Raising girls' participation in A-level mathematics: initial findings from 'good practice' case studies.

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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 studies have shown the significance to girls of their mathematics lessons and teachers, of discursive co-constructions of masculinity and mathematics, of the range of careers associated with mathematics and science, and family 'science capital'. This study identified four case-study schools and one Further Education (FE) college with unusually high participation by girls in mathematics A-level. Focus groups and lesson observations were used to explore factors relevant to girls' participation. Common factors were: preparation for demanding mathematics during key stage 4, a departmental ethos which encouraged student-teacher interactions in and out of lessons, teachers who explicitly and repeatedly confirmed that girls would succeed at mathematics A-level, appreciation of mathematics as opening doors to many careers. Messages about FM were more restrictive but emphasised interest over unusual ability.

Keywords: gender; post-compulsory; participation.

Introduction

Advanced-level (A-level) 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 supplementary A-level called Further Mathematics (FM). Recent increases in the numbers of students taking both subjects have highlighted the lack of progress in recruiting girls. The proportion of girls taking A-levels who study Mathematics is half that of boys and the proportion who study FM is under a third. This compares poorly with, for example, the United States where equal proportions of boys and girls complete high school advanced mathematics courses (Ceci & Williams, 2010). This research explores the social and institutional structures that shape girls' choices in contexts within English education where their mathematics participation is relatively high.

The literature on students' participation in mathematics gives an overview of factors that correlate with choosing A-level Mathematics. There are important historical and contextual factors, such as prior attainment, social class, school type and the number of other students taking mathematics (Department for Education, 2011; Noyes, 2009). Attitudinal factors include students' self-reported interest and enjoyment in mathematics, awareness of its utility, and perceived competence in lessons (Brown, Brown, & Bibby, 2008; OECD, 2012). These factors have complex interactions with gender: where a factor correlates well with students' aspiration to continue with mathematics then on average boys are more associated with it than girls <u>and</u> it has a stronger influence on their choice-making. For example, Mujtaba and Reiss's large-scale survey (in preparation) found that encouragement from adults was the greatest influence on girls' participation. However fewer girls than boys reported receiving advice or pressure to continue mathematics, and when they did have the same levels of encouragement this had less effect for girls' choices than for boys'. It is not obvious from such findings where causality lies and changes can be made. Discursive approaches explain these complex interactions by examining choice as a cultural practice of the self. Experiences of gender are interwoven with experiences of mathematics, constructing meanings for choosing mathematics that students can negotiate but not ignore (Epstein, Mendick, & Moreau, 2010). Archer, DeWitt and Wong (2014) use such approaches to call for less emphasis on elite science aspirations in interventions for recruiting girls into science, arguing that explicit diversity in the messages promoted to girls makes their participation easier to negotiate. Our appreciation of the complexity but also of the possibility of supporting girls' choices underpins our research interest in school structures and relationships.

The study

Case studies are being conducted in four state-funded schools and one Further Education (FE) college with two stages of data collection over 15 months. Here we report our analysis after the first stage. We identified five sites as making an impact on girls' participation in mathematics, using a combination of criteria:

- selecting sites with high proportions of girls entered for both Mathematics and FM A-levels according to Department for Education 2012-13 data;
- 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 (10% of A-level students are at FE colleges);
- preferring schools with a non-selective intake (for greater generalisability);
- willingness to participate.

Table 1 The case study schools

	Area	**Gender**	**Type**	**Size of A-level cohort in 2012-13**	**Decile for % of A-level Girls completing Maths (state sector only) in 2012/13**	**Decile for % of A-level Girls completing FM (state sector only) in 2012/13**
School A	Town	Mixed	Academy	100-150	10 (10)	9 (10)
School B	Inner city	Girls to 16	Voluntary Aided	Under 100	9 (10)	8 (8)
School C	City conurbation	Mixed	Academy	Over 300	8 (9)	7 (8)
School D	Outer city	Mixed	Academy	100-150	10 (10)	8 (9)
College E	City	Mixed	FE college	100-150	8 (9)	8 (9)

It is noticeable that few of these schools fall in the top deciles for FM entries, even when we exclude independent schools from the comparison. Many of the top decile state-funded schools are selective or single-sex schools and we considered them less useful for indicating how most schools can increase participation.

For each case study the following questions drove the research. They allowed us (and the participants) to reflect on what were significant practices in the local context, how these practices affected girls' participation and how they related to factors identified in the literature.

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

Initial visits were made over a term in autumn 2014. Focus group discussions were chosen to gain several perspectives on the same topic and to gain insights into emerging shared meanings. In each case we conducted a 50-minute focus group of 3-5 mathematics teachers exploring the strategies they considered significant for retaining girls in mathematics; a focus group with year 12 female A-level mathematics students exploring their experiences of mathematics classrooms, their perceptions of mathematics as a gendered subject and their reasons for choosing whether or not to continue; (in schools) a focus group with year 11 girls likely to study mathematics; and observation of at least one A-level or GCSE mathematics lesson focussed on features considered important by teachers and students. Data was collected in the form of field notes, transcriptions, and quantitative data on mathematics class size, module choices and mathematics GCSE and A-level grade profiles by gender.

For each case we summarised what the participants reported as local strategies affecting girls' participation, noted where there was agreement or not between teachers and students, and then considered how these practices matched factors reported in the literature. Both authors then worked between the cases to consider strategies that had elements in common, and how this related to the literature. This established three thematic strategies that the departments operationalised in different ways; further case reports were written using these themes and sent to the school (teacher) contacts for validation. Follow-up visits next year will check the robustness of these outcomes, supplement current data, and gather evidence of any new initiatives or further reflection on girls' participation.

Findings

We found no mathematics initiatives aimed specifically at girls in the case study schools. Teachers were aware that, nationally, girls were under-represented in A-level but had not examined their own data by gender or noticed their relative success. This meant that in focus groups they were often thinking through what they had done for girls and boys, and recalling past conversations about their aims and effects. The focus group method proved significant in promoting group recollections of experiences and reflections on what their effects were. We did find that each school and college had clear intentions to recruit students – both boys and girls - to mathematics A-level and this extended beyond the most able students. In schools it was considered part of the role of higher-set teachers to develop relationships with their classes that would encourage transition to A-level, based on three thematic strategies we identified of pathway career thinking, robust emotional encouragement, and flexible cognitive support for working with challenge. Girls reported a sense of progression to mathematics A-level, rather than gender-based promotion, typified by: "We're good at it, we enjoy doing it, why wouldn't we?" (year 11).

Encouraging pathways thinking before year 11

The case study departments promoted mathematics as a subject that has wide applicability. For instance, girls reported that teachers "kept on saying it would open up opportunities. It's an all-round subject. Goes with everything" (year 12). Some mathematics teachers had influential sixth-form pastoral roles which they used to promote mathematics as a companion subject. They emphasised the value of statistics for its connections to social and life sciences. Students visiting the FE college and considering science or technology were guided in preliminary interviews to take mathematics within those pathways. Such guidance was seen as making mathematics more attractive to a wide range of students. In addition, school teachers made explicit connections with A-level content in their lessons with 14-16 year olds beyond the top sets, aiming to inspire interest and show "that like everyone can do it" (year 13 student, using the discourse marker "like" to emphasise her statement).

An awareness of the utility of mathematics is associated in the literature with participation but as an extrinsic motivation. In these schools, the appeal to utility was expressed through a message of wide and multiple applicability rather than access to specific or elite courses. Choosing mathematics was presented by (and to) students as a way of honouring the scope of their own current and future interests. This inclusivity and close relation to girls' existing aspirations contrasts with the messages promoting a narrow mathematics 'pipeline' warned against in Archer et al. (2014).

All the case study schools drew from catchments with large minority ethnic communities. In several focus groups, girls or teachers referred to the high value such families placed on mathematics and sustained hard work, a value that was reflected in the approach of the mathematics department. Staff and students also pointed to the presence of female teachers who were well-respected, dynamic and teaching strong year 10/11 sets and A-level. These close-at-hand connections between mathematics, family and social relationships were reported as giving it a broad appeal. We suggest that they also strengthened access to the informal 'grapevine' knowledge about careers and pathways that comprises what Archer et al. (2014) call invaluable 'family capital' in science or mathematics.

Specific, repeated, evidence-based, personal and collective encouragement

Across the settings, girls reported that as a group they felt actively and repeatedly encouraged to take A-level mathematics, and that their teacher was overtly confident they would succeed. This was based on a relationship in which all the students' feelings and ways of working were known to the teacher, and vice versa, sometimes as a result of a departmental policy of teacher continuity. There was a close match between the teachers' and students' accounts of the relationship, and this was described in terms of teachers knowing individual students (girls and boys) well:

> Teacher A: that's why it's important I've taught them for so long; they know I care about them, and they care when they do badly, that they upset me, and stuff.
> Year 11: Teacher A is like that – she really wants to know what you enjoy doing and what affects you and the things that matter to you.

Some focus groups questioned whether recruitment for A-level was intentional or rose as a natural consequence of a trusting teacher relationship: for example "I just think the way that she teaches, it does encourage you. Like without her deliberately trying" (year 11 student). In contrast, teachers described an ongoing, specific, in-and-beyond-the-classroom emphasis on "building up confidence" for girls to take A-level. The same student's teacher reported: "I am spending a lot of time, a lot of lunch times, just talking to the girls. And they have got the 'can I do A-level' attitude. 'Am I capable of it?'" The evidence from these cases suggests, first, that the teachers do work at relationships that seem natural and, second, that such approaches are successful because they permeate teachers' actions in class and out.

The notion of 'building confidence' was a common feature of teacher talk in all these schools, associated with their caring role and girls' classroom behaviour. We considered, however, that girls presented themselves as *cautious* in their choices, rather than unconfident, using the combination of teachers' opinions and their own experience as evidence for themselves and others that their preferred approaches to mathematics would lead to success at A-level. This adds a nuance to previous findings (eg Brown et al., 2008) that girls' experience and enjoyment of mathematics lessons are important in determining their choices. We did not see or hear reported any trends in classroom time or task organisation. The lesson experience these girls described as enjoyable (and that we observed) was the opportunity to build class-teacher and pupil-pupil relationships that they trusted, because they had already helped them overcome difficulties. These allowed them to imagine future participation within familiar ways of working and practices of self. Girls and teachers contrasted this with boys' risk-taking choice behaviour.

In the four 11-16 schools visited, the departmental scheme for 14-16-year-olds included unusual depth of mathematics and/or additional mathematics qualifications offered to higher sets. Girls and teachers cited this extended curriculum as giving credible evidence that girls had succeeded at demanding mathematics and should continue. The certification was important, but the most important effect appeared to be the experiences of struggle, support and success. Girls enjoyed the experience of personal achievement coming out of strong supportive class- and teacher relationships.

Flexible opportunities for students to build and check understanding

The third feature identified from our case studies is related to the previous two, and the combination appears key to the schools' success in recruiting girls. As well as the inclusive pathways approach to A-level choice and the attention to personal evidence-based encouragement, classroom teaching offered multiple and flexible opportunities to meet mathematical difficulties and it gave messages that students should not expect single contacts in lessons to suffice to develop deep understanding.

There has been much discussion of girls' (and boys') unease in a mathematics culture when it is possible to succeed without understanding (Boaler, Altendorff, & Kent, 2011; Solomon, 2007). In these schools the dominant message was to challenge that culture: all students should experience mathematics problems where they have to think for themselves in order to succeed. The only intentional gender-related strategy reported in mixed schools was to select quieter students to answer whole class questions, because they recognised that classroom talk was often sustained by boys. The girls also reported this, but neutrally. They valued more highly when teachers managed lessons so as to facilitate low-key conversations in which girls could check their personal understanding. Several girls identified teachers who were good at explaining ideas in a variety of ways, rather than just repeating the same explanation, showing the value they placed on teachers who could combine their knowledge of students with good pedagogic knowledge of mathematics. Girls talked about experience of challenge, of pace and of competition, but not about feeling pressured to go faster than they could understand.

Final thoughts

The three themes we introduce above were common across the case studies though implemented differently in the local context. Further visits and data will help us develop our analysis. We did note an intriguing contrast: in our case studies FM participation was not a simple consequence of boosting mathematics participation. The schools' recruitment strategies were similar in one sense to those for mathematics, in recommending decisions on the basis of motivation and effort rather than perceived ability. However they lacked the deliberate collective and personal encouragement and inclusiveness of the mathematics approach. Teachers discussed FM as self-selecting and FM students as already having a sense of commitment, while some girls reported they were simply not aware of enough reasons to consider FM. This suggests that campaigns to recruit more girls into FM need to convince teachers even in schools where participation in mathematics is already high.

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