Schools' Strategies for Promoting Girls' Participation in Mathematics

Conference or Workshop Item

SCHOOLS' STRATEGIES FOR PROMOTING GIRLS' PARTICIPATION IN MATHEMATICS

Cathy Smith and Jennie Golding

Open University, UK and UCL Institute of Education, UK

Fewer girls than boys in England participate in post-compulsory mathematics. Previous studies have shown the significance to girls of their mathematics lessons and teachers, of cultural constructions of gender and mathematics, of career perceptions and family 'science capital'. A multiple case-study project investigated institutions with unusually high participation by girls in mathematics. Focus groups and lesson observations were used to explore school pedagogy and culture. Common factors were: early preparation for demanding mathematics, 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.

INTRODUCTION

There is a considerable body of research showing concern for the social, economic and institutional injustices that result from women's unequal participation in mathematics (Ceci & Williams, 2010; Forgasz & Mittelberg, 2007; Hyde & Mertz, 2009). Many such papers also argue that their nation's economic advantage relies on increasing the proportion of the population with science, technology, engineering and mathematics (STEM) skills. From these perspectives, girls who do not follow advanced mathematics courses are a potential source for recruiting more STEM-skilled workers, and hence their participation deserves scrutiny. Within this research, we particularly note studies that investigate the disinclination of some girls' (and boys') to study mathematics at a higher level (Archer et al., 2012; e.g. Mendick, 2005; Mujtaba & Reiss, 2016). This work has established a range of inter-related factors that influence individual students' study and career intentions, intersecting with gender in ways that lead to unequal participation. Our study builds on this prior research to consider girls' participation in mathematics starting from the different viewpoints of the culture and practice in schools with high participation.

Using a multiple case-study approach in the English policy context, where participation within the academic track can be measured by the choice of "A-level" subjects at age 16, we found little evidence of specific initiatives to attract girls to study mathematics. Instead, a common feature of these successful schools was a strong culture of encouraging all students to aspire to study mathematics, operationalised through a co-ordination of informal careers guidance, teacher relationships and

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pedagogic strategies. The findings suggest that schools can encourage girls by focusing on stable teacher relationships and early, supported classroom challenge.

THEORETICAL FRAMEWORK

We base our work on the understanding that choices and preferences made by individual students are constructed within the discourses of classrooms, schools and wider society (Smith, 2010). Attitudinal surveys show that students' beliefs about the gender stereotyping of mathematics vary between countries (Hyde & Mertz, 2009) and within different cultures in one country (Forgasz & Mittelberg, 2007). Thus, we see the knowledge produced about individual factors associated with participation in mathematics as indicating a range of psychological and sociological constructs that can be mobilised into gendered patterns both by local cultural practices and by wider discourses of mathematics, society and adolescent identity.

In the English context, mathematics is compulsory until the "GCSE" examination at age 16; thereafter students on the academic track choose three or four "A-level" subjects. In 2017, 24% percent of A-level students chose Mathematics and 4% chose Further Mathematics, however this reduced to 18% and 2% for girls, who are 54% of the cohort. Research suggests a range of factors that affect students' intentions to study mathematics at A-level and could be influenced by school practices. Participation is most strongly associated with high prior- and high relative- attainment in mathematics: the latter particularly affecting girls, who tend to perform well over their eight (or more) GCSE subjects (Noyes & Adkins, 2016). Contributory attitudinal factors for all students include enjoyment of lessons, perceived teacher-competence, perceived self-competence, intrinsic interest in mathematics and awareness of the utility of mathematics for supporting access to other areas; successive surveys find that girls score these lower and that they affect girls' choices more markedly (Brown, Brown, & Bibby, 2008; Mujtaba & Reiss, 2016). This suggests an important cultural influence resulting from schools' pedagogic practices and career guidance. Mujtaba and Reiss also found that fewer girls than boys, aged 13 and 15, report receiving advice and encouragement to study mathematics (and physics) and that such advice is influential for them, particularly when it is received from a trusted family- or teacher- source. Archer, DeWitt and Wong (2014) review school-level strategies for recruiting girls into STEM subjects, such as school science projects led by universities and visits from female role-models, and note that where their impact has been evaluated, they appear more successful in sustaining an early STEM interest than in changing minds. These authors call for less emphasis on elite aspirations in STEM interventions, arguing that explicit diversity in the messages promoted to girls makes their participation easier to negotiate. Our appreciation of the complexity of girls' choices but also of the possibility of supporting them underpins our research interest in school structures and relationships. We asked:

- In schools which are successful in recruiting girls into mathematics, are there any intentional strategies addressing girls' participation? How are these conceived, operationalised and evaluated by teachers?
- What messages are current in the school culture about who does mathematics?
- Are there aspects of mathematics pedagogy, of careers or teacher guidance that support girls' participation in studying mathematics? How is this support conceived and operationalised?

THE STUDY

A multiple-case study methodology was chosen in order to explore "hypothesised variations" (Yin, Clarke, Cotner, & Lee, 2006, p. 114) of school type and size, and to produce detailed, contextual information about the practices of mathematics teaching and recruitment in each school and the beliefs of teachers and students. Five sites were identified as having girls' participation in mathematics, using a combination of criteria:

- relatively high proportions of girls entered for both Mathematics and Further Mathematics 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 16-18 year college;
- preferring schools with a non-selective intake (for greater generalisability);
- willingness to participate.

Data was collected in two phases, spaced a year apart. In the initial phase, at each site one of the authors conducted: one 50-minute focus group of 3-5 mathematics teachers exploring the strategies considered significant for retaining girls in mathematics; one focus group with year 12 or 13 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; (if possible) a focus group with year 11 girls likely to study mathematics; observation of one or two A-level or GCSE mathematics lessons focussed on features considered important by teachers and students. Second-phase visits comprised an interview with each lead teacher investigating the stability of the cultural practices identified in the analysis, collecting data related to transition between year 12 and 13, and gathering evidence of any new initiatives or further reflection on girls' participation.

Teachers' and students' accounts were emphasised in our design, since we acknowledge that teaching (for teachers) and choosing subjects (for students) are highly reflexive practices, for which reasons are sought and articulated to oneself and others. Nevertheless, this approach runs the risk of foregrounding explanations that are dominant by being popularly or powerfully accepted. Focus group discussions were thus chosen to gain several perspectives on the same feature and to gain insights into emerging shared meanings. Other explanations were explicitly sought in the teacher focus groups, and coherence tested through triangulation with lessons observations, student records and respondent validation. 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.

During analysis, each case was summarised to identify what the participants reported as local strategies affecting girls' participation, and where there was agreement or not between teachers and students about practices and the effect of those. Case data was coded by how accounts of these practices matched factors derived from the literature. Both authors then worked across the cases to consider strategies that had elements in common. This established three thematic strategies common to the schools, although operationalised in different ways. Further case reports were written using these themes and sent to the school (teacher) contacts for validation.

The case study sites are outlined in Table 1, showing their type and size and their decile for girls' participation from the year preceding the study. To meet all criteria we chose sites that (initially) performed in the top three deciles of all schools and in the top two deciles of state schools.

	Area	Gender	Size of A-level cohort	Decile for % of Girls completing Maths A-level (state sector only), years -1 to +1.		
School A	Town	Mixed	100-150	10(10)	8 (9)	9 (9)
School B	Inner city	Girls to 16	Under 100	9 (10)	7 (8)	8 (9)
School C	Conurbation	Mixed	Over 300	8 (9)	8 (9)	8 (9)
School D	Outer city	Mixed	100-150	10(10)	10(10)	10(10)
College E	City	Mixed	100-150	8 (9)	8 (9)	4 (4)

Table 1

FINDINGS AND DISCUSSION

We found no mathematics initiatives aimed specifically at girls in the case study sites. Teachers were aware that, nationally and internationally, girls were under-represented in advanced mathematics but had not examined their school data by gender or noticed its relative success. This meant that in focus groups they were often thinking through what they had done to raise achievement and interest, and recalling past conversations about aims and effects on different groups of students. A common feature of all sites was that teachers gave accounts of collectively-agreed intentions and strategies to recruit *both* girls and boys to mathematics A-level and these extended beyond the most able students. All schools set by prior attainment and it was explicitly considered part of the role of higher-set teachers to develop relationships with their classes that would encourage transition to A-level. Our analysis showed these strategies were based on three themes: pathway career thinking, robust emotional encouragement, and flexible cognitive support for working with challenge. Each of these school strategies can be traced as contributing to factors identified in the literature as supporting girls' participation. In the focus groups, girls reported a sense of progression to mathematics A-level, rather than specifically gender-based encouragement, typified by: "We're good at it, we enjoy doing it, why wouldn't we?"

Encouraging pathways thinking before year 11

Teachers in the case studies promoted mathematics as a subject that has wide applicability and contributed to a range of career pathways, thus emphasising diversity. For instance, year 12 girls reported that teachers "kept on saying it would open up opportunities. It's an all-round subject. Goes with everything". Some mathematics teachers had influential sixth-form pastoral roles which they used to promote mathematics, emphasising the value of statistics, in particular, for its connections to social and life sciences. Students considering joining College E to study science or technology were guided in preliminary individual interviews to take mathematics as a companion subject, thereby 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. This was reported by students as teachers aiming to inspire interest and "show everyone can do it" (year 13 student).

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 thus presented by (and to) students as a way of honouring the scope of their own current and future interests. In this culture it became also an intrinsic motivation. This approach of inclusivity, that maintains a close relation to girls' existing aspirations, contrasts with the messages promoting a narrow mathematics 'pipeline' warned against in Archer et al. (2014).

Although an unintended variation, we noted that 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 within a career-focussed pathway, a value that was reflected in the approach of the mathematics department. Staff and students also pointed to the presence of well-respected and dynamic female teachers among those teaching top-set GCSE and A-level classes. 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 individuals and as a friendship group they felt actively and repeatedly encouraged to take A-level mathematics, and that their teacher was overtly confident they would succeed. Students ascribed this to perceiving that teachers knew the students' feelings and ways of working, and could thus offer personal guidance based on evidence not just of prior attainment but of student identity. In some schools, a departmental policy of teacher continuity explicitly aimed to create this relationship of trust. 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 students questioned whether recruitment for A-level was intentional and suggested it rose as a natural consequence of a valued pedagogic 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 and out of class.

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. Our analysis suggested that girls presented themselves as cautious in their choices, rather than unconfident: they used the combination of teachers' opinions and their own experience as evidence for themselves and others to decide whether their preferred approaches to mathematics would lead to success at A-level. This adds a nuance to previous findings (e.g. Brown et al., 2008) that girls' experience and enjoyment of mathematics lessons are important in determining their choices. In these schools, we could not identify any common features of classroom time or management. Instead, the experience these girls described as enjoyable (and that we observed) was the opportunity to build class-teacher and pupil-pupil relationships. These relationship were personal and trusted, explained through examples of how teachers had already helped them to develop strategies to overcome mathematical difficulties, and would continue to do so. They 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, choosing subjects without determining the probability of success.

In the four 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.

Flexible opportunities for students to build and check understanding

The third feature identified from our case studies is related to the previous two. 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 expect to develop deep and satisfying understanding over repeated encounters.

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. This was sometimes explicitly stated as a strategy to build mathematical resilience (Lee & Wilder-Johnston, 2017). The only intentional gender-related strategy reported in the mixed schools was to select quieter students to answer whole class questions, because teachers recognised that classroom talk was often sustained by boys. The girls also reported this strategy, but ascribed it low impact in encouraging participation. They valued more highly when teachers managed lessons so as to facilitate low-key teacher-student and student-student 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.

CONCLUSION

The three themes we introduce above were common across the case studies though implemented differently in each local context. Our study suggests three broad but achievable recommendations for schools. Firstly, teachers throughout the school should be familiar with A-level syllabuses and content so that they can perform their leading role in overtly orienting students towards participation. Secondly, teachers should have a repertoire of mathematics activities and strategies that allow students to experience challenges and seek help without a whole-class audience. Finally, it is important that mathematics teachers, parents and teachers of other subjects give overt messages to individuals and friendship groups that they expect girls (and boys) to succeed in mathematics, but that this will sometimes require persistence and hard work, as well as short-term failures.

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