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Motivating and supporting young people to study mathematics: A London perspective

Tamjid Mujtaba,* Michael J. Reiss, and Ann Hodgson

Institute of Education, University of London, UK

This paper explores which classroom and teacher factors are associated with post-16 mathematics aspirations, mathematics intrinsic motivation, and mathematics self-concept. Few studies explore all three outcomes among the same set of students or make linkages across the factors that are important to these outcomes. The analysis is based on the survey responses of 761 Year 8 (age 13) and 715 Year 10 (age 15) students from 17 London schools as learners of mathematics. The analysis indicates that teaching for engagement is important for intrinsic mathematics motivation but not for future mathematics aspirations. In addition, students' emotional responses to mathematics lessons are important for their mathematics self-concept but not for future mathematics aspirations. Advice-pressure to continue with mathematics post-16, extrinsic material gain motivation, and mathematics self-concept underpin mathematics aspirations (even after controlling for the support students received from their families in mathematics attainment). The gender difference within mathematics self-concept among these young Londoners was higher than that found across England, although there were substantially fewer gender differences in relation to questions that explored students' perceptions of their mathematics lessons and teachers. The article concludes with some suggestions for both national and London policymakers because the study of mathematics is seen as of considerable importance to both young people and the economic life of the capital.

Keywords: gender; London; intrinsic motivation; extrinsic motivation; mathematics; secondary school; post-compulsory education; aspirations

Introduction

Almost a decade ago the report *Making Mathematics Count* (Smith, 2004) on post-14 mathematics education in the UK indicated that the mathematics curriculum failed to excite interest and provide appropriate motivation for students. That report underpinned the development of new 14–19 pathways that would create opportunities for schools to enhance student motivation, create challenges, and raise attainment for all students regardless of their particular backgrounds. The report also noted 'GCSE[1] Mathematics seems irrelevant and boring and does not encourage them to consider further study of mathematics' (Smith, 2004: 86–7). The focus on, and concern about, higher-level (i.e. post-16) mathematics has stemmed from a range of factors, particularly the decline (though that has reversed in recent years) in the number of students going on to take mathematics at higher level (Sharp *et al.*, 1996; Joint Council for Qualifications, 2014). Despite the suggestions of the Smith Report, as a nation England is still struggling to match government ideals to increase the number of students continuing with higher-level mathematics. Other countries have similar concerns (see for example Committee for the Review of Teaching and Teacher Education, 2003; National Academies, 2007).

In England there is a strong emphasis among policymakers on the importance of increasing the level of mathematical skills to enable England to compete in the current competitive world

* Corresponding author. Email: tamjidmujtaba@googlemail.com.

economy. Having a large number of mathematics graduates (as well as graduates in science subjects) is seen as crucial to the economy of the country and this has underpinned the government's commitment to increasing the number of science, technology, engineering, and mathematics (STEM) professionals (Department for Business, Innovation and Skills, 2013a). Partly for this reason, the UK's present coalition government is introducing changes to the mathematics programme of study for 14–16-year-olds, together with a full curriculum review and the introduction of a new national mathematics qualification. In England, full-time education is currently compulsory up to the age of 17.[2] At the age of 16 students can either continue to study, go into some form of training, which might be an apprenticeship, or enter the labour market and study part-time. There is currently no mandatory curriculum for 16 to 19 year olds. Those who choose to stay on in full-time education and have gained the required grades in their General Certificate of Secondary Education (GCSE) examinations to take General Certificate of Education Advanced Levels (A-levels), which are still the most popular qualifications for 16–18 year olds, typically choose up to four subjects for their first year of study. There are some constraints to subject choice, such as timetabling considerations, and for certain A-levels, including mathematics, students are typically required by their school or college to meet quite stringent requirements in terms of their GCSE grades (Matthews and Pepper, 2007). Furthermore, changes currently being made mean that the first year of A-level study will no longer be available for accreditation as an Advanced Subsidiary (AS) Level. It is too early to be sure, but this and other changes proposed by the government for post-16 provision in mathematics do not inspire confidence that participation will increase sufficiently to bring England into line with most other OECD countries (cf. Hodgen *et al.*, 2010).

A school qualification in mathematics is associated with increased success in terms of entrance to university, future career, and increased earnings (Wolf, 2002; Brown, 2003). Despite this, there are still concerns about the relatively low proportion of students, compared with other countries, who continue with mathematics in post-compulsory education (Hodgen *et al.*, 2010; Royal Society, 2011) and about the shortage of suitably qualified teachers of mathematics (Brown *et al.*, 2008). To help combat this, the government is introducing the requirement for all those students who do not gain at least a Grade C at GCSE at the age of 16 to continue to work towards this qualification post-16 (Department for Education, 2013). However, this is no substitute for students opting to continue studying mathematics at a higher level. Hence the focus of this study is on the factors that support and motivate students to pursue this subject in greater depth post-16.

One of the key reasons many students do not want to continue with mathematics at a higher level is because they have already become disenchanted with the subject in compulsory education; students cite a range of negative emotions towards mathematics, such as a lack of enjoyment, and an active dislike of mathematics and there are high levels of disaffection among students on mathematics courses (for example Nardi and Steward, 2003; Brown *et al.*, 2008). Students' engagement with mathematics is underpinned by a range of factors associated with the students themselves, their families, their relationship with mathematics, and how it is taught at school. Existing research links students' mathematics self-concept (i.e. how a student feels about their mathematics capability) to a range of desired student outcomes such as academic performance and career aspirations (Lent *et al.*, 1986); persistence, engagement, and achievement at school (Skinner *et al.*, 1990); and intrinsic motivation (Bandura, 1997; Skaalvik, 1997). Furthermore, research indicates that mathematics self-concept also plays a mediating role in the effects of background variables, such as gender and prior knowledge, in terms of students' mathematics anxiety, their interest, and academic performance.

Students' attitudes towards mathematics and their own identity as mathematics learners, as well as their performance and participation, are impacted by the way mathematics is taught (Leedy *et al*., 2003). Research has suggested that some students choose to continue with mathematics once it is no longer compulsory because they like their teachers and/or have a good relationship with them (for example Norwich, 1999). A systematic review of 25 studies (Kyriacou and Goulding, 2006) indicated that teaching for engagement at secondary school (where the teacher was highly supportive, the work enjoyable and challenging, and students all felt equally valued by teachers) was the best way to increase students' efforts and motivation. Furthermore, the teaching and learning activities chosen by teachers, the classroom climate they create, and their interactions with their students have been associated with enhanced engagement internationally as well as in England (for example Dorman and Adams, 2004). There is indeed an argument for raising students' intrinsic motivation for mathematics, as opposed to their extrinsic motivation for it (for example, wanting to study mathematics because of the financial rewards it will bring), largely because intrinsic motivation leads to high-quality learning among students (Ryan and Deci, 2000), enabling them to get a better grasp of mathematical concepts (Ames, 1992). However, there are findings that indicate that extrinsic motivation is more important as a reason for students choosing to study mathematics post-16 (Mujtaba and Reiss, under review).

Motivation towards mathematics does not automatically lead to students choosing the subject at a higher level. The relationship between enjoyment, future subject choice, attainment, and learning is quite complex and very few studies have looked at all of these important outcomes for the same cohort of students. Furthermore, the distinction needs to be made between the extent to which students find mathematics intrinsically or extrinsically motivating.

This paper aims to identify the factors that relate to London students' aspirations to continue with mathematics post-16, their intrinsic valuation of mathematics, and their mathematics self-concept by analysing data obtained in the Understanding Participation Rates in Post-16 Mathematics and Physics (UPMAP) project (see Reiss *et al*., 2011). London has been chosen as an area for study because of its status as a global city and concerns that London students who outperform those in other parts of the country at age 16 are not performing as well in cumulative A-level scores (Hodgson and Spours, 2012). In addition, although the London economy is more buoyant than the economy in other regions of England, young Londoners are taking longer to enter full-time employment (Ben-Galim *et al*., 2011). This is largely because they face greater competition for jobs from highly qualified young people moving to the capital from other towns and cities in England and from abroad. While being highly qualified does not automatically guarantee employment in London, it is certainly an important starting point. The role of mathematics in enhancing London's workforce and economy was recently emphasized in the Mayor of London's report (Greater London Authority, 2012), which outlined the challenges faced by London. For example, despite London's schools having improved in attainment relative to the rest of England during the previous decade, the report indicated there was further room for improvement, citing other major world cities which were performing better in mathematics (notably ones in China, Korea, New Zealand, Japan, Finland, Singapore, Canada, and Australia). The report indicated that Shanghai students' mathematics attainment was substantially higher than that of London students; in addition, the report indicated that 24 per cent of London's students do not achieve expected national levels in primary mathematics.

Methodology

The UPMAP project (2008 to 2011) obtained approximately 29,000 survey responses from students across the UK (see Reiss *et al.*, 2011). Throughout this paper we refer to the larger England sample in order to help contextualize the findings from our London sample. The London analysis within this paper draws on the survey responses of 1,476 12–13 and 14–15 year-old (Year 8 and Year 10) students as learners of mathematics from 17 London schools. Within the London sample, consideration of any interactions between ethnicity and gender was not possible due to relatively small sample sizes (see below). Similarly, no attempt has been made to test for differences between Year 8 and Year 10 students or between school type (due to relatively small sample sizes and given that the focus of our paper is on exploring trends among London students, rather than on how such trends are influenced by students' age or school type). The wider UPMAP study also used multivariate analysis to explore similar issues to those explored in this London-based paper. However, as there were more schools within the national UPMAP study (133+), we were able to use multi-level modelling procedures (see Mujtaba *et al.*, forthcoming). Nevertheless, the multi-level modelling analysis focused largely, as we do in this paper, on student characteristics rather than school characteristics, mainly because our analysis of school-level variance indicated that only around 7 per cent of the variation in students' post-16 participation scores was attributable to school factors.

The UPMAP data (in both London and the UK more generally) were not based on a representative sample of students as we intentionally targeted a bigger proportion of high-attaining schools and students (so as more powerfully to be able to identify factors that related to post-16 mathematics and physics uptake). The sampling of the UPMAP study was heavily weighted towards students who were predicted to get grades A* to D in GCSE mathematics and physics/science. There were 17 state (non-fee-paying) London schools within our sample (10 girls' schools, 2 boys' schools, and 5 mixed schools). Such a sample will have a bearing on the types of associations we find and report on the London data. The FSM[3] categories were as follows: 0–5 per cent (1 school), 9–13 per cent (5 schools), 13–21 per cent (5 schools), 21–35 per cent (3 schools), 35–50 per cent (2 schools) and 50 per cent+ (1 school).

Very little research uses quantitative data to explore mathematics factors (education aspirations, intrinsic motivation, and self-concept) by analysing the importance of a range of variables after controlling for the influence of students' background characteristics. The analysis in this paper attempts to fill this gap. So, for example, our analysis will illuminate how important extrinsic material-gain motivation is for increasing mathematics aspirations after controlling for the well-known influences of self-concept and gender. Our multivariate analysis will highlight the relevant and particular contributions of each factor. The student surveys we designed included items derived from established psychological constructs as well as measures we created. Student questionnaires were designed following a review of the literature that considered factors that may influence post-compulsory participation and went through five rounds of piloting. A factor analysis using principal components affirmed some of the constructs, although it also led to minor changes in others. The detailed methodology surrounding the survey and how it fits within the wider project is provided in Reiss *et al.* (2011). Cronbach's alphas were used to assess the internal consistency of all constructs, which were found to have fair to high reliability (.6–.9). Items/constructs reported in this paper utilize a 6-point Likert scale. A high score (4, 5, or 6) represents agreement/positive responses, with 6 being strong agreement/most positive attitude; the other end of the scale (1, 2, or 3) represents disagreement/negative responses, with 1 being strong disagreement/most negative attitude.

Results

Descriptive statistics and gender differences of key variables

Student perceptions of teachers

The survey explored students' perceptions of their mathematics teachers. Nearly all of the items that explored students' views of mathematics teachers formed the construct 'perceptions of mathematics teachers' (though there were a few other items about teachers that were a part of other constructs). The overall mean scores (see Table 1) indicate that students were most in agreement about the importance of their teachers setting them homework, followed by their teachers believing that all students can learn mathematics, and their teachers really wanting them to understand mathematics. The only gender differences were with boys being most in agreement with 'My teacher is good at explaining maths' (ES (effect size) =.19); nationally, the effect size of this gender difference was .02 and was not statistically significant. London girls were most in agreement with teachers treating all students the same regardless of their mathematics ability (mean of 4.67 versus 4.40 nationally) and about teachers liking all students (mean of 4.22 versus 4.00).

Emotional response to mathematics lessons

Students responded positively to the items about emotional responses outlined in Table 2, although as a group these responses were not as positive as the items which explored perceptions of lessons. London students were most positive about: 'When I am doing maths, I don't get upset' (4.96) (similar to national findings, mean 5.11). A statistically significant gender difference was found: boys reported feeling less bored, less likely to daydream, and less likely to get upset than girls (ES=.18).

Perceptions of mathematics lessons

Collectively London students responded positively to items asking them about their perceptions of their mathematics lessons (see Table 2). London students responded most positively to: 'When I am doing maths, I am learning new skills' (4.69) and 'I can see the relevance of maths lessons' (4.53). These findings are similar to national findings where the means are 4.57 and 4.47 respectively. London students were least positive about looking forward to mathematics classes (3.45) – a result that is similar to national findings (3.33). A statistically significant gender difference was found with this item, with boys being more likely to look forward to classes than girls. Boys were statistically significantly more likely to report learning new skills when doing mathematics and enjoying their mathematics lessons.

Boys responded more positively to 'Thinking about your maths lessons how do you feel you compare with the others in your group' (ES= 0.47) (an item that is part of the self-concept construct). Interestingly, this effect size was larger than that reported from our England sample (ES=.37). Boys also responded more positively than girls to 'When I am doing maths, I always know what I am doing' (ES=.32). The effect size here was very similar to the national findings (ES=.31).

Table 1: Year 8 and 10 students' perceptions of their mathematics teachers

Item	*All students*			*Boys*			*Girls*			*Comparison (boys and girls)*		
	N	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	*t*	*df*	*Effect size Cohen's d*
Overall perceptions of maths teachers												
My maths teacher treats all students the same regardless of their maths ability.	1342	4.60	1.393	322	4.40	1.429	1020	4.67	1.376	-2.904	522.457	0.19**
My maths teacher seems to like all the students.	1287	4.17	1.564	312	4.00	1.686	975	4.22	1.520	-2.087	483.456	0.14*
My maths teacher believes that mistakes are OK as long as we are learning.	1374	5.04	1.124	327	4.98	1.243	1047	5.06	1.084	-0.977	490.644	0.07
My maths teacher believes that all students can learn maths.	1371	5.28	0.897	334	5.25	0.991	1037	5.29	0.865	-0.657	506.968	0.04
I like my maths teacher.	1432	4.35	1.515	348	4.31	1.569	1084	4.36	1.498	-0.537	564.276	0.03
My maths teacher has high expectations of what the students can learn.	1373	5.20	0.932	331	5.18	0.966	1042	5.20	0.922	-0.270	534.598	0.02
My maths teacher is interested in me as a person.	1093	3.61	1.606	277	3.60	1.640	816	3.62	1.595	-0.141	465.550	0.01
My maths teacher is interested in what the students think.	1311	4.50	1.394	318	4.51	1.427	993	4.50	1.384	0.142	521.647	0.01
My maths teacher wants us to really understand maths.	1400	5.28	0.910	336	5.29	0.962	1064	5.28	0.894	0.230	530.194	0.01
My maths teacher marks and returns homework quickly.	1358	4.45	1.448	326	4.58	1.429	1032	4.41	1.453	1.919	553.335	0.12
My maths teacher is good at explaining maths.	1405	4.50	1.483	340	4.72	1.416	1065	4.43	1.498	3.290	600.140	0.20**
Other items related to teachers (but do not form the perceptions of teacher construct)												
My maths teacher doesn't only care about students who get good marks in maths.	1294	4.66	1.418	313	4.47	1.511	981	4.73	1.383	-2.631	490.100	0.18**
My maths teacher doesn't let us get away with not doing our homework.	1373	4.93	1.331	333	4.92	1.410	1040	4.93	1.306	-0.203	526.907	0.01
My maths teacher sets us homework.	1429	5.37	0.905	339	5.38	0.877	1090	5.37	0.915	0.159	585.084	0.01

Item	All students			Boys			Girls			Comparison (boys and girls)		
	N	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	*t*	*df*	*Effect size Cohen's d*
Advice pressure to study mathematics post-16												
I have been advised by someone else that maths is a good subject to study after my GCSEs.	1427	4.53	1.515	346	4.49	1.540	1081	4.54	1.508	-0.518	571.860	0.03
My teacher thinks that I should continue with maths beyond my GCSEs.	840	5.00	1.201	213	5.05	1.061	627	4.97	1.246	0.876	425.683	0.06
My friends think that I should continue with maths after my GCSEs.	781	4.29	1.501	177	4.37	1.392	604	4.26	1.531	0.854	311.406	0.07
Someone in my family thinks that I should continue with maths after my GCSEs.	1056	4.92	1.343	269	5.01	1.264	787	4.88	1.368	1.445	498.499	0.10
My friends are going to study maths after their GCSEs.	824	4.00	1.402	196	4.26	1.320	628	3.92	1.416	3.120	346.411	0.25**
Advice pressure to study maths construct (overall construct).	1455	4.430	1.211	352	4.5385	1.166	1103	4.3934	1.223	2.009	616.155	0.12*

* significant at .05; ** significant at .01; *** significant at .001

Table 2: Year 8 and 10 students' perceptions of their maths lessons and self-concept

Item	†All students			Boys			Girls			Comparison (boys and girls)		
	N	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	*t*	*df*	Effect size Cohen's *d*
Items which measured emotional response to mathematics lessons												
I do not find it difficult to apply most maths concepts to everyday problems.	1428	3.76	1.399	348	3.82	1.491	1080	3.74	1.369	0.91	548.211	0.06
When I am doing maths, I do not get upset.	1444	4.96	1.333	348	5.11	1.264	1096	4.91	1.351	2.581	618.637	0.15*
When I am doing maths, I am not bored.	1446	3.47	1.482	347	3.67	1.492	1099	3.40	1.474	2.971	574.976	0.18**
When I am doing maths, I do not daydream.	1448	3.64	1.588	349	3.87	1.594	1099	3.56	1.580	3.197	581.177	0.20**
Items which measured perceptions of mathematics lessons												
In my maths lessons, my teacher explains how a maths idea can be applied to a number of different situations.	1401	3.76	1.280	346	3.73	1.426	1055	3.78	1.230	-0.516	523.479	0.03
In my maths lessons, I have the opportunity to discuss my ideas about maths.	1441	4.18	1.331	349	4.22	1.317	1092	4.16	1.336	0.651	593.984	0.04
I can see the relevance of maths lessons.	1434	4.53	1.260	349	4.60	1.245	1085	4.51	1.264	1.171	595.965	0.07
When I am doing maths, I pay attention.	1448	4.33	1.185	349	4.41	1.209	1099	4.30	1.177	1.446	572.836	0.09
I look forward to maths classes.	1451	3.47	1.456	352	3.62	1.431	1099	3.43	1.462	2.143	603.207	0.13*
When I am doing maths, I am learning new skills.	1444	4.69	1.077	351	4.83	1.053	1093	4.65	1.082	2.803	605.357	0.17**
I enjoy my maths lessons.	1446	3.78	1.464	348	3.96	1.446	1098	3.73	1.466	2.621	590.016	0.16**
Items which measured mathematics self-concept												
When I am doing maths, I always know what I am doing.	1453	3.69	1.332	348	4.01	1.251	1105	3.58	1.341	5.418	618.328	0.32***
I do well in maths tests.	1448	4.32	1.153	352	4.63	1.033	1096	4.22	1.171	6.121	664.129	0.35***
I am good at maths.	1429	4.63	1.085	348	4.96	0.940	1081	4.52	1.106	7.278	681.978	0.41***
Thinking about your maths lesson how do you feel you compare with the others in your group?	1251	3.57	1.070	331	3.93	1.017	920	3.44	1.056	7.511	602.858	0.47***
I do not need help with maths.	1450	3.71	1.501	346	4.25	1.448	1104	3.54	1.478	7.948	587.260	0.49***
Self concept (overall construct).	1468	4.125	0.981	354	4.51	0.881	1114	4.00	0.978	9.083	652.088	0.53***

* significant at .05; ** significant at .01; *** significant at .001

Self-concept

As a group, London students had a high mathematics self-concept with some variation among individual items. Students reported most favourably towards the item: 'I am good at maths' (4.63) – compared to students in England as a whole (4.41). All of the self-concept items contained statistically significant gender differences, in favour of boys. The self-concept construct itself had the largest effect size for gender differences (ES=.53), compared to a figure of .47 for England students.

Advice-pressure to study mathematics

This measure explores the advice or pressure students received from those around them, such as parents or teachers, to continue with mathematics after the age of 16. London students on average had high levels of advice-pressure to study mathematics (see Table 1). There were some differences between the individual items that created this construct, with students more likely to respond positively to their teachers thinking they should continue with mathematics post-16.

Extrinsic material gain motivation

'Extrinsic material gain motivation' relates to the belief that obtaining a qualification in mathematics in post-compulsory education would be useful for some tangible reward, for example for access to higher education or future employment prospects. Overall, London student means indicate that students were in high agreement about the extrinsic gain of having a post-16 mathematics qualification (see Table 3). Students were most in agreement with the statement 'I think maths is a useful subject', which was in line with national trends (mean 5.08), with boys more likely to see the importance of extrinsic material gain motivation.

Extrinsic social gain motivation

The construct 'extrinsic social gain motivation' measures students' engagement with mathematics for relational gains. Students were most in agreement with 'Being good at maths impresses people' (London mean 4.06; national mean 3.77). In London there were no statistically significant gender differences, though there were some nationally.

Intrinsic motivation

We distinguish between extrinsic and intrinsic motivation; students who are intrinsically motivated to take mathematics do so because they find the subject enjoyable or interesting or because they mention some form of positive emotion that they experience when doing mathematics. Students were most in agreement with the statement 'To be good at maths, you need to work hard' (4.81) and least in agreement with 'To be good at maths you need to be creative' (2.61) – these findings were broadly in line with the national means (4.83 and 2.64 respectively). In addition, there was a statistically significant gender difference for this item, with boys more likely than girls to report that to be good at mathematics people need to be creative (ES=0.33).

Table 3: Year 8 and 10 students' perceptions of mathematics

Item	*†All students*			*Boys*			*Girls*			*Comparison (boys and girls)*		
	N	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	*t*	*df*	*Effect size Cohen's d*
Items which measured extrinsic material gain motivation												
These days, everybody needs to know some maths.	1432	5.13	.991	343	5.11	1.007	1089	5.14	0.986	-0.496	563.511	0.03
Maths helps you in solving everyday problems.	1418	4.67	1.192	341	4.68	1.150	1077	4.66	1.206	0.281	595.063	0.02
People who are good at maths get well-paid jobs.	1325	4.65	1.038	314	4.68	1.100	1011	4.64	1.019	0.578	491.506	0.04
I think maths is a useful subject.	1452	5.22	0.924	352	5.29	0.897	1100	5.20	0.931	1.537	611.585	0.09
I think maths will help me in the job I want to do in the future.	1420	4.51	1.420	345	4.67	1.375	1075	4.45	1.431	2.509	601.600	0.15*
Items which measured intrinsic motivation												
Those who are good at maths are clever.	1341	4.17	1.384	322	4.11	1.496	1019	4.19	1.348	-0.897	496.402	0.06
Maths teaches you to think logically.	1356	4.75	1.066	323	4.76	1.073	1033	4.74	1.065	0.308	535.128	0.02
To be good at maths, you need to work hard.	1420	4.95	1.144	339	5.00	1.210	1081	4.94	1.122	0.735	532.804	0.05
Maths is important in making new discoveries.	1300	4.12	1.360	320	4.21	1.346	980	4.09	1.365	1.388	549.160	0.09
In maths, it is interesting to find out about the laws that explain different phenomena.	1387	4.00	1.455	329	4.19	1.391	1058	3.95	1.470	2.712	574.140	0.16
Maths is interesting.	1420	3.83	1.494	340	4.03	1.477	1080	3.76	1.495	2.902	574.148	0.18
I think maths is an interesting subject.	1435	4.05	1.366	349	4.26	1.323	1086	3.98	1.373	3.419	607.531	0.21**
To be good at maths, you need to be creative.	1330	2.65	1.353	323	2.98	1.477	1007	2.55	1.294	4.755	490.530	0.33***
Items which measured extrinsic social gain motivation												
Being good at maths impresses people.	1319	4.06	1.343	302	4.04	1.417	1017	4.07	1.322	-0.260	467.418	0.02
Maths improves your social skills.	1291	2.91	1.458	307	2.91	1.503	984	2.91	1.444	0.013	494.877	0.00
Being good at maths makes you popular.	1246	2.12	1.201	299	2.30	1.307	947	2.06	1.161	2.902	455.927	0.21**
Aspirations to continue with mathematics post-16												
I intend to continue to study maths after my GCSEs.	1428	4.33	1.511	350	4.65	1.397	1078	4.23	1.532	4.849	643.143	0.29***

* significant at .05; ** significant at .01; *** significant at .001

Table 4: Associations between perceptions of mathematics teachers and lessons with mathematics aspirations, self-concept, and intrinsic motivation

Survey items which measured students' perceptions of mathematics teachers and lessons	Future mathematics aspirations	Self concept	Intrinsic motivation
I like my maths teacher.	0.121**	0.138**	0.252**
My maths teacher has high expectations of what the students can learn.	0.087**	0.103**	0.209**
My maths teacher believes that all students can learn maths.	0.141**	0.135**	0.206**
My maths teacher wants us to really understand maths.	0.172**	0.164**	0.265**
My maths teacher sets us homework.	0.097**	0.033	0.107**
My maths teacher believes that mistakes are OK as long as we are learning.	0.117**	0.111**	0.195**
My maths teacher is interested in me as a person.	0.134**	0.198**	0.249**
My maths teacher seems to like all the students.	0.134**	0.154**	0.231**
My maths teacher is interested in what the students think.	0.130**	0.153**	0.270**
My maths teacher doesn't only cares about students who get good marks in maths.	0.096**	0.139**	0.068*
My maths teacher doesn't let us get away with not doing our homework.	0.065*	0.040	0.043
My maths teacher treats all students the same regardless of their maths ability.	0.114**	0.123**	0.206**
My maths teacher is good at explaining maths.	0.150**	0.229**	0.271**
My maths teacher marks and returns homework quickly.	0.114**	0.127**	0.188**
I look forward to maths classes.	0.432**	0.421**	0.553**
In my maths lessons, my teacher explains how a maths idea can be applied to a number of different situations.	0.282**	0.271**	0.395**
In my maths lessons, I have the opportunity to discuss my ideas about maths.	0.229**	0.270**	0.342**
I enjoy my maths lessons.	0.402**	0.432**	0.524**
I can see the relevance of maths lessons.	0.349**	0.331**	0.502**
When I am doing maths, I am learning new skills.	0.340**	0.382**	0.492**
When I am doing maths, I pay attention.	0.315**	0.398**	0.442**
I do not find it difficult to apply most maths concepts to everyday problems.	0.075**	0.241**	0.083**
When I am doing maths, I am not bored.	0.329**	0.352**	0.378**
When I am doing maths, I do not get upset.	0.160**	0.312**	0.174**
When I am doing maths, I do not daydream.	0.259**	0.324**	0.315**

** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed); shaded area shows the dependent variable with which these survey items had the strongest association.

Aspirations to continue with mathematics post-16

We used a 6-point Likert item that asked students whether they were intending to continue with mathematics post-16. A high score (4, 5, or 6) represents an intention to continue with mathematics post-16 with 6 being 'strongly agree'; the other end of the scale (1, 2, or 3) represents disagreement to continue, with 1 being 'strongly disagree'. Table 3 gives the overall mean response (4.33) – which is slightly higher than the England average (4.09).

In line with findings for the England sample, there was a statistically significant difference between boys and girls in favour of boys (ES=.29), comparable to the England sample (ES=.24). Table 4 shows the relationship between the key survey items which underpin the constructs that explore perceptions of lessons and teachers with mathematics aspirations; 'I look forward to my mathematics classes' and 'I enjoy my maths lessons' were the strongest associations (.432 and .402 respectively).

Factors that influence London students' aspirations to continue with mathematics post-16, students' mathematics self-concept, and mathematics intrinsic motivation

We used hierarchical OLS regression procedures to determine the most important factors in explaining the variance in our three dependent variables. The dependent variables (aspirations to continue with mathematics post-16, mathematics self-concept, and mathematics intrinsic motivation) and the independent variables (using actual constructs), for example advice-pressure to study mathematics (whether they were actual constructs or individual items), were measured on a 6-point Likert scale, ranging from 6 'strongly agree' to 1 'strongly disagree'.

The Variance Inflation Factor (VIF) and the tolerance diagnostic factor are measures of co-linearity. A tolerance diagnostic factor was calculated whenever each new variable was introduced into the regression models in order to assess the linear relationship between each introduced independent variable and those already in the equation. The tolerance of each of the models was much greater than 0.1 (tolerance less than 0.1 indicates multi co-linearity). The VIF measures the impact of co-linearity amongst the variables, with values greater than 10 indicating multi co-linearity. The VIF for each of the models was less than 2.1.

Students' aspirations to continue with mathematics post-16

This analysis explores what factors influence London students' aspirations to continue with mathematics after the age of 16. Explanatory variables were included in a particular order (in a five-stage model), to reflect their theoretical and empirical relevance, building on the findings of the England results. There were no statistically significant influences of intrinsic motivation and emotional response to mathematics lessons when tested in model 4, so these measures were removed and are not reported below. The findings reported here for our London schools largely match findings conducted on our national sample of schools.

The influence of students' background characteristics (model 1)

Students' background characteristics were the first variables controlled for within the regression models; we wanted to see what, in addition to these characteristics, had an influence on students' aspirations. Prior attainment and socio-economic status failed to have any statistically significant influence (probably due to the type of school and student sample we had) and therefore were subsequently removed. In line with other existing research (and our national findings), girls were less likely to express intentions to continue with mathematics post-16 (b = –.122, $p<.001$) and the model was statistically significant (R^2 = .015, $F(1, 1363)$ = 20.496, $p<.001$). Once we accounted for students' perceptions of lessons, the effect of gender lost statistical significance; we retained gender as a control primarily because of the substantially larger number of females within the sample and because in our larger national sample, gender was a statistically significant predictor of intention to continue with mathematics post-16. Furthermore, our descriptive analysis of London students indicated that gender differences within self-concept were particularly prominent within our London sample.

Perceptions of mathematics education (added in model 2)

In order to substantiate the impact of students' perceptions of their mathematics education (perception of teachers, lessons, and emotional response to lessons) on future mathematics aspirations we included these measures before we tested for the influence of constructs that took account of the encouragement students received to continue studying mathematics (for example, advice-pressure to study mathematics and home support for achievement in mathematics) and students' motivation and self-concept (for example, extrinsic material gain motivation, intrinsic motivation, and self-concept). There was no influence of 'perceptions of mathematics teachers'. We did find a statistically significant influence of 'perceptions of mathematics lessons' (b = .474, $p<.001$) and the model change was statistically significant (R^2 = .224, $F(2, 1362)$ = 213.645, $p<.001$); this construct remained statistically significant once we controlled for students' extrinsic material gain motivation in model 5 (b = .099, $p>.001$).

External support for mathematics learning and attainment (added in model 3)

There was a statistically significant association between 'home support for achievement in mathematics' (a construct which measures support that students derive from the family in raising mathematics attainment) and post-16 mathematics aspirations (b = .075, $p<.01$). Examples of some of the items within this construct are: 'Someone in my family wants me to talk to them about my maths work' and 'Someone in my family wants me to be successful at school in maths'.

We found that there was a statistically significant association between 'advice-pressure to study mathematics' (a construct which measures influences from a range of people in and out of school to study mathematics post-16) and post-16 mathematics aspirations (b = .446, $p<.001$). Examples of some of the items within this construct are: 'Someone in my family thinks that I should continue with maths after my GCSEs' and 'My teacher thinks that I should continue with maths beyond my GCSEs'. The model change was statistically significant with the inclusion of these constructs (R^2 = .189, $F(4, 1360)$ = 253.707, $p<.001$).

Mathematics self-concept (added in model 4)

In model 4 we controlled for the influence of mathematics self-concept, given its known influence on aspirations and well-established gender differences. In line with our national findings we found there was an independent statistically significant influence of mathematics self-concept on post-16 mathematics aspirations (b = .147, $p<.001$) and the model change was statistically significant (R^2 = .014, $F(5, 1359)$ = 215.074, $p<.001$). This was significant even after controlling for the support students received from their families in mathematics attainment.

Mathematics extrinsic material gain motivation (added in model 5)

In the final stage of our OLS regression analysis we controlled for the influence of mathematics extrinsic material gain motivation. It was important to explore whether the relationship between self-concept and aspirations was moderated by extrinsic material gain motivation (added here) because in our national results we had found this to be the largest factor in explaining mathematics aspirations. This construct had an independent statistically significant influence on post-16 mathematics aspirations (*b* = .235, $p<.001$) and the model change was statistically significant (R^2 = .032, $F(6, 1358) = 203.563$, $p<.001$) – again, a finding which was similar to our national results. An example of an item from this construct is: 'I think maths will help me with the job I want to do in the future'.

The final model fit (Table 5) has a reasonable amount of the variance in post-16 mathematics aspirations explained by the variables in the model (adjusted R^2=.471).

Table 5: OLS regression estimates of factors that influence London secondary school students' aspirations to study mathematics post-16

	Std. Error	*Standardized coefficients Beta (b)*	*T value*	*Co-linearity statistics*	
(Constant)	0.259		-5.355***	*Tolerance*	*VIF*
Gender	0.072	-0.062	-3.056**	0.947	1.055
Perceptions of mathematics lessons	0.044	0.099	3.754***	0.554	1.804
Advice-pressure to study mathematics post-16	0.032	0.355	13.922***	0.596	1.677
Home support for achievement in mathematics	0.036	0.042	1.796	0.716	1.396
Mathematics self-concept	0.037	0.141	5.847***	0.664	1.506
Mathematics extrinsic material gain motivation	0.051	0.235	9.053***	0.577	1.733

Notes: Dependent variable: aspirations to study mathematics post-16; * significant at .05; ** significant at .01; *** significant at .001; VIF and tolerance diagnostic are measures of co-linearity (tolerance less than 0.1 indicates multi co-linearity and for VIF values greater than 10 indicate multi co-linearity).

The findings of the sequential OLS regression analyses indicate a relationship between post-16 mathematics aspirations and advice-pressure to study mathematics; extrinsic material gain motivation; home support for achievement in mathematics; and mathematics self-concept. These findings were not entirely unexpected given that our analysis of a national sample of students generated comparable findings, although within our London sample the influence of gender was not statistically significant. However, we are not suggesting that gender is definitely not significant within the context of London. It may be that these findings are a reflection of our sampling population; we had a large number of single-sex schools, which have been found to be associated with higher educational aspirations among females (for example, Lee and Bryk, 1986; Spielhofer *et al.*, 2004).

Factors associated with mathematics self-concept: Multivariate OLS regression findings

Given the important role of mathematics self-concept in mathematics engagement, we decided to explore which aspects of students' mathematics education are associated with their mathematics self-concept after controlling for the known influence of gender (the bivariate analysis indicated gender differences within self-concept amongst London students were important, indeed higher than in the England sample). Given that mathematics is important for students' lives regardless of whether they intend to continue with it post-16, mathematics self-concept is important for students' engagement and enjoyment of the subject even if they do not continue with mathematics once it is no longer compulsory.

Rather than explore the association of actual constructs with self-concept, we explored the associations of the items that underpinned these constructs with self-concept (and for the intrinsic value models). The justification for this is that we wanted to know what exactly it was about teachers and lessons that was most important in explaining the variance in self-concept (and, in later analysis, intrinsic value). The following two items, which explored students' perceptions of the way their mathematics teachers engaged students with mathematics (and underpinned the perceptions of lessons construct) had the strongest associations with self-concept: 'In my maths lessons, my teacher explains how a maths idea can be applied to a number of different situations' (R=.271), followed by 'In my maths lessons I have the opportunity to discuss my ideas about maths' (R=.270) (see Table 4). The items which directly explored perceptions of teachers had much weaker associations with self-concept. Table 4 also shows similar patterns when comparing associations with aspirations to continue with mathematics post-16 and intrinsic value; the associations were 'In my maths lessons, my teacher explains how a maths idea can be applied to a number of different situations' (mathematics aspirations: R=.282; intrinsic value: R=.395) and 'In my maths lessons I have the opportunity to discuss my ideas about maths' (mathematics aspirations: R=.229; intrinsic value: R=.342).

Table 6: OLS regression estimates of factors that influence London secondary school students' self-concept in mathematics

	Std. Error	*Standardized coefficients Beta (b)*	*T value*	*Co-linearity statistics*	
(Constant)	0.151		13.453***	*Tolerance*	*VIF*
Gender	0.050	-0.174	-7.971***	0.984	1.016
I find it difficult to apply most maths concepts to everyday problems.	0.016	0.147	6.581***	0.949	1.054
When I am doing maths, I do not get upset.	0.017	0.150	6.566***	0.897	1.115
I think maths is an interesting subject.	0.021	0.212	7.25***	0.550	1.820
In my maths lessons, my teacher explains how a maths idea can be applied to a number of different situations.	0.018	0.069	2.916**	0.831	1.204
I enjoy my maths lessons.	0.020	0.148	4.972***	0.529	1.890
When I am doing maths, I pay attention.	0.021	0.178	7.031***	0.736	1.359

Notes: Dependent variable: Mathematics self-concept; * significant at .05; ** significant at .01; *** significant at .001; VIF and tolerance diagnostic are measures of co-linearity (tolerance less than 0.1 indicates multi co-linearity and for VIF values greater than 10 indicate multi co-linearity).

Such findings highlight the importance of the way in which teachers engage students within their lessons in developing self-concept, future aspirations, and intrinsic value. Students' emotional responses to mathematics lessons are more strongly associated with mathematics self-concept than with students' aspirations to continue with mathematics post-16 or mathematics intrinsic motivation (see Table 4). So, for example, 'I find it easy to apply most maths concept to everyday problems' is associated with self-concept (R=.241). Similarly, 'When I am doing maths, I don't get upset' is more strongly associated with self-concept (R=.312) than with mathematics aspirations (R=.160) or intrinsic value (R=.174).

Exploratory analysis indicated that the best predictors would be those that explored students' perceptions and emotional responses to mathematics lessons. The fit of this final model (see Table 6) was much better (adjusted R^2=.379, F(7, 1311) = 115.945, p<.001). The following items were found to have independent statistically significant influences: gender (girls had a lower self-concept than boys) (*b* = – .174, p<.001); 'I find it easy to apply most maths concepts to everyday problems' (*b* = .147, p<.001); 'When I am doing maths I do not get upset' (*b* = .150, p<.001); 'I think maths is an interesting subject' (*b* = .212, p<.001); 'In my maths lessons, my teacher explains how a maths idea can be applied to a number of different situations' (*b* = .069, p<.01); 'I enjoy my maths lessons' (*b* = .148, p<.001); and 'When I am doing maths, I pay attention' (*b* = .178, p<.001).

Factors associated with the intrinsic motivation for mathematics

The statistical associations between students' intrinsic motivation for mathematics and their perceptions of their mathematics teachers were mostly stronger than the associations found between these items and self-concept and aspirations to continue with mathematics post-16 (see Table 4). Table 4 shows the strongest associations between the survey items and the dependent variables (mathematics aspirations, self-concept, and intrinsic motivation) through the use of shading. These associations suggest the importance of mathematics teachers intrinsically motivating their students and creating a sense of enjoyment and pleasure in mathematics.

The items which formed a part of the perceptions of lessons construct had stronger associations with intrinsic value as compared with the associations with aspirations to continue with mathematic post-16 or with mathematics self-concept. So, for example, 'I look forward to maths classes' had a correlation of .553 with intrinsic value as compared with aspirations to continue with mathematics post-16 (R=.432) or mathematics self-concept (R=.421). Again, these findings suggest that what happens in lessons may be more important for creating a sense that mathematics is of personal value than it is for raising aspirations for further study or self-concept. These findings complement the findings from the OLS regression analysis, which shows that in terms of being associated with high student aspirations to continue with mathematics post-16, perceptions of lessons and teachers are not as important as having high self-concept and high extrinsic material gain motivation.

In order to ascertain which of the 'perception of teacher' items had an independent statistical association with intrinsic motivation, an OLS regression analysis was conducted. Gender was not statistically significantly associated with intrinsic motivation (unlike self-concept and aspirations to continue with mathematics post-16) and was therefore removed from the model. The two items which discussed how teachers taught mathematics knowledge had independent associations with intrinsic motivation: 'In my maths lessons, my teacher explains how a maths idea can be applied to a number of different situations' (*b* = .315, p<.001) and 'In my maths lessons I have the opportunity to discuss my ideas about maths' (*b* = .239, p<.001). Furthermore, one other item also had an independent association with intrinsic motivation for mathematics: 'My mathematics teacher believes that all students can learn mathematics' (*b* = .118 p<.001). This final model only explained a small amount of the variance in mathematics intrinsic motivation (adjusted R^2=.231, F(3, 1295) = 130.710, p<.001).

Building on the model above, the OLS regression analysis then explored whether students' perceptions and emotional responses to their mathematics lessons had independent associations in explaining the development of their mathematics intrinsic motivation. The inclusion of these items improved the model fit (adjusted R^2=.414, F(6, 1253) = 149.272 p<.001) and the final model is shown in Table 7. The following items were found to have independent statistically significant influences on students' intrinsic motivation of mathematics: 'In my maths lessons, my teacher explains how a maths idea can be applied to a number of different situations' (*b* = .189, p<.001); 'In my maths lessons, I have the opportunity to discuss my ideas about maths' (*b* = .094, p<.001); 'My teacher believes all students can learn maths' (*b* = .049, p<.05); 'I can see the relevance of mathematics lessons' (*b* = .251, p<.001); 'When I am doing maths I always know what I am doing', (*b* = .132, p<.001); and 'When I am doing maths, I am learning new skills', (*b* = .238, p<.001).

Table 7: OLS regression estimates of factors that are associated with London secondary school students' intrinsic motivation

	Std. Error	*Standardized coefficients Beta (b)*	*T value*	*Co-linearity statistics*	
(Constant)	0.132		7.922***	*Tolerance*	*VIF*
In my maths lessons, my teacher explains how a maths idea can be applied to a number of different situations.	0.016	0.189	8.061***	0.850	1.177
In my maths lessons, I have the opportunity to discuss my ideas about maths.	0.016	0.094	3.850***	0.781	1.281
My maths teacher believes that all students can learn maths.	0.022	0.049	2.136*	0.889	1.125
I can see the relevance of maths lessons.	0.018	0.251	9.746***	0.704	1.421
When I am doing maths, I always know what I am doing.	0.016	0.132	5.436***	0.793	1.261
When I am doing maths, I am learning new skills.	0.022	0.238	8.844***	0.642	1.558

Notes: Dependent variable: Mathematics intrinsic motivation; * significant at .05; ** significant at .01; *** significant at .001; VIF and tolerance diagnostic are measures of co-linearity (tolerance less than 0.1 indicates multi co-linearity and for VIF values greater than 10 indicate multi co-linearity).

Discussion

Our analysis of these survey data for a sample of 1,476 London students indicates the importance of gender issues for mathematics self-concept and, to some extent, illustrates how gender is associated with girls' lower aspirations to continue with mathematics in post-compulsory education, although this was not significant in the final model. Our analysis on a national sample of approximately 5,000 Year 10 students found that high-aspiring girls had similar responses to high-aspiring boys, and these girls as a group had more positive perceptions, attitudes, and motivations, particularly towards mathematics-related constructs, than did low-aspiring boys and girls (Mujtaba and Reiss, under review). The girls in the London sample had higher mathematics aspirations than we found nationally.

At the same time, we are aware of the limitations of this study and that analysis on gender alone, in isolation from ethnicity and social class, will not give a true picture of disadvantage. We acknowledge that working-class girls from certain ethnic minorities have a more difficult time in school, particularly when trying to take STEM subjects that are traditionally seen as atypical (Archer *et al.*, 2012). Another limitation of this analysis is that it does not consider the difference individual schools or departments within schools can make, which has recently been established for mathematics A-level participation (Noyes, 2013).

Our OLS regression analyses indicate considerable variation with regard to which aspects of students' mathematics education are important for future mathematics aspirations, for current intrinsic motivation, and for mathematics self-concept, with different factors being more important for each of these outcomes. The results in Table 5 outline the final factors that were important in explaining post-16 mathematics aspirations. These findings indicate that the constructs 'perception of mathematics lessons' and 'perception of mathematics teachers' are not significant predictors of students' intentions to continue with mathematics post-16, particularly in the final model when we controlled for the influence of 'extrinsic material gain motivation' and 'advice-pressure to study mathematics'. Such findings are similar to those of analyses we conducted on the entire England dataset. We concluded then, as we do now, that there are a number of reasons why such findings do not imply that there should be more of an emphasis in school pedagogy on creating awareness about the material gain of a post-16 mathematics qualification over teaching for engagement. First, the influence of teachers and lessons is likely to be absorbed by such constructs as 'extrinsic motivation' and 'self-concept' as it is rare for any attitude to exist in isolation from another. Second, as our findings with intrinsic motivation indicated, perceptions and experiences of mathematics teachers and lessons were important – and the emotional response to mathematics lessons had the greatest influence on the development of mathematics self-concept. Although the constructs that measured the influence of teachers and lessons were not as strong/effective predictors of students' future mathematics aspirations as other measures, our analysis on the national dataset has demonstrated that individual items within these constructs have a strong effect on intended participation in mathematics, in particular 'I look forward to maths classes'. However, the importance of this particular item was lost within the overall construct (although such items were still not as important as extrinsic material gain motivation, advice-pressure to study mathematics and self-concept). The findings from the literature review and our own analyses indicate the important connections between mathematics self-concept and secondary school students' post-16 mathematics aspirations.

We explored which mathematics education factors are related to self-concept, given that this is crucial to students' academic performance, career aspirations, engagement, and intrinsic motivation (Lent *et al.*, 1986; Skinner *et al.*, 1990; Skaalvik, 1997; Marsh *et al.*, 2005). The student factors most strongly associated with mathematics self-concept were largely to do with the intrinsic value of mathematics lessons and other factors associated with lessons (ease of applying concepts, the way teachers teach mathematics, students paying attention). In addition, there was a strong gender effect in self-concept which was more prominent among London students than nationally. There is some indication that boys' higher mathematic self-concept is underpinned by their more positive emotional response to lessons as well as their having more positive experiences of their mathematics lessons. So, for example, Table 2 demonstrates that boys were more positive about 'When I am doing maths I do not get upset' and 'I enjoy my maths lessons' and these items were also significant predictors of self-concept in the OLS regression analysis.

The factors that were associated with intrinsic motivation in the final OLS regression model were somewhat different than for self-concept. Factors associated with skill acquisition and teaching for engagement, for example teacher encouragement, seeing the relevance of mathematics lessons, learning skills, and knowing what they are doing, were most important for intrinsic motivation. There was one item which was important both for self-concept and for intrinsic motivation: 'In my maths lessons, my teacher explains how a maths idea can be applied to a number of different situations'. This suggests that teaching for engagement is important for the development of both self-concept and intrinsic motivation, though this was not directly related to future mathematics aspirations. Students' perceptions of their mathematics teachers and their perceptions of their mathematics lessons were positively associated with their intrinsic motivation for mathematics – more so than for either self-concept or future mathematics aspirations. Seeing the relevance of mathematics lessons was exceptionally important for intrinsic motivation (R=.502), although not as important for future mathematics aspirations or self-concept. Equally, aspects of students' emotional response to mathematics lessons had little or no relevance for future mathematics aspirations or intrinsic motivation but were very important for mathematics self-concept.

Examining the findings which take a multivariate approach (Tables 1–3) and exploring the influence on any given variable after taking account of other explanatory factors suggests that strategies that are created to enhance mathematics self-concept should be different from those that are intended to increase intrinsic motivation for mathematics (where teaching for engagement is important) or to boost students' aspirations (where students need to be made aware of the tangible benefits of having a post-16 qualification in mathematics). Policy, as well as teaching methods, needs to take into account that students' desires to learn more about mathematics (their learning goals as impacted by intrinsic motivation) may not necessarily be linked tightly with their future aspirations (which are influenced by extrinsic motivation) but that self-concept is associated with both. Policies aimed at increasing participation in A-level mathematics could start by considering how to boost the extrinsic material gain motivation amongst student groups with low participation and retention rates, perhaps by targeting parents as well as students, given the former's key role in providing the advice-pressure that stimulated or supported students to continue to study mathematics. It may also be the case that in an elective curriculum for 16–19 year olds, increasing the range and level of mathematics qualifications on offer post-16 might help to entice young people to opt for the subject. On the other hand, policies designed to increase students' intrinsic engagement with mathematics (thus leading to enhanced mathematical knowledge which would be useful for a range of reasons in students' lives) could focus on the quality of teaching and learning in the classroom. What this study therefore suggests is that national policies, such as the requirement to continue with GCSE-level mathematics post-16 if it has not been acquired at 16, can only go so far in supporting the greater uptake of the subject. It is at the classroom level that changes need principally to be made. This is likely to mean a major push on teacher recruitment and continuing professional learning for those already in the profession to meet the increased demand for high-quality mathematics teachers. There is a shortage of specialist mathematics graduates who go on to become mathematics teachers in schools and further education colleges and this is one of the reasons why the government would like more students to continue with post-16 mathematics (Department for Business, Innovation and Skills, 2013b). Our findings suggest ways in which mathematics aspirations can be raised so as to ensure more students continue with the subject post-16. In London, the Mayor's Excellence Fund, which is a source of financial support to address some of the issues raised by the Mayor's Education Inquiry, is an important attempt to raise the profile of teaching and learning in a number of core subjects, including mathematics. There must surely be a case for using this funding to prioritize the recruitment of new, inspirational mathematics graduates to teaching, alongside a targeted programme of continuing professional learning for serving mathematics teachers in London.

Notes

1. General Certificate of Secondary Education, the examinations taken by 16-year-old students in England, Northern Ireland and Wales.

2. From 2015 young people will have to stay in some form of education or training up to the age of 18 and the majority are likely to remain in full-time education programmes of different types.
3. Free school meal – a rough measure of deprivation.

Notes on contributors

Dr Tamjid Mujtaba

Tamjid Mujtaba is a research officer at the Learning for London@IOE research centre at the Institute of Education, University of London (www.ioe.ac.uk/Learningforlondon). She has an interest in equity issues in education, the primary focus being on gender and ethnicity.

Professor Michael Reiss

Michael Reiss is Pro-Director: Research and Development and Professor of Science Education at the Institute of Education, University of London, Director of the Salters-Nuffield Advanced Biology Project. and an Academician of the Academy of Social Sciences. For further information see www.reiss.tc.

Professor Ann Hodgson

Ann Hodgson is Assistant Director for London and Director of the Learning for London@IOE Research Centre at the Institute of Education, University of London.

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