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

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Key Messages

This study suggests that the flexibility of type, depth and duration of support from FMSP, and the diversity of implementation models available to schools, 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.

UCL Institute of Education Supporting Advanced Mathematics Project

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

- *Headline benefits:* These are claimed expected and planned-for outcomes, so powerfully accepted in the school community as 'good' that they did not necessarily need further explanation or critique. They are usually framed as justifications to the school of investing staff resources in the change, and include: retention of more academic students, support of a variety of aspirational pathways, effects on A-level Mathematics participation and attainment, teacher retention and development.
- *Teacher Identity:* Teachers claim emotional and intellectual satisfaction/renewal from engaging with new teaching and 'some wonderful maths', including from seeing students behave and think more mathematically. They claim FMSP-provided CPD has improved pedagogical and subject knowledge. It has developed teacher confidence and teachers' perceptions of their role, and hence 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 three of the schools, changes in pedagogy catalysed by the introduction of FM and associated CPD 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 school or wider colleagues. However, interactions with FMSP, including with resources and with Area Coordinators (ACs), appear fundamental. 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; it includes availability of expert advice on strategic, administrative and mathematical questions.
- *Benefits to students***:** Initial motivation is often to enable access to particular aspirational pathways, but teachers suggest wider benefits arise from each area above. They 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.

[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.

The study

Nationally there is a consensus that Further Mathematics (FM) is a valuable subject that should be available, and indeed promoted, to every interested student. Evaluations of the Further Mathematics Support Programme (FMSP)[2] have suggested that introduction of FM brings wider impact. This study 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 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 impact beyond the introduction of an additional subject into the curriculum, with the purpose of informing school and wider communities about possible wider benefits, affordances and constraints of such a move, including the challenges associated with embedding it.

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 elucidated and challenged our understanding. 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 and informal observations that were sensitive to other hitherto unidentified issues. Case studies were conducted with four stages of data collection over 15 months. We report our analysis of that data, relating to the period Sept 2014 to Nov 2015.

To assist in reflection, teachers were asked:

- 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?

The findings 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, since what teachers believe is happening both reflects and influences what happens in schools. The longitudinal nature and classroom observations provided some opportunities to test the robustness of teacher claims for their stability, spread and instantiation: claims were largely consistent with what we observed, formally and informally, within the departments.

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

The Case Study Schools

Further details of both case studies and study outcomes can be found in the full report[3]. All schools had initially delivered FM in a flexible[4] 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.

Table 2 The case study schools

School	1	2	3	4
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
FM AS cohort size 2015-16	12	0	0	1
Flexible AS/AL FM	√	√	√	√
TAM[5] + TFM[6] 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	√

Case Study School 1: Embedding and sustaining Further Mathematics

Case Study 1 is a large mixed multicultural 11-18 school on the fringe of London. FM's instigator left for a promoted post in 2014 so that the department's focus over the study was on sustaining and developing what had been initiated by others. The FMSP Area Coordinator (AC) was originally drawn on for advice, but teaching has always been in-house, building on a relatively strong store of subject knowledge across the department. 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.

Distributed leadership in the department aimed to share responsibility for developing AL Mathematics and FM, and consistent supporting pedagogy at KS3/4, and these ideas were embedded through strategic placing of teachers and rich pedagogy and student-focused talk in the department. They enjoyed an unusually productive departmental professional learning community, with the claimed shared aims and values consistent with what we observed. This, and their previous 'success', appear to give them confidence to take on new initiatives and find ways of making them work. They underpin the embedding and sustaining of FM provision they now enjoy.

Case Study School 2: Competing school priorities

[3] Golding, J. and Smith, C. (2016) *Wider school effects of engaging with the Further Mathematics Support Programme to introduce Further Mathematics: Final report* UCL Institute of Education Press

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

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

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

Case Study 2 is an 11-18 converter academy in a socially and culturally mixed area of outer London. The main priority for the school was said to be cultivation of 'key performance data', and budgetary pressure appeared to severely limit resources, CPD opportunities and viability of small classes. A new HoD introduced FM two years before the study, aiming to retain able GCSE students and compete with "buzzy" sixth form provision elsewhere. Teachers reported some success, but small recruitment meant FM was withdrawn by SLT for 2015-16 and the HoD left.

Introduction had drawn heavily on FMSP support, and increase in A-level numbers was seen as iterative, with students gaining confidence to be seen to work on mathematics with peers and teachers, focusing on maths-rich careers, and making it 'OK to get stuck'. Two teachers had invested heavily in FMSP TAM and TFM courses, both judging them '*life-changing*'. Teachers' accounts largely focused on effects of FMSP advice and professional development on teaching and professional wellbeing, and on the effect of introducing more demanding work in KS4.

Embedding in this school appears to have been challenged by competing school priorities. Physical scattering and other pressures appeared to limit opportunities for the department to engage in deep professional discourse and spread benefits; we observed that the claimed changes in pedagogy often seemed to need further development. The main challenge to embedding both FM and its wider effects here has been the unusually demanding threshold used by senior decision makers to commit resources to its support.

Case Study School 3: Teachers developing independently

Case Study 3 is a large, mainly white British, 11-18 academy in a small coastal town. FM was introduced one year before the study, but although offered for 2015-16, did not recruit. Staffing resource is tight and 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, together with twilight sessions with the FM lead. The HoD appeared little involved with FM provision, claiming other priorities in the department, and left after the first year of the study; another teacher attended a TAM course but did not stay at the school.

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 at KS5, appear limited by both the reported necessity for prioritising department resources on KS4 and the paucity of 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.

Case Study School 4: New Sixth Form

Case Study 4 is a small multi-racial inner-city 11-18 girls' school in the Midlands. 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 including the Head of Department (HoD). The Key Stage 5 mathematics lead (KS5ML) has negotiated a mix of FMSP face-to-face tuition, online interactive lectures, specialist part-time teaching, and in-house use of staff non-contact time. We saw teachers enjoying rich, learning-focused interactions, often catalysed by the HoD, who is very focused on teacher development, or KS5ML.

Teachers in this school cite a range of benefits from the introduction of A Level Mathematics and FM, 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 variable extent, and in different ways, these schools have all benefited from FMSP support, but have still needed to adopt a 'solution-focused' approach to sustain FM provision. In schools 1 and 4 introduction has been linked by the HoD to development and challenge for teachers, seen as a good in its own right. All claim catalysis of an enhanced school profile for the department, 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. Impact is greatest where there is at least moral support from the HoD, as well as from SLT.

The introduction of Level 2 FM as preparation for A Level Mathematics and FM is said to have been developmental for teachers but provision and impact have been diluted by changes in policy surrounding early entry for GCSE. The spread of claimed benefits of FM introduction and related courses varies, but 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. Evidence for these is strongest in schools 1 and 4.

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. These boost confidence and are valued as affirming identity as teachers of mathematics. Teachers claim FMSP-promoted values such as engagement, independence, challenge, and thinking mathematically are consistent with their deeply-held beliefs and this too is affirming. Where the department works well together to share the fruits of these opportunities, teachers view themselves as participating in valued professional activities such as critical discussion of mathematics and of pedagogy outside the 'draining routines' of teaching.

Effects on Pedagogy

All schools reported a range of FMSP-recommended pedagogical approaches, 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. Such approaches varied in the extent to which they were observed, as did spread beyond target classes: although teachers in all schools talked about this, observed spread varied with the strength of the department as a professional learning community. All teachers talked about a growth in confidence and depth of teaching and assessment, observed in noticeable positivity in classroom ethos.

Effects on recruitment and retention

Student participation in A Level mathematics increased in all four schools. Teachers could point to particular high-achieving students whom historically they might have expected to move elsewhere at 16 (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 particular sorts of students, both from studying Further Mathematics and

some direct or indirect impact on peers' performance, through peer support or higher quality of in-class interactions as a result of having more mathematically knowledgeable students.

Improved retention or recruitment of teachers is harder to establish, but there were some direct claims of retention through the professional development and satisfaction involved in the initiative. More generally the extensive claims made in all schools about improved job satisfaction and 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 very differently. The range and flexibility of this, as well as the flexible structure of the FM course, appeared critical to early delivery. Initial FMSP tuition 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. Individuals felt TAM and TFM courses were highly influential on both pedagogy and teacher identity, and where the department functioned as a professional learning community, these benefits were seen to spread beyond the individual teacher.

FMSP courses offered highly-valued contact and debate with teachers from other schools, adding to the professional 'recharging' arising from such provision. FMSP-provided online resources were widely drawn on, though 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 coherence of approach appeared to be a result of the density of rich professional talk in these departments, and teachers here 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 affect the way in which FM was being introduced – and its wider benefits. Departments 1 and 4 appeared to be functioning as a professional learning community, encouraged by school leadership; both appear well-placed for embedding of FM. Departments 2 and 3, in contrast, where sustainability of FM appears to be under threat, functioned with low density of network.

The role of the senior leadership team

Introduction of FM requires a resource and timetabling, as well as a teacher development and enrichment, commitment at a whole school level. 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, while in schools 2 and 3, to different extents, there were competing priorities for SLT. Schools currently work in a high stakes accountability environment, and 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. Claims of increase in aspiration among other students, and in participation and attainment in A Level Mathematics, appear to be supported by evidence. So too are enhanced teacher knowledge, commitment and

refreshment. In all schools benefits appear to spread beyond target classes, and in all, we saw at least some evidence of lively teaching for deep understanding and connection-making that teachers claimed was an effect of this change. This resulted 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 transfer these characteristics 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 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 has supported introduction or continuation of FM. 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 active support for such change from both SLT and the whole department, 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, and can remain fragile for a number of years after its introduction, because of contingent events, conflicting priorities and 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. While the intentions of most of these are consistent with the messages promoted by FMSP with such beneficial effect in the case study schools, 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 threat to 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.