

The fragility of A level Further Mathematics in schools/colleges in England

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Over the last decade there has been a marked increase in the number of students studying, and schools/colleges offering, A level Further Mathematics in England – 14,298 entries across 1428 state institutions in 2015, compared to 5,627 entries across 762 state institutions in 2005. Mathematics in Education and Industry's government funded Further Mathematics Support Programme (FMSP) has been influential in stimulating the increase. This paper draws on FMSP analysis and aspects of an independent evaluation (2014-16) by Sheffield Hallam University, including the creation of an 'FM Security' construct derived from School Census data¹ (2013-2015). Findings show a third of schools or colleges change status over this period. Concepts of organisational Further Mathematics capital are used to interpret the analysis. We reflect on reasons for these patterns in relation to the wider Further Mathematics education landscape, including recent policy/budgetary changes that threaten to reverse the positive trends in Further Mathematics.

Keywords: Further Mathematics; post-compulsory mathematics; policy; mathematics capital; widening participation

Introduction

Major changes to the most studied qualification in the compulsory schooling of students up to the age of 16 in England, GCSE Mathematics, have taken place in 2015. Furthermore, impending changes are to take place in 2017 for A level Mathematics/Further Mathematics (Lee, 2016). It is therefore timely to consider the notion as to the fragility of a specific A level qualification – Further Mathematics.

This article originates from work undertaken as part of an external evaluation of the government funded Further Mathematics Support Programme (FMSP) by academics at Sheffield Hallam University (Boylan, Demack, Stevens, Coldwell & Stiell, 2016). The FMSP not only enables all students who wish to study Further Mathematics to have access to tuition, but also supports teachers and students in schools and colleges in a variety of ways (Lord & Lee, 2016). Current and historical participation data¹ was considered and an FM security construct created. In addition, the idea of Further Mathematics capital is outlined and reviewed in light of the analysis and evaluation undertaken.

Increases in Further Mathematics participation and entry

Since 2004 both the numbers taking AS and A level Mathematics and AS and A level Further Mathematics have increased. This is in absolute terms and as a percentage of the total entries to AS and A levels, see Table (i).

Table (i) Participation in A & AS level Maths & Further Maths 2004-2015

¹ "16-18 Performance Tables underlying data"

www.education.gov.uk/schools/performance/download_data.html

	Total number of A level entries	A level Maths entries as a % of total entries	A level Further Maths entries as a % of total entries	Total number of AS level entries	AS level Maths as a % of total entries	AS level Further Maths as a % of total entries
2004	675,924	6.8%	0.8%	878,794	5.8%	0.3%
2015	758,768	10.8%	1.8%	1,086,702	10.2%	1.5%

Source: Adapted from the Statistical First Release - SFR 38 2015 Table 14 (see www.gov.uk/government/statistics/a-level-and-other-level-3-results-2014-to-2015-provisional)

In line with this, since 2004 there has been a 10% increase in the number of state establishments offering A level Mathematics, but an 87% increase in the number offering Further Mathematics (Table ii). This is during the period of the FMSP (2009-present) and its predecessor the Further Mathematics Network (2005-2009).

Table (ii) State establishments with candidates taking Further Mathematics

	State establishments with candidates taking A level Further Mathematics	State establishments with candidates taking A level Mathematics	Percentage access* to Further Mathematics
2004/05	762	1926	40%
2009/10	1171	1874	63%
2014/15	1428	2115	68%

Source: DfE/MEI.

*Note. It is a requirement for certification in AS/A level Further Mathematics that AS/A level Mathematics has been, or is concurrently, being certificated, see: JCQ (2010).

The fact that the modal entry to A level Further Mathematics is just 1 student per establishment goes some way to highlight the subject's fragility. This has been the case for a number of years; table (iii) presents data for the past three years. As the number of candidates entered per establishment increases, the number of establishments decreases, in other words there are fewer establishments with higher numbers of candidates. In contrast, for A level Mathematics the number of establishments for each of number of candidate entries remains fairly constant.

Table (iii) State establishments with number of candidates taking Further Mathematics (Mathematics) up to 10 entries

	State establishments with number of candidates taking A level Further Mathematics (and separately, A level Mathematics)									
	1 entry	2	3	4	5	6	7	8	9	10
2012/13	203(73)	167(74)	151(68)	150(65)	116(76)	98(86)	69(72)	54(57)	50(71)	28(50)
2013/14	208(82)	196(72)	172(58)	128(84)	118(93)	101(73)	84(62)	55(61)	52(63)	53(61)
2014/15	203(73)	199(71)	185(71)	157(78)	119(51)	105(74)	87(84)	68(79)	46(64)	40(66)

Source: DfE

Developing a security construct

A 'security status' was constructed that considered the stability in the number of A level Further Mathematics entries over a three year period. Table (iv) below shows how these security statuses were constructed using data from 2013/14, 2012/13 and 2011/12 entries for A level Further Mathematics.

Table (iv) Construction of the security status

Number of A level Further Mathematics entries over 3 years (2011/12, 2012/13, 2013/14)	n	%	Assigned Security Status
No entries in all 3 years	674	29.9	None
Two years with 0 entries, 1 or 2 in other year	226	10.0	Least secure
One year with 0 entry, 1 or 2 in other year	114	5.1	Least secure
3 or more in any one year, low or none in other years	216	9.6	Less secure
At least 1 in all 3 years, no more than 3 in any year	44	2.0	Less secure
At least 1 in all 3 years, 3 or more in any one year	310	13.7	Less secure
Three or more entries in all 3 years	530	23.5	Relatively secure
10 or more in all 3 years	142	6.3	Highly secure
Total	2256	100.0	

Source: adapted from 16-18 qualification and subject level results

www.education.gov.uk/schools/performance/download_data.html

Further Mathematics security analysis

The security status for 2013/14 was considered in relation to school/college characteristics. The following was found:

- selective schools are most likely to have secure numbers of students taking Further Mathematics A level
- schools with higher numbers of Further Mathematics students have lower levels of students eligible for FSM and a slightly lower proportion of students with Special Educational Needs and Disabilities or School Action Plus. There is little difference in Further Mathematics uptake amongst schools with varying proportions of students with English as an Additional Language
- schools with a male only intake (at KS5) have significantly higher numbers of students taking Further Mathematics compared with female only schools and mixed schools. Highly secure schools have an average of 70% of boys on roll and 30% of girls on roll, whereas for relatively secure schools and less secure schools the average percentage of boys on roll and girls on roll is very similar (close to 50/50)
- higher attaining schools at KS4 (based on % attaining 5+ A*- C including English and maths GCSEs) tend to have higher Further Mathematics security
- similarly schools with higher average point scores at KS5 have a larger proportion of students doing Further Mathematics and thus greater security

The above findings for Further Mathematics security accord with previous research on patterns of participation in A level Mathematics (see Matthews & Pepper, 2007; Noyes, 2009).

Changes in Further Mathematics security

Security status was calculated for a further two periods of 3 years and patterns of change identified. The table below summarises changes from 2012/13 (based on 2010/11, 2011/12, 2012/13 entries) to 2014/15 (based on 2012/13, 2013/14, 2014/15 entries):

Table (v) Change in security 2013 to 2015

2012/13 (2010/11, 2011/12, 2012/13 data)	2014/15 (2012/13, 2013/14, 2014/15 data)						
		None	Least secure	Less secure	Relatively secure	Highly secure	Total
	None	487	104	56	0	0	647
	Least secure	76	132	108	0	0	316
	Less secure	13	56	334	138	1	542
	Relatively secure	0	0	91	368	35	494
	Highly secure	0	0	0	28	107	135
	Total	576	292	589	534	143	2134

Analysis therefore shows:

- in total 706 centres experienced a change in status (33% of the total)
- 442 centres moved towards a more secure status (63% of those experiencing a change in status)
- of the 647 centres who had no records for A level Further Mathematics in 2010/11, 2011/12 or 2012/13, 160 (25%) moved into the more favourable categories of "least secure" and "less secure"
- of the 316 centres in the "least secure" category in 2012/13, 108 (34%) moved in a positive direction to "less secure" whilst 76 (24%) moved into "none"

The general pattern of movement of centres towards a more secure status reflects the general increase in numbers of Further Mathematics students. However, the analysis shows that this increase is not restricted to centres that already had relatively high levels of Further Mathematics entries. The analysis also reveals that the number of entries is less stable in less secure centres; there is a continuing fragility of entries in some of these centres. In summary, there has been an increase in both capacity and sustainability of Further Mathematics provision, although there is potential for further improvements.

Further Mathematics capital

The concept of Further Mathematics capital is an extension of the concept of science capital – a means to conceptualise the interplay of social, cultural and familial practices, knowledge and relationships that support engagement in science and influence patterns of participation (Archer, DeWitt, Osborne, Dillon, Willis, & Wong, 2012, also Archer, Dawson, DeWitt, Seakins, & Wong, 2015). This can be extended to consider mathematics capital (Noyes, 2016, Williams & Choudry, 2016, also Noyes, 2009; Noyes & Adkins 2016). However, in this paper we focus on a further extension to consider organisational Further Mathematics capital.

A mixed-methods approach was used to investigate this as part of the external evaluation of the FMSP. This included teacher interviews and student focus groups. Teachers identified the characteristics, context and attainment profile of the school and its student intake as the primary factor that either enabled Further Mathematics engagement or, could also be a barrier to [more] engagement. Senior leadership support was important, as were personal success stories of students who had excelled in Mathematics/Further Mathematics.

Key aspects of teacher capital found were:

- enjoyment of mathematics
- commitment, energy, accessibility in relation to mathematics
- capacity to teach Further Mathematics (in post 16 settings) or to offer additional support for those taking "Live Interactive Lectures (LiL)" and similar provision
- a Further Mathematics enthusiast/champion (including in 11-16 settings someone who encourages engagement with mathematical problem solving and so on)

Departmental features contributing to organisational capital were:

- cohesive and supportive relationships
- specialist mathematics teachers
- contribution to A level teaching being the norm
- commitment to enrichment and a 'love' of mathematics
- investment in students interested/capable of doing Further Mathematics

The concept of Further Mathematics capital offers a way of conceptualising the role of the FMSP in the way it positively impacts on both individual and organisational capacity to engage in Further Mathematics through the following aspects of the programme.

- **Enrichment experiences.** Positive enrichment experiences through KS3 and KS4 were identifiable as a recurring element across a number of student timelines of their mathematical experience and choices. Enrichment experiences also helped support positive mathematical and so Further Mathematics cultures
- **Tuition.** Making Further Mathematics more available including supporting high security centres to extend module options
- **CPD.** Strengthen teaching skills and knowledge
- **On-line resources.** For other centres (including those with low/no Further Mathematics security), the free Integral resources provided by the FMSP were identified as providing access to materials that helped less experienced staff develop their skills at an individual level

The FMSP is a particularly important part of school-level Further Mathematics ecologies in contexts where the internal ecologies do not support secure or in some cases any Further Mathematics entries.

Looking to the future: fragility of Further Mathematics?

Whilst Further Mathematics capital has been established as a concept, several features emerged as threats to maintaining it, these include:

- recruitment and retention of experienced/qualified teachers
- squeeze on budgets
- the impact and the availability of Further Mathematics in-house most keenly experienced by centres with lower security ratings
- distance from or links with enrichment at local universities

Most teachers were unsure what the impact of future changes to GCSE and A level mathematics qualifications and curricula would be, but a few saw this as a potential barrier to future take up of Further Mathematics. In particular that a two year A level course in a challenging subject like Further Mathematics could be thought of as too risky - particularly for less confident students (as the AS qualifications are de-

coupled and the examined material does not form the first half of an A level qualification).

All of these issues in respect to Further Mathematics capital are happening at a time where there is considerable apprehension over the changes to post-16 funding and to the curriculum as cited at the beginning of this article. Whilst no-one wishes to see a reduction in student numbers study AS/A level Mathematics and Further Mathematics going forward, with all of the changes there is great potential for a drop in participation to happen, due to the challenges faced by centres.

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