptual underpinning to rules. For example, he now included differentiation from first principles in his A-level teaching as he had observed that FM students understood differentiation better when they had seen the connections with gradients, algebra and limits. He had bought graphic calculators via FMSP and used them both as a processing aid and to support movement between graphical and symbolic representations. Other teachers had attended FMSP training and used the calculators to

support statistics calculations in KS4 and A-level. HoD2 identified that teachers found FMSP resources particularly appropriate for their students, of whom about half have a B grade at GCSE.

There has been a small impact on KS4 pedagogy, focussed on support for transition to A-level. In the first year of FM A-level, the department offered Level 2 FM in lesson time as an extra qualification to mathematics students who had completed early-entry GCSE. HoD2 considered this supported recruitment to FM and Mathematics A-level for the most able. Since the end of early entry, the department maintained the offer to self-selected year 11 students in an after-school class, but has not seen the same take-up. Teachers have developed resources for summer bridging work in preparation for A-level.

### Sources of change

This department are still in the early stages of trying to embed Further Mathematics provision. They have drawn heavily on FMSP advice and online, face-to-face and resource support, and used that to frame their own developing provision. By the end of the study the FMSP-promoted intentions were widely espoused although the wider impact on pedagogy was observed to be fairly limited. Teachers' evaluation of FMSP resources was still fairly pragmatic, for example relating to questions often being more accessible to mediocre A-Level students than those typical in a textbook. (This is in contrast to the more nuanced evaluation by teachers in School 1, who were more actively critical, valuing the resources as supportive of contingent teaching.) Other FMSP input, such as participation by one teacher in a TAM course, was said by her to be highly influential in her development, but the benefit of this was not claimed to have spread and she has now left the school.

*In conclusion*, the leadership and department in this school recognise the benefits of introducing FM, and some possible wider effects such as student aspiration, retention and attainment .However, the beneficial impact, and full commitment to growth in participation at KS5, appear somewhat limited by both the reported necessity for prioritising department resources at KS4 and the very limited teacher interactions focused on A-level teaching. Teachers directly involved in FM, and those whose teaching allocation has changed as a result, claim to have developed their teaching identity, but observed effects on pedagogy were limited to some A-level teaching. Embedding of the FM A-level offer in year 12 remains fragile, with none running in 2015-16.

## Case Study School 4: New Sixth Form

Case Study 4 is a small inner-city 11-18 girls' school in the Midlands. It recent Ofsted report praises outstanding teaching and management across key stages. Most families are from minority ethnic backgrounds, largely Pakistani, Bangladeshi and African, and a very high proportion receive free school meals. Teachers feel that mathematics is valued in students' homes and that a core of parents subscribe strongly to aspirational (single-sex) education. The school expanded a few years ago to include a sixth-form, and offered Further Mathematics (FM) from the outset. Mathematics is well established, with three teachers on TAM or TFM courses. FM recruits 1-4 girls a year and module provision/timetabling has been personalised. Three students have completed the full AL FM, and the subject now sits in an option block. The Key Stage 5 mathematics lead (KS5ML) has negotiated a mix of FMSP face-to-face tuition, online interactive lectures, specialist part-time teaching, as well as in-house use of staff non-contact time. We saw teachers enjoying rich, learning-focused interactions, catalysed by the Head of Department or KS5ML.

There are 7 full time teachers in the department and two part-time. Data was collected from three interviews with the KS5ML, one with the Head of Department (HoD) and two A-level teachers, 3 lesson observations with the KS5ML and one with another teacher.

### Department Development

Both the HoD and the KS5ML present the effect of introducing FM as a dual benefit to individual students and the school as a whole. They argue that the example of students with high academic potential choosing to remain in year 12 and experiencing excellent personalised teaching is valuable when competing against larger girls' grammar schools and inspires younger students to follow suit. The power of this 'headline benefit' of retention through raising aspirations is evident in the SLT's and teachers' sustained willingness to find funds and create staffing strategies to *'make it work here'*. FM is seen as a way in which the school and department are strongly aligned: teachers talk interchangeably about them as having an ethos of meeting students' individual needs.

The department is seen to be growing, both in the sense of recruiting more teachers to meet A-level demand and in its teachers' professional status. It is clear that curriculum innovations are not new here; however the HoD reports that teachers' understanding of A-level teaching has influenced the strategic decisions that he leads 'down the school' such as introducing 'mathematics mastery' in KS3. Five teachers are involved in discussions about teaching approaches suitable for A-level and preparation for A-level. Three of these are also involved in developing initiatives at KS4 and 3. These different facets come together as a perception that the department has proven itself dynamic, resourceful and with a coherent response across the range of mathematics needs. The department appears to have sufficient available subject knowledge to be able to build successfully on FMSP interventions.

### Teacher Identity

Many of the mathematics teachers are long-established, while a few including the KS5ML are newer staff appointed after A-level introduction. For some staff, job satisfaction requires variety and the range of FM modules was a factor in deciding *'if I want to stay in a school and teach for a few years'.* FM was thus associated with retaining for longer the kind of teachers who do aim to move on. The effect on long-standing staff was more surprising to the HoD, and he emphasised the impact of FMSP courses such as TAM and TFM: *'I think what's happened to the teachers, looking at the staff who are doing it, they seem ... better refreshed. There's no staleness; there's always a fresh challenge. And with maths, apart from all the government changes which are imposed on us, these are happy things for us to be doing you know.'* The teachers who took part in these courses described identifying themselves as being learners again, meeting new ideas and being supported to experiment with the ones they thought useful while at the same time benefitting their students. The harmony between working for their own development and for the students' needs was a recurring feature of these accounts. As in the HoD's comment above, they contrasted the freedom of learning for ones' own professional improvement and the constraint of implementing others' directives. Teachers also valued the opportunities brought by A-level to attend local FMSP and HEI events, primarily for their students but also for themselves as professionals to network, share expertise and get information beyond the school.

### Pedagogy

In this school, the few FM students have been taught by three experienced teachers and the reported impact from their inclusion is minor: FM students are encouraged to work independently on harder questions or take on a leadership role in AL lessons. In contrast the growth of A-level teaching and the experiences of teachers on the TAM and TFM courses are reported as influential for pedagogy. The lessons we observed involved engaging and open-ended tasks that teachers considered to be *'more interesting ways of introducing topics to students and making it more relevant for the students.'*

Earlier in the school, teachers made a distinction between the mathematics needs of potential A-level students and others who needed functional maths. They reported department decisions based on discussions of balancing the students' needs to gain qualifications with their need to think more independently. They felt that their experience of A-level teaching gave them a new awareness of what students *can* do that led to more appropriate modelling of skills by teachers for younger students, aimed at developing *'thinking skills and not giving them mechanical routines'.* They enriched the algebraic content of the main school curriculum by introducing problems that bridge topic areas (e.g. in one lesson year 11 students solved quadratic trigonometric equations either directly or by substituting c= sinx). This was formalised by introducing level 2 qualifications in algebra and further maths alongside GCSE for the year 11 top set: ''*some of them do need that challenge. It's providing that challenge, but also prepares them for A-level maths'.* Some (but not all) teachers take their experience of A-level teaching into lower years, feeling more confident to manage the unpredictability of group work and student discussion.

### Sources of change

The flexibility and personalisation of FMSP support appeared central to this department's '*finding ways to make it work here'*, with a range of affordances taken advantage of and resources and approaches adapted and built on as teachers developed ownership of FM provision. At least as critical to the whole department's pedagogy and development as teachers were TAM and TFM courses, whose ethos and approaches were seen to impact on both teacher interactions and mathematics teaching across the school. Teachers also valued the opportunities such courses gave for professional interactions beyond the school, and the benefits of these were again said to permeate the whole department, so that the range of FMSP impacts was magnified by a department functioning which had dense professional communication and shared values.

*In conclusion*, teachers in this school cite a range of benefits, centred around more confident and challenging pedagogy across the school, and teacher development and job satisfaction, and these claims were entirely consistent with what we observed. Benefits appeared to stem from reflections on practice that were inspired by new A-level teaching but also in particular from their access to FMSP PD courses and enrichment events, both enhanced by and enhancing the professional learning community nature of the department.

## Conclusions

### Effects on the Department

To a greater or lesser extent, and in different ways, these schools have benefited from FMSP support, but have still needed to adopt a 'solution-focused' approach to sustain FM provision. In schools 1 and 4 the introduction has been linked by the HoD with development and challenge for teachers, and this is seen as a good in its own right. All four schools claim it has catalysed an enhanced profile for the department within the school, but in schools 1 and 4 this is additionally framed as instrumental in developing a successful, confident and attractive department for both teachers and students. Such claims are closely related to powerful contemporary discourses surrounding aspiration, retention of able students, and improved student attainment at A-Level; concerns that are well aligned with the vision of these schools as a whole.

Leadership within these departments works in different ways, but the innovation has had most impact where leadership is distributed, though with active or at least moral support from the HoD, as well as from SLT.

All four departments introduced Level 2 FM to prepare students for A Level Mathematics and FM, in terms of both knowledge and confidence. This initiative is said to have been developmental for teachers but has been diluted by changes in policy surrounding early entry for GCSE. There is some evidence that lower participation in Level 2 FM had an adverse effect on FM A-Level participation (for example, in school 3).

The spread of claimed benefits of the innovation and related courses varies between departments. In all there is talk of pedagogical benefits spreading beyond the target classes, and varying degrees of claim about spread to teachers not directly affected. On both counts, evidence for such wider impact was stronger in schools 1 and 4 than in schools 2 and 3.

### Effects on Teacher Identity

Teachers across schools claim intellectual and emotional refreshment from participating in FMSP-provided courses or from teaching FM, the latter partly because it requires investment in their own learning and partly because of the nature of the 'lovely' mathematics involved. They value FMSP-provided support as affirming their identity as teachers of mathematics, and boosting their confidence. They claim FMSP-promoted values such as engagement, independence, challenge, and learning to think mathematically are typically consistent with their deeply-held beliefs and this too is affirming. Where the department works well together to share the fruits of these opportunities, and especially in schools 1 and 4, teachers view themselves as participating in valued professional activities such as critical discussion of mathematics and of pedagogy outside the 'draining routines' of teaching. Teachers without an extensive non-specialist background claim extended FMSP courses or support enhance their identity as teachers of mathematics, and in several cases used the words 'life-changing'.

### Effects on Pedagogy

All schools reported a range of pedagogical approaches that had been recommended by FMSP and which they understood as laying deep foundations for FM and other mathematical progression. These included a greater emphasis on algebraic fluency, reasoning and connection-making, with students encouraged to develop multiple strategies and representations. Teachers talked about these as consistent with their own beliefs and values, but they varied in the extent to which such approaches were seen in observations. Similarly, teachers in all schools talked about the spread of such approaches to their teaching beyond their target classes, though there was mixed evidence for this in practice. Spread beyond target teachers varied with the strength of the department as a professional learning community, being much more evident in schools 1 and 4 where teachers in the department enjoyed frequent deep subject pedagogy-based discussion. However, all teachers involved in the development also talked about a growth in confidence and depth of teaching and assessment, and that this was reflected in greater positivity in classroom ethos.

### Effects on recruitment and retention

Student participation in A Level mathematics as well as A Level FM clearly increased from historical levels in all four schools. Teachers could point to particular high-achieving students who historically they might have expected to move elsewhere for sixth form provision (and to those who did, in schools 2 and 3 when FM provision ceased). Within A Level Mathematics classes they could also identify improved performance of students of a particular background, both those studying Further Mathematics and some direct or indirect impact on peers' performance, through either peer support or higher quality of interactions in the class as a result of the presence of more knowledgeable students.

Improved retention or recruitment of teachers is harder to establish, but there were some direct claims about teachers staying longer in the school because of the professional development and satisfaction involved in teaching Further Mathematics or other interactions with FMSP. More generally the extensive claims made in all schools about greater teacher job satisfaction and improved sense of professional identity could reasonably be assumed to support teacher retention in the profession if not in the particular school.

### Sources of change

The four case study schools drew on FMSP support in very different ways. In each case, early teaching of FM was not by full timetable and full teacher allocation at least in the early years, so that the flexible nature of available FMSP support, as well as the flexible structure of the FM course, was critical to early delivery: to a greater or lesser extent departments introducing FM needed to have a 'solution-focused' mindset. Where FMSP initially provided face to face or online tuition, this was later used differentially, with school 3 using it to heavily frame their own provision but, e.g. school 4 drawing on their own knowledge and confidence to adapt and personalise that. Where, in three of the schools, teachers attended TAM or TFM courses, all claimed these were highly influential at an individual level in terms of both pedagogy and teacher identity. In school 4, where the department functioned as a professional learning community these benefits were seen to spread beyond the individual teacher.

FMSP-provided online resources were widely drawn on in all schools, though both conceptualised and used in a more nuanced way in schools 1 and 4. These two schools also evidenced greater embedding in their main school teaching of FMSP-promoted strategies (such as asking students to make sense of graphic representations) and values (such as resilience and explanation). This was perhaps as a result of the high quality and frequency of professional talk in these departments that promoted coherence of approach. For some, especially teachers in schools 1 and 4, FMSP courses also offered highly-valued contact and debate with teachers from other schools, adding to the professional 'recharging' arising from such provision.

Finally, teachers in schools 1 and 4 especially claimed deep professional reflection with colleagues, and alignment of department and school priorities, as support for both initiation and embedding of change. Where there were obviously competing school or department priorities, as in schools 2 and 4, and fewer robust learning-focused teacher interactions, changes appeared more superficial and the long-term viability of FM provision less secure.

### *Department leadership and professional community*

Across the range of our interactions, we identified meta-themes of leadership and professional community which appeared to be impacting on the way in which FM was being introduced – and the associated benefits. Leadership of the change varied across schools. In school 1, there was clearly distributed leadership involving the 3 teachers interviewed, whereas in school 2 the Head of Department (to Summer 2015) appeared to be pivotal to introduction, entering into protracted and sometimes hard-won negotiations about timetabling, teacher allocation and, critically, teacher development opportunities. This department had lacked the depth of available knowledge to introduce new modules without substantial support, so without teacher development would only have been able to introduce FM with external teaching, which school leadership was said to be reluctant to do – and which would probably have severely limited the extent of wider effects. Leadership of FM in school 3 was firmly in the hands of the KS5ML, whereas in school 4, the KS5ML took the lead for students but the HoD retained oversight of staffing, and was enthusiastically engaged in supporting colleagues to develop their teaching by engaging with new A-level modules.

In terms of the department functioning, those in schools 1 and 4 appeared to be functioning as a professional learning community, encouraged by school leadership; they showed a high density network, with low/high centrality of leadership respectively[9]. Both appear well-placed for embedding of FM, with school 1 already well on that road. School 2 and school 3 departments, in contrast, functioned with low density of network, though with highly centralised/distributed leaderships respectively. The sustainability of the introduction in both appears to be under threat.

[9] de Lima, J. Á. (2008). Department networks and distributed leadership in schools. *School Leadership & Management, 28*(2), 159-187.

### *The role of the senior leadership team*

Introduction of FM requires a resource and timetabling commitment at a whole school level; similarly, teacher development and enrichment takes time and even if this is the teacher's own, their emotional response and professional identity benefit from school and department leadership appreciation of this. It is therefore unsurprising that in the two schools where department and senior leadership values appeared to align in strong support of the initiative, greater embedding was apparent. It can be difficult, though, to discern relationships of the department or individual teachers with SLT: for example, those reported by HoD1 in school 2 differed from those reported by HoD2, and teachers too changed the thrust of their narrative as time passed. It is, though, clear that in schools 2 and 3, to different extents, there were competing priorities for SLT. Schools currently work in a high stakes accountability environment, and lie in different positions in relation to this. Master discourses notwithstanding, evidence of benefit might have to be strong for them to support an apparently costly course for a small number of students.

### *Benefits for students*

In all four schools, students have been able to access FM at A Level without changing institutions at age sixteen, even though that provision is not yet embedded in two of the schools. Of itself, this would seem to be a limited benefit of a considerable investment – in time and effort as well as money, although it is hard to quantify the benefits of the related high aspiration and concomitant valuing of mathematics within a school community. However, the 'headline benefit' claims of increased aspiration beyond those particular students, and greater participation and attainment in A Level Mathematics as a result of the introduction of FM, appeared to be supported by evidence, as were enhanced teacher knowledge, commitment and refreshment. Even where this reached only target teachers the benefits appeared to spread beyond target classes. Across the case study schools, we saw at least some evidence of lively teaching for deep understanding and connection-making that teachers claimed was an effect of this change resulting in more confident and participative classrooms, and departments saying they felt enriched and successful because of their ability to offer FM: these gains are positive for the range of students in a school. Further, once they are embedded, teachers take such positive attitudes, and the related professional skills and knowledge, to other schools as they move, and students carry a positive framing of mathematics into adult life.

## Final thoughts and a cautionary note

These case studies demonstrate a wide range of possible benefits – either direct or indirect - to a wide range of students, through the introduction of FM with the support of FMSP. They incidentally show how the flexibility of the current modular assessment structures can support introduction or continuation of FM. If that is a desirable end then such flexibility might need to be retained.

Our observations about the ways in which the nature of leadership of innovation, together with the quality of department as a professional community, can support or limit the spread and sustainability of positive implications of the introduction of FM, suggest there is good reason to develop these areas of a department's functioning. Leadership and professional community should also be considered when proposing change: not only is change that is concentrated in an individual or small number of teachers vulnerable in case of their departure or re-allocation, but these studies suggest it might also limit the potentially wider advantages such innovations can bring. Further, these studies suggest it is worth finding ways of brokering both SLT and whole-department active support for such change, if sustained and wide benefits are to be enjoyed. Practical and psychological preparation of students from KS3 onwards is the responsibility of the whole department, and part of a coherent mathematics provision.

As a note of caution, the studies show the momentum for FM can be slow to build, at the mercy of students and staff moving on and of outside pressures; further, it can remain fragile for a number of years after its introduction, in part because of the necessary change of culture within a whole department. Given the high marginal cost of introducing FM where there is none, it would seem worth maintaining active support by the FMSP well past first teaching by the school's own teachers, though needs are variable and so personalisation of support should be preserved. During this time, plans should be made for the nature of support available in the longer term, perhaps through a teacher development plan and the ongoing provision of area meetings and online resources.

Further, the evidence about the sometimes perverse unintended consequences of other policy initiatives suggests that there is no room for complacency even where FM teaching appears established. As well as new policy pressures, the next few years see, at the least, the working through of some big existing policy changes for teachers of mathematics, and for the range of students. The intentions of most of these are consistent with the messages promoted by FMSP with such beneficial effect in the case study schools, and allow a coherent vision of a year 7 to year 13 FM curriculum. It remains to be seen whether they will be supported by the validity of assessment, support materials, teacher development and funding regimes that might enable their effective introduction without threatening access to and participation in FM. If we as a nation are serious about our commitment to enhancing the mathematical functioning of the range of our young people, then these are challenges we should meet.