

Wider school effects of introducing a higher level mathematics course with flexible support: initial findings from case studies

Jennie Golding and Cathy Smith

UCL Institute of Education

In England entrance to mathematics-intensive courses at high status universities now usually requires achievement of a 'Further Mathematics' (FM) qualification as well as Mathematics A-level. Introduction in the small proportion of schools/colleges where teaching for FM is not routinely available is supported by the Further Mathematics Support Programme (FMSP). This study identified four case-study schools which had recently introduced FM with the support of FMSP, and asked what the wider effects of its introduction were. Semi-structured interviews and lesson observations were used to explore teachers' accounts. Common themes were 'master discourses' of introduction, effects on individual teachers and departments, and development of pedagogy. Additionally, we identified differential impacts of department leadership and of the department as a professional community.

Keywords: master discourse, teacher identity, pedagogy

Introduction

Advanced-level (A-level or AL) mathematics is a non-compulsory mathematics course, taken by over a quarter of university-track students aged 16-18 in England and Wales. A much smaller proportion, around 4%, study the additional AL called Further Mathematics (FM), with about 7% studying Further Mathematics to AS (half an AL). All these courses are currently modular, and within FM there are a number of choices, which enables significant flexibility in delivery. Some study of FM or its equivalent is increasingly required for entry to mathematics-intensive courses at high status universities. Significant national investment has therefore been made in increasing participation in FM through funding the Further Mathematics Support Programme (FMSP) and its predecessor organisations; their brief is now interpreted as supporting greater participation in all higher level mathematics, including through enrichment of earlier teaching, since e.g. Solomon (2007) shows participative identities are established much earlier than post-16 course choice. The FMSP offers inter alia face to face and online teaching of FM modules, online resources for both teacher and student use, substantial teacher development courses including TAM (Teaching Advanced Mathematics) and TFM (Teaching FM), shorter online and blended learning professional development, student study days, and often area teacher support meetings. In recent years the FMSP has targeted those schools not regularly offering Further Mathematics and has attempted to support them in doing so, through the work of their Area Coordinators (ACs). The reported research comprises case studies of four such schools.

Establishing teaching of Further Mathematics in a school requires investment in extra teaching, often for a relatively small number of students. At a school level introduction therefore requires justification through analysis of the range of likely impacts, especially in times of budgetary constraint. This study therefore asked 'What

are the wider effects of introducing Further Mathematics into a school with FMSP support?’

The study

Our approach was one of a purposive set of studies of four 11-18 mathematics departments who have recently (between one and three years prior to September 2014) introduced the teaching of FM at AS and/or A Level. 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 and constraints of such a move, including the challenges associated with embedding.

The research prioritised accounts given by teachers: we asked them to describe the conduct of a particular change in institutional practice and trace how this affected other practices and ways of thinking about their work. Accounts are of course to some extent co-constructed by researcher(s) and participants. Our approach to analysis was a constructivist grounded one positing multiple realities and multiple perspectives on these realities.

Method

We used a sequence of semi-structured interviews with key players (the Head of Department, the Head of 16-18 mathematics where different, 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 arise across and within case studies, and over time as teachers’ experiences developed and a subsequent year’s teaching had to be planned. Interviews were triangulated by classroom observations focused on identified effects, but also sensitive to other hitherto unidentified issues. We collected data from each school in four stages, as in Table 1. We report our initial analysis of that data.

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

	Event	Purpose
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.	Establish background to introduction and related facts to date. Understand initial shared, and sometimes negotiated, accounts of impact to date.
	Observation of teacher A, with subsequent short interview	Triangulation of identified effect, identification of possible lines of enquiry; probing of individual perception of relevant issues.
Stage 2: Spring 2015*	Observation of teacher B, with subsequent short interview	Triangulation of identified effect, identification of possible lines of enquiry; probing of individual perception of relevant issues.
	Email or telephone contact with teacher A and Head of Department	Any advance on accounts of current impact, from an individual perspective.

Stage 3: Summer 2015	Email or telephone contact with school participants	Perceptions of impact to date towards the end of the academic year, especially any assessment-related impacts. Probing of any effects on planning for the next academic year.
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).	Shared accounts of impact to date; probing of issues identified from analysis and preliminary summation.
	Observation if deemed useful and appropriate.	Triangulation and further probing of claimed effect.

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

- 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?

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. Interviews were recorded and fully transcribed. The purpose of group interviews was to gain several perspectives on claimed impacts, and to gain insights into emerging shared meanings.

Two teachers of advanced mathematics (FM or Mathematics at AS or AL) in each school agreed to offer a subsequent lesson observation that demonstrated some of the classroom-level changes claimed, and were afterwards given a short interview with a focus on both the identified area and other relevant areas emerging from the observation. Remote contacts with teachers in Spring and Summer 2015 were designed iteratively to probe emergent data, and served to update individual accounts. For example, as differences in department interactions surfaced, later interviews probed those through a request for a diagram showing pedagogic interactions between teachers related to FM, to A-level and to KS3/4 initiatives.

Data was collected in the form of transcriptions of interviews and field notes of informal interactions and observations. Grounded data analysis was by reciprocal (two researchers') coding and categorizing of emergent themes, with gaps between field events allowing for emerging themes to be probed in later interactions, leading to the emergence of a constructivist grounded account (Charmaz, 2006). Additionally, given the challenges in establishing methodological credibility, transferability and dependability when claiming a grounded approach (Bruce, 2007), an external expert colleague was used to challenge interpretation and analytical frameworks, and teachers were asked to validate reported accounts.

Findings

Case study schools varied in their use of the FMSP. All schools had initially delivered FM in a flexible and to some extent, individualised way, sometimes using FMSP tuition; usually they moved towards 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 AL Mathematics and FM. In all schools we found a group of ‘focus teachers’ larger than the one or two teachers responsible initially for recruiting and teaching FM. This had evolved either through changing responsibilities or from being put forward for professional development via FMSP contacts. 3 of the schools had teachers who had engaged in TAM or TFM, whereas school 1 had a department already knowledgeable at this level. All claimed an increase in AL Mathematics participation as a result of the introduction of FM. These outcomes were achieved with varying degrees of support and encouragement from school management teams. However, it is noticeable that whereas teachers at schools 1 and 4 claimed good management support and appeared to be embedding FM very successfully, though they were at different stages of doing so, schools 2 and 3, where senior support was less marked, reported ‘insufficient’ uptake to run it in 2015-16.

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	200	230	330
No of teachers of mathematics	10	8	10	9
FM intake 2014	15	14	4	4
Flexible AS/AL FM	✓	✓	✓	✓
TAM + TFM graduates in department	0+0	2+1	2+1	1+0
FMSP tuition of FM modules	No	No	2012-13	2011-15
AL number boost reported	✓	✓	✓	✓
Curriculum change for 14-16 year olds	✓	✓	✓	✓
SLT support (funding/KS4 deployment)	✓	x	Some	✓
FM for 2015 starters in place	✓	x	x	✓

Teacher accounts were analysed under six emergent themes: teacher identity, department issues, pedagogy, benefits to students, other master discourses, and sources of 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 flexible introduction of FM, often involving material new to teachers, cost them substantial non-allocated time for teaching, support – and learning.

Teacher change

Teacher accounts from all schools claim emotional and intellectual satisfaction or renewal from teaching FM or from associated changes, including from seeing students behave and think more mathematically and engage with ‘some wonderful maths’ (HoD, school 4). Where needed, FMSP-provided CPD has improved not only pedagogical and subject knowledge, but has impacted on confidence and teachers’

perceptions of their role. A teacher whose own background is in another field claims, for example, that TAM has ‘made me feel like a maths teacher’ (teacher B, school 2).

Pedagogy

Teachers in at least three of the schools say that pedagogic changes catalysed have been profound, and focused on teaching for deeper understanding and link-making, on valuing reasoning and increasing challenge. Some of our observations support this claim, but it is hard to substantiate the extent, given teachers’ tendency to claim change where there is limited evidence for it (Spillane, 2004).

Master discourses including benefit to students

Teachers, and especially Heads of Departments, often have to compete for limited resources in terms of timetabling, staffing and release for CPD, and will develop ‘master discourses’- unexceptionable ‘goods’ which have exchange value with those they wish to influence (Ball, Maguire, & Braun, 2012). We found teachers in all schools made extensive use of such master claims, for example retention of more academic students, support of aspirational pathways, effects on AL Mathematics participation and attainment, and teacher retention (through career development and satisfaction).

They also talked, though often tangentially, about the benefits to students beyond the acquisition of another qualification, claiming benefits in particular connected with deeper and more challenging and knowledgeable teaching, emphasis on reasoning and fluency, and support for aspirational and to some extent personalised pathways.

Range of impact and the influence of department leadership and community

Across the range of our interactions, we identified meta-themes of leadership and professional community which appeared to be associated particularly with the impact of the associated benefits beyond focus teachers. In schools 1 and 4, the department functioning could be characterised as being that of a ‘professional learning community’ (Vescio, Ross, & Adams, 2008), that is, a high density network with shared values which works collaboratively to sustain professional learning with a focus on improved student learning, and supported in this by school leadership. Here, department functioning seemed to support the spread of benefits to teacher identity and pedagogy well beyond focus teachers and their classes, and active change-focused discourse appeared to embed those changes. Leadership roles and prior knowledge base in these two departments were very different, with low/high centrality of leadership respectively (de Lima, 2008). Additionally, department 1 enjoyed a substantial prior subject and subject pedagogical knowledge base, whereas department 4 was initially very reliant on FMSP to enhance their professional knowledge to the point where they could teach FM themselves. The introduction of FM in both has involved creative use of structures and opportunities (a ‘can-do’ approach that teachers claim creates ‘buzz’) and teachers in both claim it has enhanced the profile of the department in the school and led to articulation of ‘department values’ and development of pedagogy across an extended age range.

In contrast, departments 2 and 3 showed low-density networks, with limited pedagogy-focused discourse and a variety of pressures evident. Leadership was centralised/distributed, respectively. In school 2 the Head of Department to summer

15 (HoD1) appeared pivotal to introduction of FM and related 14-16 courses, entering into protracted negotiations with school leadership about timetabling, teacher allocation and necessary teacher development opportunities at a time when these were claimed to be rare, even if all that was required was 'in principle' support. Two teachers there claim enormous direct benefit from a range of FMSP development opportunities and some sharing of resources takes place but HoD1 felt time and location pressures militated against much in-depth teacher professional sharing; the new HoD says she would like to attempt greater sharing of ideas. Leadership of FM in school 3 was firmly in the hands of the 16-18 Mathematics lead, with the then Head of Department little involved. Most teachers there appear to work in relative isolation for AL teaching, so that spread of support from FMSP is limited. In both these schools the benefits of introduction appear limited largely to the focus teachers, though some of those teachers claim pedagogical benefits spread beyond their A-level classes. Both departments now have new leadership, so future directions are unclear, but in both sustainability of the introduction is in question.

Final thoughts

These case studies demonstrate a wide range of possible benefits – either direct or indirect - through the introduction of FM with the support of FMSP. They incidentally show how the flexibility of the current modular structures can support introduction or continuation: if that is desirable 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 such changes, suggest these areas should also be considered: not only is change that is concentrated in an individual or small number of teachers vulnerable in case of their departure or re-allocation, it also limits the potentially wider advantages such innovations can bring.

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