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Gender and Participation in Mathematics and Further Mathematics: Final Report for the Further Mathematics Support Programme

Cathy Smith and Jennie Golding



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FMSP Case Studies: promoting girls' participation in mathematics

Fewer girls than boys in England participate in post-compulsory mathematics and the recent increase in popularity of Mathematics and Further Mathematics (FM) at age 16 has not changed the gender balance. Previous research has shown the significance to girls of their perceptions of mathematics lessons and teachers, of discursive co-constructions of masculinity and mathematics, of the range of careers associated with mathematics and science, and of family 'science capital'¹. Working with the FMSP, IOE has designed and carried out case study research to examine strategies and factors that have contributed to unusually high participation by girls in mathematics A-level. This report further develops the Interim Report², analysing data from the final visits and confirming findings for the four case-study schools and one Further Education (FE) college.

The Study

Case studies were conducted in four state-funded schools and one Further Education college identified as making an impact on girls' participation in mathematics. Teacher and student focus groups and observations were used to examine strategies and factors that have contributed to unusually high take-up of A-Level mathematics.

The case study sites were selected by a combination of these approaches

- asking all FMSP area co-ordinators and IOE contacts for recommendations of schools or colleges that they considered to have unusually good girls' participation;
- examining published DfE school-level data on the proportions of girls entered for Mathematics and Further Mathematics A-level in 2012-13³;
- ensuring some diversity in region and school type, including one school where classes are single-sex to 16 (as girls' participation is higher in single –sex schools) and one FE college (as 10% of A-level students are at an FE or Tertiary college);
- preferring schools with a non-selective intake (for greater generalisability);
- willingness to participate (2 initial requests declined).

In recent years, an average 40% of those completing Mathematics A-level are girls. The imbalance is greater for Further Mathematics (FM) A-level with just under 30% being girls (lower by a few percent in FM for the state-funded sector). For this study we chose not to prioritise this within-mathematics measure since the focus was on increasing girls' participation rather than comparison with boys'. Instead we used the measures given for

¹ See Smith, C. (2014) *Gender and participation in mathematics and further mathematics A-levels: a literature review for the Further Mathematics Support Programme*. London: UCL IOE.

² Smith, C., and Golding, J. (2015) *Gender and Participation in Mathematics and Further Mathematics: Interim Report for the Further Mathematics Support Programme*. London: UCL IOE

³ DfE. (2014a). *A level and other level 3 results: academic year 2012 to 2013 (revised)*. Retrieved from <https://www.gov.uk/government/statistics/a-level-and-other-level-3-results-england-2012-to-2013-revised>

England by the DfE from 2013-16: the proportion of girls completing mathematics and FM A-levels out of the cohort aged 16-18 who completed at least one A-level that year. On this measure, in 2012-13, all selected sites exceeded average performance, whether calculated for all schools in England or for only state sector schools:

Averages in 2012-13	Number of students in A-level cohort	Number of Female Students in A level cohort	% of Girls completing Mathematics	% of Girls completing Further Mathematics
England	261,468	143,303	20.4	2.4
England (State-funded sector)	227,294	126,390	18.4	1.8

Three of our case study sites have asked to be named in this report, while two have pseudonyms. The case studies are sited in the North-West, South-East, East Midlands and London, with the following characteristics.

	Area	Gender	Type	Size of A-level cohort in 2012-13	Decile for % of Girls completing Maths in 2012/13 (state sector only)	Decile for % of Girls completing FM in 2012/13 (among state sector only)
School A (Shenley Brook End School, Milton Keynes)	Town	Mixed	Academy	100-150	10 (10)	9 (10)
School B	Inner city	Girls to 16 then mixed	Voluntary Aided	Under 100	9 (10)	8 (8)
School C (Beauchamp College, Oadby)	City conurbation	Mixed	Academy	Over 300	8 (9)	7 (8)
School D	Outer city	Mixed	Academy	100-150	10 (10)	8 (9)
College E (The Manchester College)	City	Mixed	FE college	100-150	8 (9)	8 (9)

It is noticeable that few of these schools fall in the top decile for Mathematics entries, even when we exclude independent schools from the comparison. This results from our decision to avoid schools where internet searching suggested a history of selective intake. Many of the state-funded schools in the top decile are either single-sex schools or over-subscribed

former grammar schools and we considered them less useful for determining how most schools can increase participation. Previous studies suggest that girls' participation is higher in single-sex schools because more girls with A or B grades choose mathematics. We thus restricted the sample to one single-sex school, with a mixed sixth form.

The corresponding figures for girls' participation in 2012-13 and 2013-14 (before the study) and 2014-15 (during the study) are shown in the table below. These are included for comparison and validation but were not used for initial selection. Three of the schools have sustained their relatively high participation for girls in mathematics A-level over the study period. School B showed variation in girls' participation, perhaps due to its smaller sixth form size, but this could not be explored as the school did not participate in follow-up visits. Recent DfE data for the FE college showed a sharp fall in 2014-15 to below-average girls' participation; however these figures do not include students aged over 18 (for example, the follow-up visit elicited that there were more girls in the actual student body, and small AS/A2 Further Maths groups in both 2013-14 and 2014-15 with the latter being all female).

Looking at Further Mathematics, it remained the case that high girls' participation in maths did not necessarily translate into high rates for Further Maths, although most sites have sustained at least one girl per year. Variations in the proportion are expected because of the smaller numbers taking FM, with class sizes between 1 and 23.

Site	Size of A-level cohort	Decile for % of Girls completing Maths (plus in state sector only)			Decile for % of Girls completing FM (plus in state sector only)		
		2012/13	2013/14	2014/15	2012/13	2013/14	2014/15
School A (Shenley Brook End School, Milton Keynes)	100-150	10 (10)	8 (9)	9 (9)	9 (10)	9 (9)	9 (9)
School B	Under 100	9 (10)	7 (8)	8 (9)	8 (8)	8 (8)	9 (10)
School C (Beauchamp College, Oadby)	Over 300	8 (9)	8 (9)	8(9)	7 (8)	6 (7)	7 (6)
School D	100-150	10 (10)	10 (10)	10 (10)	8 (9)	No girls	7 (7)
College E (The Manchester College)	100-150	8 (9)	8 (9)	4 (4)	8 (9)	None aged 16-18	None aged 16-18

The research questions driving the study in each case are:

1. How is girls' participation in mathematics related to their prior attainment in mathematics?

2. Are there any intentional strategies addressing girls' participation in mathematics or STEM recruitment more generally? How are these conceived, operationalised and evaluated?
3. Are there aspects of mathematics pedagogy that support girls' self-concept, enjoyment or interest in studying mathematics?
4. Are there aspects of careers or teacher guidance that support girls' self-concept, enjoyment or interest in studying mathematics?
5. What messages are current in school culture about who does mathematics?

A case study methodology was chosen to produce detailed, contextual information about the practices of mathematics teaching and recruitment in each school and the beliefs of teachers and students about gendered participation in mathematics. Teachers' and students' accounts are emphasised in our design, acknowledging that teaching (for teachers) and choosing subjects (for students) are highly reflexive practices, for which reasons are sought and articulated to oneself and others⁴. Nevertheless, this approach runs the risk of foregrounding explanations that are dominant because they are popularly or powerfully accepted. Other explanations were explicitly sought in the teacher focus groups, and coherence tested through triangulation with lessons observations, student records and respondent validation.

Initial visits were made over a term in autumn 2014 to carry out the following field work at each site:

- A 50 minute focus group of 3-5 mathematics teachers, including the head of KS5 mathematics, exploring their strategies for retaining girls in mathematics and their responses to contributory factors of pedagogy and guidance identified in the literature review;
- Compiling quantitative data on mathematics class size, module choices and mathematics AS or A-level grade profile by gender for year 12 and 13 students for the years 2013-14 and 2014-5;
- Observation of an A-level or GCSE mathematics lesson with a schedule based on factors identified as promoting participation;
- A 50-minute focus group with five year 12 girls who chose to study A-level mathematics exploring their experience of mathematics classrooms, their perceptions of mathematics as a gendered subject and their reasons for choosing whether or not to continue;
- In schools A-D, a 50 minute focus group of five year 11 girls predicted A* to B in mathematics GCSE with the same structure as above.

A summary description of each case was prepared and sent to each site for respondent validation in early 2015.

⁴ Smith, C. (2010) *Choosing more mathematics: happiness through work?* Research in Mathematics Education, 12 (2). pp. 99-115.

Follow-up visits in autumn 2015-16 comprised an interview with each lead teacher confirming the stability and extent of the trends observed, collecting data related to transition between year 12 and 13, and gathering evidence of any new initiatives or further reflection on girls' participation.

Findings

This section reports the findings of the whole study. For each case, an overview of the context is followed by the summary from the interim report and discussion of new findings related to girls' participation, focusing in particular on patterns in transition between years 11, 12, and 13, new developments at the school and uptake of Further Maths. Then we review the common features of the case study schools, as identified in the interim report and with extended discussion after the follow-up visits.

Case Study School A: Mixed, Town Comprehensive

Shenley Brook End Academy

Shenley Brook End is a large, mixed comprehensive 11-18 converter Academy of about 1500 pupils. It recruits largely from its catchment - a district of a large town – and is a popular over-subscribed school. There is some movement of students for A-level, both in and out. In 2013 it lay in the fourth quintile for proportion of students with free school meals. The proportion of students from minority ethnic groups is higher than the national average but not a majority; most students are of White British origin. It has a history of involvement in mathematics, having previously been a Mathematics and Computing Specialist school and now involved in leading a maths hub.

In the interim report, we identified three related factors that ensured the school's success in recruiting girls to A-level mathematics:

- Teaching at the school prepares many Key Stage 4 students for A-level mathematics, for example expecting all top set student to take Level 2 Further Maths in lesson time, and provides connections with A-level content that demystify reports of its difficulty.
- Students feel that a range of different ways of learning mathematics are valued and supported by teachers, and will lead to success.
- Careers advice in the school starts early and promotes mathematics as keeping options open, with a particular emphasis on the broad career relevance of mathematics with statistics, which is an option at AS and A-level.

The school was selected for this study on the basis of having nearly double the national average percentage of girls taking mathematics and further mathematics in 2012/13. Follow-up data showed that year to be exceptional; however an above-average performance has been sustained. In the classroom, this gender balance is not so marked since boys also participate very well. Over the two years of the study, the mathematics cohorts ranged from 38% to 45% female. The Statistics-only AS level class has the highest proportion of girls, half being female, while some Further Mathematics and mechanics classes have been over 90% male.

The school accepts students with a GCSE grade B to take mathematics, and a grade C to take statistics in year 12. As reported in regional data⁵, the school finds that, out of the B-grade students, more boys than girls choose mathematics A-level, but it does recruit a number of girls with both B and C grades for mathematics or statistics. The school data on retention is consistent with teachers' perceptions that more boys than girls change subjects away from mathematics in the first weeks of year 12; however the proportions who leave between year 12 and 13 were similar for boys and girls. Thus this school fits the patterns that high-attainers are more likely to choose mathematics, and that boys' numbers are boosted by the participation of those with B grades. It has been successful in finding routes that support participation for enthusiastic students with lower grades, at least in year 12, and this has raised girls' participation through to A-level.

Follow-up visits investigated new developments in mathematics teaching that could affect participation. The first of these resulted from abandoning early entry at GCSE, with the result that the department focused more on the distribution of grades from A* to B. Extra morning revision sessions were scheduled, intended for students on a B grade. The staff noticed its popularity among high-performing girls:

However, all the girls in my group who are already at that A* level...oh, can we come along? And then they all wanted to come along just to....I suppose boost their own self-confidence and helping others as well. So it was very, very well attended by the girls, and especially the more able girls. I guess it gives them a bit of confidence really that they can do it.

The teachers had discussed how to manage this diversion from the original purpose of the group. They chose to encourage the girls and also to let them attend sessions in friendship groups rather than normal classes. This flexibility in providing support for students in the way they want it is another example of how the school operationalises its value for different ways of learning (see summary above).

Core maths was another new initiative in 2015-16. The school recruited a class of 20 of whom 13 were girls. Care was taken not to reduce the A-level cohort, so that Core Maths was not offered until after GCSE results had confirmed A-level choices, and then opened to anybody not taking maths or statistics A-level, within an 'extended studies' block. The message given by the head of KS5 continues to promote mathematics as widely useful, with a range of options for different career needs:

we say core maths really is for those students who really don't want to do A-level maths because they don't need it... But they still need some maths for other subjects that they need. So they're doing business or they're doing geography or biology, and still need that kind of mathematical component. Or they just want to continue with their maths and study things they think might be useful.

⁵ eg Noyes, A. and Adkins, M. (2016). Studying advanced mathematics in England: findings from a survey of student choices and attitudes. *Research in Mathematics Education*, 18(3): 231-248.

In a similar vein, D1 was offered for students interested in computer studies, and when this failed to recruit enough for a whole class, was offered as a stand-alone module in the same block.

These strategies for matching mathematics courses to future career needs are seen by teachers and students as significant in recruiting widely for mathematics and statistics. It produces a different effect on participation in Further Mathematics. FM is treated as a specialist subject that is suitable for some career paths and for those students – usually boys – who have no other viable choices at A-level. This is enough to sustain a group, and during the study boys and girls took further mathematics in equal numbers in the school. However teachers emphasised how careful they are to advise girls about the requirements of universities and that further mathematics narrows careers options, specifically for medicine.

Case Study School B: Single-Sex to 16

School B is a federated (nominally catholic) comprehensive in an inner-city area. Unusually, it comprises separate boys' and girls' schools 11-16, together with a mixed sixth form – over 1500 students overall, with similar numbers of boys and girls. The proportion of students eligible for pupil premium is over twice the national average; about half have English as a second language. The girls' school is seen to be more successful than the boys'; the sixth form is also seen as successful although many more academic students go elsewhere at 16, there being multiple choices easily accessible. About 25% of students are of White British origin with an above average proportion of students from minority ethnic groups, the biggest of which is Black British African.

In 2012-13, fewer than 100 students completed at least one A-level; out of these, nearly 40% of the girls sat Mathematics A-level and just over 40% of boys. 3% of the girls took Further Mathematics A-Level, and 10% of the boys. The school was selected for this study on the basis of these above-average proportions of girls taking mathematics and further mathematics in a large, comprehensive school with a small sixth-form. The data more recently collected shows that girls' participation in the mathematics classes has been variable but still above-average, and teachers report that in most years, but not all, boys' participation only slightly exceeds girls'. In some years further mathematics participation is comparable, in others there are only boys. Girls' participation in 2015-16 promised to be particularly strong, with an outstanding cohort of girls in the top set, taught by a female teacher, intending to stay into the sixth form and study mathematics and/or further mathematics.

In the interim report, we identified two related factors that ensured the school's success in recruiting girls to A-level mathematics:

- Mathematics teaching, and single sex grouping, in the school inspire confidence and although the school is focused on exam performance in KS3/4, some mathematics teachers are aware of disadvantages for students' mathematical understanding when students are not challenged, and are able to mitigate some of this.

- There are particular (female) teachers in the school who act as personal champions for the group of top set girls and their future participation in mathematics, both within the student group and in the department.

Further mathematics also gains from the popularity of the mathematics department and is seen as a secure AS-level subject, especially by students recently arrived from abroad.

Unfortunately the school did not participate in follow-up visits.

Case Study School C: Upper School

Beauchamp College

Beauchamp College is a large, comprehensive 14-18 converter Academy of about 2000 pupils. It recruits locally within a city conurbation and is seen as one of the more successful schools in the area. In 2013 it lay in the lowest quintile for proportion of students with free school meals. The majority of students are from established minority ethnic groups. Mathematics is a strong department in the school, which is involved in leading a maths hub.

In the interim report, we identified two related factors in the school's success in recruiting girls to A-level mathematics:

- Teaching at the school anticipates able Key Stage 4 students studying A-level mathematics and makes participation feel expected, personally achievable and pleasurable.
- Careers advice promotes mathematics as relevant and essential for keeping options open and achieving career goals, confirming girls' judgements in their subject choices.

In 2012-13, several hundred students completed at least one A-level; out of these, over 25% of girls sat Mathematics A-level and around 40% of the boys. Numerically the mathematics classes had nearly twice as many boys than girls. This ratio was similar for further mathematics numbers, with 2% of girls and 4% of boys taking the full A-level. Despite the prevalence of boys, the school was selected for this study on the basis of recruiting above-average proportions of girls to take mathematics and average proportions for further mathematics in a very large comprehensive school. This above-average performance has been sustained, and classes are more balanced. Over the two years of the study, the mathematics cohorts ranged from 40% to 48% female. Within this, most classes are in fact balanced but the Further Maths AS and A2 classes (between 10% and 30% female) bring the average down. The main A-level FM teacher in the school is male, and lesson observations showed boys dominating the public teacher-student talk. Girls are supported by departmental messages about the utility of mathematics and teachers' willingness to support and engage with individuals .

More boys than girls take further mathematics in the school, and students associate this imbalance with a perception that they need to provide their own impetus to choose it. Teachers note that the school has a policy that FM must be a fifth A-level and that they find they are "persuading girls to do it and boys not to do it". The remedy is a one-year AS FM course, intended to meet the needs of year 13 students who discover they would benefit

from FM, for example for entry to economics degrees. This is taught by a woman and comprises nearly half girls. The option of this one year course is seen as valuable in redressing initial subject choices that prove limiting for girls.

The school accepts students with a GCSE grade B to take mathematics. In the second year of the study, the department had become more aware of gender patterns. They had become more intentional in asking teachers to speak informally to year 10 and 11 girls with the potential for As and A*s and encourage them into A-level. They had also noticed that, while external students joining the school in year 12 tended to be boys with As and A*s, there were a number of girls coming from within the school sets 3 and 4 and wanting to take mathematics, and they welcomed these students. This pattern may account for the higher proportion of boys gaining A or B module grades at the end of year 12 (71% to 49%). Over half the students continued from AS to A2 mathematics; this included slightly more boys (64%) than girls (58%). The school is committed to setting an expectation that all year 11 top set students and some lower set students will progress to A-level mathematics.

Follow-up visits investigated new developments in mathematics teaching that could affect participation. The school had worked particularly on developing resilience in students, emphasising the value of starting questions without a clear strategy and giving “permission to be wrong and it be a really good mistake to make”. They associated this with raising performance among low-attaining boys and high-attaining girls, who were both limited by risk-averse behaviour in mathematics. They also commented that girls continued to take more advantage of the department’s extra revision sessions and its open door policy of giving ‘ten minutes help’ to KS4 and 5 students. This provision of less public support was seen as important to keeping mathematical conversations with girls.

Case Study School D: Rapid Improvement in Mathematics

School D is a large, comprehensive 11-18 converter Academy of over 1000 pupils in an outer city area. There is also a Primary department of a similar size. It recruits largely from its catchment – a suburb that is often a first move from more stressed inner city areas – and is seen as rapidly improving. It has an above-average proportion of students with free school meals. The vast majority of students are from minority ethnic groups, with about 10% in the early stages of English language acquisition. It has experienced substantial improvement in recent years, gaining ‘outstanding’ in its last full inspection and going from strength to strength in terms of measurable outcomes.

In the interim report, we identified three related factors in the school’s success:

- Students are emotionally and cognitively prepared for A-level by a Key Stage 4 curriculum that builds up challenge gradually, in highly structured ways.
- The school confirms family messages that many students will need mathematics in their careers; and adds a message that the majority of students can succeed in mathematics, and encourages them to aim for A-level from KS3 onwards.
- Girls feel that they are known by their teachers and that their personal work habits are attended to.

In 2012-13, over 100 students completed at least one A-level; out of these, just over 60% of the girls sat Mathematics A-level and just over 70% of boys, but similar numbers of each. In further mathematics, over 3% of girls and the same of boys took the full A-level. The school was selected for this study on the basis of these above-average proportions of girls taking mathematics and further mathematics in a large, comprehensive school. Data more recently collected shows that participation in mathematics post-16 continued to thrive. Overall, numbers taking mathematics in recent years were similar for boys and girls, with classes from 43 to 50% female. Retention between AS and A-level is good, with only 24% of boys dropping mathematics and 32% of girls. The mathematics department promotes its successes so that: “students right down the school know that maths is good here.”

The coming introduction of the new GCSE was not planned to change the school’s approach of early entry mathematics GCSE aiming at an A grade, then studying level 2 Further maths qualifications in preparation for A-level.

Some years have seen significantly more boys taking Further mathematics. This is not presented as much more difficult than mathematics but is regarded as an extra for the very interested. Teachers see the mechanics in FM as affecting girls’ choices, and also perceive a friendship group effect where a few girls will decide together on FM in year 11. Recruitment focuses on a narrower range of those who display marked interest and is not normally targeted at girls:

And we wouldn’t go overboard on encouraging them to do FM, it’s a very personal thing I think, for those who really, really enjoy maths and want to spend a big proportion of their time doing it. Whereas for the boys, a lot of them will just jump in with both feet.

The school appreciates that this limits girls who “don’t really ‘catch’ maths until they’re in the sixth form, despite having done well before that – they suddenly get hooked when they see the power and the elegance of some of the things you meet at AL”. They had anecdotes of girls reading university guidance that FM is preferred and applying elsewhere to study mathematics, while boys applied regardless. The department appears less concerned with identifying where FM could be useful for future study than it is for mathematics.

Case Study E: Further Education College

The Manchester College

The Manchester College is a large inner-city College. It recruits from a very wide catchment including outlying rural areas and is seen to be upcoming. The large majority of its students come from areas of high economic and social disadvantage, and are from minority ethnic groups; a significant minority are recently arrived, with very limited English.

Clearly an FE college has different strategies from a school in that they cannot ‘grow their own’ mathematics students in the way that the four previous case study schools have aimed to do. In the interim report we identified that this college has:

- Developed an identity for itself that is centred around engineering and technology employment opportunities, and is recognised within the college and in the local press;

- Invested in personal careers advice for new students, and for prospective students at open evenings, emphasising pathways in which mathematics is an essential companion or central subject;
- Created an atmosphere in which students find it easy and rewarding to take on extra work and seek help, including support for individualised further mathematics programmes of study.

In 2012-13, over 100 students completed at least one A-level; out of these, just under 30% of the girls and just over 55% of boys sat Mathematics A-level, though numerically there were similar numbers participating. 3% of girls completed Further Mathematics, and 10% of boys. The college was selected for this study on the basis of these above-average proportions of girls taking mathematics and further mathematics for Further Education colleges, where participation tends to be relatively low⁶. The data more recently collected shows that since 2012-13 girls' participation has generally been numerically less than boys', though still at a good level for FE. Over the two years of the study, the mathematics cohorts ranged from 37% to 54% female. Data sources are not always consistent for this college, partly because of the very flexible patterns of entry in sitting and resitting A and AS-level modules, sometimes over three years.

Follow-up visits investigated new developments in mathematics teaching that could affect participation. The FE college reported strong effects of funding and reorganisation. The management had decided to prioritise vocational education at the college so that recruitment and careers guidance were downplaying academic A-levels and the number of mathematics classes had fallen. There was nevertheless sustained demand from students, particularly those for Eastern Europe, to plot their own route through mathematics and further maths A-levels.

In further mathematics, participation was generally greater by boys, although usually more girls than boys picked up AS Further Mathematics in year 13, when they've become "hooked" on it. The policy change to funding a fourth A-level only where students average a grade B meant that FM was now rarely offered if 3 other A-levels were viable.

The lead teacher continued to provide a rich programme of visits and events that promoted STEM and engineering. As a result of participation in this project she had changed the way she advertised these, by publicising in the more gender-balanced mathematics group before doing so in the science and engineering groups. This had further increased girls' take up of those opportunities.

Overall Findings

The following common features were identified in the interim report and have been confirmed by the last analytic phase. New findings have been added in sections 1-4 and 5b, preceded by *.

• ⁶ In 2013-13, 14% of the female cohort in FE/ tertiary colleges took mathematics and 1% took FM.

- 1) The case study schools had not been involved in specific initiatives to attract girls to study mathematics; instead there was a strong culture of encouraging students to aspire to take mathematics at A-level. Girls did not see the need for such initiatives because the dominant attitude was “we’re good at it, we enjoy doing it, why wouldn’t we?”

*Participation in this research raised awareness of girls’ participation in mathematics within the department. Several departments reported in the follow-up study that they had increased their thinking and monitoring on gender issues. Girls’ participation was considered more systematically when evaluating new practices. Examples were: a year 11 teacher used the number of girls attending revision classes as a positive factor in their evaluation; Year 10 teachers were tasked with identifying girls and groups of girls with the potential to study A-level and communicating this to them informally and regularly; a department head reflected on the new school focus on resilience in relation to its differential impact on girls and boys; a STEM lead noticed that information about extra-curricular STEM career opportunities had previously been disseminated through classes that already had a gender imbalance, and looked for ways to reach more girls. In such ways, the departments aimed to embed strategies that had previously been implicit or teacher-specific.

- 2) In these schools there was a strong expectation, even pressure, from teachers on students that they will get a B and above at GCSE and then choose A-level mathematics. This expected mathematics pathway was communicated before year 10, and as early as year 8.

*All the schools had an admission requirement for A-level mathematics set at a level that included the expected GCSE performance of all in the top sets and some in others. Where departments encouraged students with a B or C in GCSE they expected some drop out in the early weeks of year 12 and the school had mechanisms for change. Fewer girls than boys left at this stage, increasing their relative participation. Retention between AS and A-level mathematics was broadly similar for boys and girls in each school.

- 3) The school and college departments were active in promoting mathematics as a subject that has wide applicability, and so opens doors to many valued degree courses and careers. Girls in this study aspired to careers/degrees in: the forces, sports science, law, teaching, maths, maths & music, bio-chemistry, medicine , neurobiology, dietician, orthoptics, youth work, engineering, physics, computing, forensic science, aeronautical engineer, computer engineer, pharmacy and other medical sciences, and several had not yet decided. This argument is visible in corridor and classroom displays of the relevance of mathematics to careers and to ‘changing the world’. Girls reported it significant to their enjoyment when teachers took the time to explain how abstract mathematics topics can be applied in practical situations. It was significant to their decision making when teachers talked to them personally about their futures and the flexibility of mathematics in whatever they decide. The message repeated by girls in these schools emphasises broad exchange utility for good courses over the value of mathematics for accessing elite courses.

In addition, two of these schools timetabled AS Further Mathematics in year 13 in order to support students who discovered they required it for degree courses. They encouraged girls to consider this option.

- 4) The schools all offered a Mathematics A-level option that includes statistics in year 12 and they promoted this as beneficial because of its social-science applications. Girls are more likely than boys to consider careers supported by studying statistics, so this school –level offer is understood to match their needs and promote participation.

*Three cases offered statistics-only (ie S1 and S2) routes to A-level; two of these also had a smaller mechanics-only route but the single-sex girls' school did not. The other two schools specified S1 in year 12 and M1 in year 13, intentionally starting with S1 for wider appeal. All FM routes included mechanics and statistics.

- 5) Teachers instilled a belief that students will succeed in Mathematics A-level. This is reported by the girls as critical in their choice, and it is accomplished by a combination of strategies.

- a) Schools A, C and D have chosen to introduce more mathematics topics and qualifications alongside GCSE in the year 11 scheme of work for students who are expected to gain a B or above (and in some cases already have). In itself, this establishes habits of high expectations and hard work. The actual effect of gaining another qualification is not mentioned by staff or students. Instead the girls valued the opportunity to evaluate their interest in some topics they would meet in A-level, to test the emotional and social effects of working on what is reported to be a very difficult material, and to discuss with their teachers how they are coping. In school B, the girls reported similar feelings from working on the most advanced GCSE material. In school A, a trip that introduced A-level material was popular for the same reason.

- b) Teachers in all schools made themselves available to individual students both in and out of lessons. Requests for help were taken seriously. Girls reported that teachers know them individually, know how they like to work and accommodate this. Teachers in the three mixed schools described only one purposefully girl-friendly teaching strategy: to direct questions to quieter students. This was observed in during whole-class teaching phases of lessons where some students, usually boys, made the majority of spontaneous comments about learning, and teachers encouraged others to contribute questions, answers or comments. The girls reported a slightly different perspective on teaching strategies: they valued teaching that gave opportunities to check understanding by discussion with friends, by quiet conversations with the teacher and to return out of lessons if necessary. In several of the schools, and in the college, students could choose which A-level modules or year 11 qualifications they would study, and although some girls disliked the lack of whole-class teaching and organised group work that resulted, they still valued the responsiveness to individual preferences. *Four cases operated a version of 'open door' departmental policy where it was accepted that students could seek help outside lessons, and this was considered to involve mainly girls.*

- c) Girls in these schools feel they are repeatedly and positively encouraged by teachers to choose mathematics for A-level in private conversations and in public. This happens without any mention of stereotypes of gendered participation in mathematics. Teachers suggested that girls lack confidence compared to boys, while girls frame this more positively as being mature and cautious in their decisions. There was no message in these schools that lower confidence affects one's mathematics ability. Instead teachers reiterated that the girls' past performances and work habits indicate that they will succeed.
- 6) There were at least two respected female mathematics teachers in each school who taught year 11 top sets and A-level classes, and were cited as influential by staff and students.
 - 7) Schools were assisted by strong family appreciation of the value of mathematics and the role of hard work. Family encouragement was brought up spontaneously by the girls who suggested that high family expectations in general were connected with continuing with mathematics. In schools B, C and D, and college E this was also linked to the high valuation of mathematics within families in minority ethnic communities. In those situations, schools had a role in providing accurate and realistic careers advice.
 - 8) Further mathematics provision was stable in each school, supported by senior staff, with a protected place in the timetable even in years when numbers were small.
 - 9) Recruitment for further mathematics emphasised intrinsic motivation. Teachers encouraged students to consider whether they enjoy working independently on lots of mathematics questions, and built an understanding that this subset should take further mathematics: a 'motivated core' rather than a 'clever core'. However, even in these schools, there was less direct encouragement to take further mathematics. Some girls felt that this affected girls' participation: those who publicly put themselves forward during year 11 (mainly boys) were welcomed and increasingly referred to as motivated future further mathematicians, while those who were quieter (mainly girls) were not.
 - 10) There is a belief among teachers and parents that Further Mathematics A-level is not suitable for students considering medicine; this is highlighted in career advice for girls, for whom medicine is treated as a likely aspiration. Some schools have responded to university requirements for grades to be achieved in year 13 and managed teaching so that the Mathematics and Further Mathematics A-levels are completed together.

Recommendations

The findings of this follow-up work have supported the recommendations made in the 2015 Interim Report. These have already informed the design of a pilot intervention study that investigates how such strategies could be adopted in other schools. Here we summarise the recommendations of the interim report and how they have been taken forward.

Recommendation 1: The study found that teachers' awareness of the national picture of girls' under-representation in STEM was mentioned - if at all – as local to physics and

engineering. Their interest in issues of engaging girls in mathematics itself suggests that this may be a good time to raise the profile of strategies to recruit girls. The study reinforces the importance of the FMSP's role in the professional development of KS4 teachers and departments in understanding how schools can trace the effects of their practice on students' decisions.

Actions: The FMSP and UCL IOE have worked with Maths Hubs to communicate accurate information about the issues around girls' participation, to recommend how schools can adopt curriculum and classroom-level strategies for preparing and encouraging all students that will be particularly effective with girls, and to provide instruments for evaluating the effect on students' motivation. Girls' participation is a focus of the Level 3 working groups and continued FMSP research.

Recommendation 2: We recommend that the FMSP should develop a limited collection of activities for use in open evenings, taster days, mathematics lessons and other opportunities to promote mathematics and further mathematics. These activities should introduce A-level topics through problems accessible to year 10 students and parents. There should be separate promotional activities for Further Mathematics that should stress its distinctiveness and variety so that it is not viewed as more of the same.

Actions: The FMSP has developed information for teachers and presentations for parents and students that are designed to promote mathematics to boys and girls. Further materials have been developed and are being trialled in four schools involved in a new pilot project to implement strategies for raising girls participation. They provide a set of enrichment materials that show how mathematics is used to inform decision making in real-life social situations. See <http://furthermaths.org.uk/girls-teacher-resources>.

Recommendation 3: Three goals for professional development are relevant to girls' participation, and would benefit all students:

- Teachers should be familiar with A-level syllabuses and content so that they can perform their leading role in overtly orienting students towards it during years 10 and 11. Girls in these studies were heavily influenced by class teachers who could tell them what to expect of A-levels, and who highlighted during lessons how their existing mathematical ways of working would benefit them.

Actions: The FMSP's continuing CPD aimed at new GCSE and A-level increases the number of teachers who are informed about the nature of A-level and the progressions from new GCSE to A-level. In the FMSP's CPD, providers communicate the importance of showing girls that they are ready for A-level mathematics.

- Teachers should have a repertoire of mathematics activities and strategies that allow students to experience challenges and seek help without a whole-class audience, including those for individual-, pair- or group-work. Girls value a balance of whole class teaching and less public exchanges and support in developing their own ways of understanding and working on mathematics.

Actions: The FMSP have published a briefing leaflet, *Girls' participation in A level Mathematics and Further Mathematics* (<http://furthermaths.org.uk/files/FMSP-Girls->

[in-Maths.pdf](#)) (<http://furthermaths.org.uk/files/FMSP-Girls-in-Maths.pdf>), sent to all registered schools to disseminate the strategies identified in this report.

- It is important that teachers and others engaging with girls (including both parents and teachers of other subjects) give overt messages that they expect girls (and boys) to succeed in mathematics, and that this will sometimes require persistence and hard work, as well as short-term failures. Such messages are still sometimes counter-cultural. Girls in the study valued and responded to such support, but it needs to be given on an individual as well as a wider basis, particularly in relation to success in pursuing Further Mathematics.

Actions: The FMSP and UCL IOE have worked with Maths Hubs to communicate accurate information about the issues around girls' participation, to recommend how schools can adopt classroom-level strategies for preparing and encouraging all students to engage with challenging mathematics, and to provide instruments for evaluation the effect on students' motivation.

Future Steps

During 2016-17, a new study is being piloted by the FMSP, tracking schools who are promoting take up of A-level mathematics among girls and recording challenges and effects in the classroom. These schools are developing local strategies to increase girls' participation that are based on the recommendations from the Interim report. The outcomes of this study will guide the FMSP in determining how much support is needed for schools to make changes that pervade classroom practice and make a difference to girls' participation.

Changes to performance measures are likely to impact on some of the KS3/4 strategies we have noted as supporting girls in mathematics. Changes in per capita funding will almost certainly impact on the number of students who are allowed or encouraged to study four subjects at A-level. Clearly this affects A2 Further Mathematics which was offered as a fourth subject in these cases. This could add to a cycle in which the challenging funding situation disincentivises small classes, such as, typically, FM, for everyone. It will also disincentivise participation in Mathematics for those less confident of success. A recurrent message from this research is that girls are alert to the perceived risks of studying mathematics and less aware that their existing performance minimises those risks. It will be of even greater importance for schools to encourage accurate perceptions among girls and to have strategies that allow students to try a subject and change when necessary. Several of these schools offer AS FM in year 13, responding to and building up consistent demand from girls aiming for mathematically demanding university courses.

We recommend that policy change must be actively monitored for unintended impact on provision of FM AS in year 13, and girls' participation in all forms of Level 3 mathematics. Changes in A-Level specifications need to be clearly and widely communicated, in good time, if teachers of KS3/4 students are to build capacity and buy-in amongst their students.