Oxford Review of Economic Policy, Volume 36, Number 4, 2020, pp. 816–835

Gender, achievement, and subject choice in English education

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Abstract: In common with other OECD countries, there is a gender gap in educational achievement in England favouring girls. This carries through to tertiary education. On the other hand, boys are far more likely to engage in STEM in post-16 vocational education and at university. The underachievement of boys overall, but over-representation in STEM, presents significant challenges for policy. This paper documents changes in the gender gap over the last 20 years in England and discusses findings in the light of international evidence. It concludes that education policies, in academic and in vocational spheres, can be designed to reduce gender inequalities that exist in both.

Keywords: gender gap, educational achievement, STEM

JEL classification: I20, I24

I. Introduction

Across most industrialized countries, female educational attainment has increased massively over recent decades and females go on to tertiary education in greater numbers than males. On the other hand, females are much less likely to choose science, technology, engineering, and maths (STEM) in upper secondary or tertiary education. Two policy concerns arise from these observations: (*a*) why do males underachieve in

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This work was supported by the Centre for Vocational Education Research (funded by the Department of Education) and the Economic and Social Research Council through the Centre for Economic Performance. We are very grateful to the editor and referees for helpful comments.

doi:10.1093/oxrep/graa050

education and what can be done about it? (*b*) why do females not pursue STEM fields in greater numbers? Both questions matter from an efficiency standpoint if they arise because of distortions in how the education system or society operates. They also matter from an equity standpoint when one considers that there is a high payoff to education, particularly in some STEM fields. This has implications for the gender pay gap.[1]

This paper documents how the gender gap in educational achievement has evolved over the last couple of decades in England, building on and further developing the earlier work of Machin and McNally (2005). We also investigate the gender gap in post-compulsory education and evaluate the extent to which this is driven by prior achievement and institutional characteristics. We further explore the role of these characteristics for influencing whether individuals choose STEM subjects in further and higher education. We use linked administrative data sets that track students through school, further, and higher education.[2] We primarily focus on cohorts that ended their compulsory full-time education in 2003 and 2013, as this gives us time to track the educational progress of students in post-compulsory education for the latter cohort.

Machin and McNally (2005) found that emergence of the gender gap at age 16 in the national examination system in England coincided with the introduction of the GCSE examination in 1988. One potential reason for this is the importance of coursework, though other factors might include a gender differential in skills that are rewarded by the GCSE assessment. As with this earlier paper, an important caveat is that measures in the assessment system within England do not fully measure the gap in human capital between boys and girls, but rather a gap at compulsory school-leaving age which is also coupled with those aspects of achievement that are deemed important by the education and examination system.

In this paper, we continue from where the earlier paper left off by looking at how achievement gaps have evolved since 2000 (section II). We take each phase of education in turn, from primary school to higher education. We consider how the raw gender gap can be accounted for by the limited information included in administrative data sets such as demographics, prior achievement, and school-level indicators. We then put our findings into an international context (section III) before a discussion of the broader literature and policy context (section IV). We conclude in section V.

II. The gender achievement gap

(i) Primary school

In England, children start school at the age of 5 and complete their primary education at age 11. The National Curriculum is divided into various ‘Key Stages’, at the end of

[1] Although the gender gap has narrowed over recent decades, progress has currently stalled. It has been well documented that differential participation in STEM fields is one of the drivers of the gender pay gap (e.g. Blau and Khan, 2017; Francesconi and Parey, 2018).

[2] The National Pupil Database (NPD), the Individual Learner Record (ILR), and data from the Higher Education Statistics Agency (HESA). These have been linked to HMRC records on employment and earnings which are used to a limited extent in this paper. The Longitudinal Educational Outcomes data (LEO) has been made available to the Centre for Vocational Education Research for research projects on its programmes, of which this paper forms part.

which they are evaluated either by their teacher or in the framework of national tests. In primary school, the two relevant phases are Key Stage 1 (age 5–7), which ends with a teacher assessment at age 7 and Key Stage 2 (age 7–11) which ends with national tests at age 11. These form the basis of the School Performance Tables. For both these assessments, much attention is paid to whether young people meet the target indicator, which is the 'expected standard' of achievement at that age.

Figures 1(*a*) and 1(*b*)show the gender gap in the percentage of boys and girls achieving targets in reading, writing, and maths at the end of Key Stage 1 and Key Stage 2, respectively. The figures show how this gap has evolved since 2000. Appendix Table A1 shows full summary statistics for the main educational outcome measures used in the text.

Figure 1(*a*) shows that girls outperform boys in every subject at age 7. The gap is sizeable in reading and writing and very small in maths. The trends are generally stable with a slight narrowing between 2010 and 2015 for reading and writing. In Figure 1(*b*), a very similar story can be told except there is little or no gender gap in maths and the gender gap in reading and writing narrowed significantly between 2010 and 2015. In 2016, a new more challenging curriculum was introduced for both Key Stage 1 and Key Stage 2, and the grading scheme also changed.[3] As a result, the percentage of boys and girls achieving the 'expected standard' fell across all subjects. The effect was greater for boys in reading and writing (though not for maths) and therefore the gender gap widened in those subjects. It is not surprising that boys are more affected than girls by higher standards in the subjects in which they are less well performing. This does not necessarily affect students' behaviour or future performance unless it affects how teachers treat them or how they (or their parents) see themselves.[4] As this curriculum reform is recent, it is too early to evaluate whether it had longer-term consequences.

It has been well documented that there is a higher variance in test scores for boys than girls in most OECD countries (e.g. Machin and Pekkarinen, 2008), with an increased prevalence of boys in the upper part of the distribution of maths and in the lower part of the distribution for reading. This is true when we consider maths and reading scores at age 11.[5] Looking at the proportion of boys (girls) in the top and bottom quintile for reading, this is 16 per cent (21 per cent) and 22 per cent (16 per cent), respectively. For maths, this is 22 per cent (17 per cent) at the top and 20 per cent (22 per cent) at the bottom.[6]

Table 1 shows how gender gaps in achievement measures at the end of primary school are affected by the inclusion of other variables. As outcome measures, we use whether a student achieves the 'expected standard' in reading, writing, and maths (i.e. used in Figure 1 to calculate the gender gap) and whether a student achieves a high standard in these subjects (i.e. level 5 or above). While over 80 per cent of students achieve the expected standard in these subjects, much fewer achieve level 5 or more (see Appendix

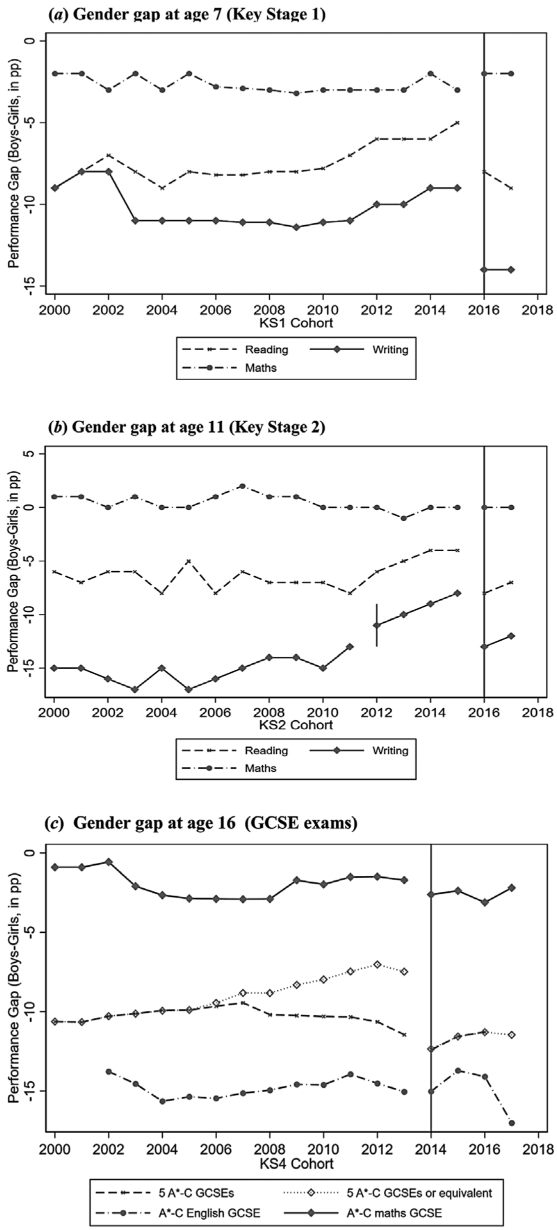
[3] Specifically, the Department for Education (DfE) overhauled the format and content of assessments (SATS) taken in Year 2 and Year 6, to reflect the new curriculum. These were taken for the first time in May 2016. There is also a new grading system, replacing the previous national curriculum levels.

[4] Murphy and Weinhardt (2020) show that student rank in primary school has an important effect on subsequent performance. Although the change in standards does not necessarily affect rank, student awareness of not meeting a threshold might similarly have an effect on their self-efficacy.

[5] The ratio of the male to female variance in 2013 is 1.06 and 1.10 in maths and reading scores, respectively.

[6] This is computed using data from 2013.

Figure 1: Gender gaps in the achievement of targets at age 7 and age 11. (*a*) Gender gap at age 7 (Key Stage 1). (*b*) Gender gap at age 11 (Key Stage 2). (*c*) Gender gap at age 16 (GCSE exams)



Notes: Own calculations based on data from DfE Statistics and NPD microdata. Figure (*a*): up until 2015, the indicators used to calculate the gender gap refer to the % of pupils with level 2 or above. From 2016, they refer to the % of pupils achieving the expected standard in a new more challenging curriculum. Figure (*b*): up to 2015, the indicators used to calculate the gender gap refer to the % of pupils with level 2 or above. From 2016, they refer to the % of pupils achieving the expected standard in a new more challenging curriculum. In writing, the evaluation was based on tests up to 2011. From 2012, this is teacher assessed. Figure (*c*): data used come from the School Performance Tables (2000–1) and NPD microdata (2002–17). Note that: (i) Wolf reform effective from 2014; (ii) from 2016 new accountability measures were introduced; (iii) from 2017 grades changed from letters to numbers. Also, up until 2007, performance in the indicator '5 A*–C GCSEs' also includes GNVQs (which were subsequently abolished).

Table 1: Regressions for achievement at age 11

	(1) Achieved target	(2) Achieved target	(3) Achieved higher level (L5+)	(4) Achieved higher level (L5+)
KS2 reading				
Male	–0.050***	–0.004***	–0.070***	–0.014***
	(0.001)	(0.001)	(0.001)	(0.001)
KS2 writing				
Male	–0.097***	–0.041***	–0.145***	–0.092***
	(0.001)	(0.001)	(0.001)	(0.001)
KS2 maths				
Male	–0.002**	0.035***	0.043***	0.077***
	(0.001)	(0.001)	(0.001)	(0.001)
Controls	no	yes	no	yes

Notes: 2013 Key Stage 2 cohort. *p<0.10, **p<0.05, ***p<0.01. Robust standard errors in parenthesis. N=523,548 in columns 1, 3; 509,268 in columns 2, 4. Controls include: demographic and socio-economic information (i.e. ethnicity; whether English is spoken as a first language; and whether the student is eligible to receive free school meals), previous educational attainment in Key Stage 1 and school fixed effects.

Table A1) and thus these different outcome measures capture whether gender gaps differ across the distribution.[7]

Table 1 shows raw gender gaps at age 11 for whether students achieve the expected standard and higher standard in columns (1) and (3) respectively. We use the 2013 cohort for this analysis.[8] The raw gaps are larger for the higher standard, at 7 and 14 percentage points (favouring girls) in reading and writing, respectively. However, we also see that boys have a distinct advantage in maths, where the attainment gap is 4 percentage points.

Columns (2) and (4) show gender gaps after we condition on available variables in administrative data—other demographic and socio-economic information (i.e. ethnicity; whether English is spoken as a first language; and whether the student is eligible to receive free school meals), previous educational attainment, and school fixed effects. After including these controls, the gender gap in reading almost disappears, is reduced by over a third in writing, and becomes larger in maths (favouring boys). The main driver of differences between the raw gender gap and the gap after including controls is prior attainment at age 7.[9] The results including controls reflect how the gender gap in maths becomes wider over time at primary school.

Appendix Table A1 shows summary statistics for the raw gender gap within subgroups compared to the overall gender gap (those eligible for free school meals; Black; Asian). Although the absolute performance varies across these sub-groups

[7] The percentage achieving level 5 or more is more reflective of gaps that emerge when using the raw scores (i.e. a continuous measure of performance). This is not shown here for reasons of space, but results are available on request.

[8] We use 2013 because at the time of undertaking the analysis, this is the cohort for which we have permission to use NPD data for the purposes of the Centre for Vocational Education Research project to which this relates.

[9] In an additional exercise, we add the controls progressively to uncover the main drivers of gender gap. These also include school-level variables (i.e. proportion of females in the school-year group). We do this for all the outcomes discussed in this paper. Although the results are not included in the interests of space, we refer to findings of interest in the text and they are available upon request.

(and it is notable how much worse students perform if they come from a disadvantaged background), the gender gap is broadly stable within groupings compared to the overall gap.

(ii) Secondary school

Students enter secondary school at age 11 and undertake exams for the General Certificate of Secondary Education (GCSEs) at age 16. This marks the end of compulsory full-time education. GCSEs come at the end of Key Stage 4 of the National Curriculum and grades in GCSEs contribute towards the School Performance Tables. The performance of students in these exams affects what they can do in post-16 education. Getting a Grade C or above (Grade 4 in the new terminology) in English and maths is important for being able to access more selective courses and institutions (Machin *et al.*, 2020). Getting five or more 'good grades' (i.e. Grade C/4 or above) is also an important indicator.

Figure 1(*c*) shows the gender gap in various GCSE measures and how this has evolved between 2000 and 2017.[10] As before, summary statistics are shown in Appendix Table A1. There is a substantial gap favouring girls in English and in overall measures of GCSE performance (five or more good grades; with and without vocational equivalents). At this age, there is also a small gender gap in maths, but it favours girls. There have not been marked changes in the gender gap over time, but there had been some improvement (making boys less disadvantaged) in the GCSE measure that includes vocational equivalents. The change in 2014 reflects the implementation of the Wolf reforms to vocational education.[11] This reform involved the removal of many vocational qualifications from what could be counted in the performance tables. The background to this was the perception that schools were encouraging students to take easy subjects to make their performance measure look better. Although the reform affected all students, it had a bigger effect on boys and hence the gender gap in this measure increased (thereafter being the same as the GCSE measure without vocational equivalents).

Table 2 shows regressions for the gender gap in these measures with and without controls (similarly to that shown for primary school in Table 1; in this case, controls also include attainment at the end of primary school). We show this for the following outcome variables: whether the student meets the target of 5 good grades at GCSE—including and excluding equivalents (i.e. rows 1 and 2 respectively), whether he/she obtains a good grade in English (row 3) and maths (row 4). For English and maths, we also show the gender gap among top performers (i.e. those attaining A–A*).[12] Girls outperform boys

[10] From 2016 onwards a new 'Progress 8' measure is introduced in the Performance Tables which is difficult to compare with the earlier measure. Therefore, we take the performance indicators from the NPD microdata. We stop at 2017 as this is the last year of data available to us for this project.

[11] Details of implementation available here:
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/405986/Wolf_Recommendations_Progress_Report_February_2015_v01.pdf Courses taught on the 'approved list' started in September 2012 and therefore are reflected in the performance measures at GCSEs 2 years later (note Key Stage 4 is from when students are aged 14 to 16).

[12] For these outcomes, the gender gap is very small at the bottom of the distribution.

Table 2: Regressions for achievement at age 16

	(1)	(2)		
5+ A*–C GCSEs or equivalents				
Male	–0.075***	–0.047***		
	(0.001)	(0.001)		
5+ A*–C GCSEs				
Male	–0.115***	–0.080***		
	(0.001)	(0.001)		
Controls	no	yes		
	(1)	**(2)**	**(3)**	**(4)**
English GCSE	**A*–C**		**A–A***	
Male	–0.151***	–0.096***	–0.101***	–0.061***
	(0.001)	(0.001)	(0.001)	(0.001)
Maths GCSE	**A*–C**		**A–A***	
Male	–0.019***	–0.018***	0.001	–0.008***
	(0.001)	(0.001)	(0.001)	(0.001)
Controls	no	yes	no	yes

Notes: Cohort undertaking GCSEs in 2013; *p<0.10, **p<0.05, ***p<0.01. Robust standard errors in parenthesis. N=642776. Controls include: demographic and socio-economic information (i.e. ethnicity; whether English is spoken as a first language; and whether the student is eligible to receive free school meals), previous educational attainment in Key Stage 2, school-level variables at KS2 (i.e. proportion of females in the school-year group in KS2), and secondary school fixed effects.

on all measures with the smallest gap in maths. For English, the gender gap is only a little lower at the very top of the distribution. However, in maths, the gender gap is negligible at the top of the distribution.

The effect of including controls is to reduce the gender gap in the overall GCSE measures (with or without equivalents) and GCSE English by around one-third. The fact that substantial gaps remain even after controlling for detailed scores at the end of primary school (as well as other controls) shows that the performance of girls relative to boys continues to grow during secondary school. In contrast, there is little change in the (small) gender gap for maths with or without controls.

(iii) The gender gap in post-compulsory education

After age 16, students enter post-compulsory education, generally for about 2 years (although a proportion drop out). Upper secondary education in England consists of a 'Level 3' qualification in either A-levels (the academic pathway) or a vocational qualification. These qualifications are essential for entry to university and have been associated with good labour market outcomes (e.g. McIntosh, 2006). However, many people fail to achieve upper secondary education, leaving education eventually with only GCSEs or a vocational equivalent at or beneath that level (i.e. Level 2 or below).

In Table 3 we show the gender gap for cohorts that undertook their GCSE exams in 2003 and 2013 for a range of outcomes. We only look at individuals up until the age of 19 as this is as far as we can observe individuals for the more recent cohort. In panel A, we look at drop-out from education (i.e. not observed in education at age 18; and NEET (not in education, employment or training) at age 18). In panel B, measures

Table 3: Post-compulsory education

	2003			2013		
	Males	**Females**	**Gender gap, 2003**	**Males**	**Females**	**Gender gap, 2013**
	Panel A. Drop–out from education at age 18					
Not observed in education	0.25	0.20	0.05	0.14	0.11	0.03
NEET	0.13	0.12	0.01	0.08	0.06	0.02
	Panel B. Further education (16–19)					
Achieved Level 2 or more	0.60	0.67	–0.07	0.87	0.92	–0.05
Achieved Level 3 or more	0.47	0.56	–0.09	0.62	0.73	–0.11
At least one STEM aim in 16–19 education	0.66	0.53	0.13	0.65	0.54	0.11
Enrolled in apprenticeship	0.16	0.13	0.03	0.18	0.15	0.03
	Panel C. Tertiary education up to age 19					
Enrolled Level 4 or 5	0.03	0.04	–0.01	0.02	0.02	0
Enter university (Level 6+)	0.22	0.28	–0.06	0.23	0.31	–0.08
STEM at university (conditional on entry)	0.34	0.17	0.17	0.46	0.25	0.21
N	316,784	305,070		329,240	313,536	

Notes: Drop-out measures are measured at the age of 18. Further and tertiary education measures are measured by the age of 19 (that is, with information up to 3 academic years after the end of Key Stage 4 in 2013). Many students enrol in higher education at a later date, so the indicators related to higher education measure enrolment in the first possible year that students can enter higher education. STEM subjects for further education are science and mathematics, engineering and manufacturing technologies, information and communication technology. STEM subjects at university include: biological and physical sciences, mathematics, computer science, and engineering and technology.

of achievement in further education are considered. These are whether the individual achieved a qualification at Level 2 or more (i.e. GCSE or vocational equivalent) by age 19; whether he/she achieved a qualification at Level 3 or more (i.e. A-level or a vocational equivalent such as BTECs); whether he/she pursued at least one STEM aim within further education; and whether he/she enrolled on an apprenticeship. Finally, in panel C, we consider outcomes in tertiary education which include whether an individual is enrolled in Level 4 or Level 5 qualifications. These are higher-level vocational qualifications that are at sub-degree level, including Higher National Certificates, Higher National Diplomas, and Foundation Degrees. We investigate whether the individual enters university to do a degree (i.e. Level 6 qualification) and finally whether he/she pursues a STEM degree (conditional on entry).

For both cohorts, men are more likely to drop out of education at age 18 and be classified as NEET. These are important outcomes because it puts young men at a higher risk of wage scarring effects and crime participation resulting from youth unemployment in the longer term (Gregg and Tominey, 2005; Bell *et al.*, 2018). For the more recent cohort, the gender gap was 3 and 2 percentage points, respectively. There has been an increase of 1 percentage point in the gender gap in the probability of being classified as NEET, but a reduction in the gender gap with regard to participation in education beyond the age of 16. This latter gap changed from 5 to 3 percentage points. Appendix Table A1 shows a similar gender gap within groups defined (broadly) by socio-economic status or ethnicity, although clearly overall outcomes are much worse for those from low socio-economic backgrounds (those eligible to receive free school meals).

In further education, females are more likely to achieve qualifications at both Levels 2 and 3. However, they are less likely to have at least one STEM aim among their further education outcomes. There are many more women than men achieving at least a Level 3 qualification (a gender gap of 11 percentage points for the more recent cohort) but many more men than women with STEM included in their further education qualification (a gender gap of 11 percentage points). Men are also more likely to be enrolled on an apprenticeship (a gender gap of 3 percentage points). Whereas more men used to leave education at age 16, in more recent times they are more likely to achieve a Level 2 qualification (where the gender gap has also narrowed). However, the gender gap has widened in the probability of achieving a Level 3 qualification. The gender gap in the probability of being enrolled in an apprenticeship is unchanged and there has been a slight improvement in the probability of enrolling in STEM within further education (the gender gap has decreased by 2 percentage points).

Considering tertiary education, the very small fraction of both men and women enrolling in Level 4/5 courses by age 19 reflects both the fact that these types of education are more likely to be accessed by older students and the fact that there is little provision at these levels (even when older students are included). The lack of higher vocational education in England has been well documented and stands in sharp contrast to other countries (Augar Review, 2019). In higher education, there is an 8 percentage point gender gap favouring women for the 2013 cohort. This has increased by 2 percentage points compared to the earlier cohort. However, women are much less likely than men to undertake STEM degrees within higher education. The gap for the more recent cohort is 21 percentage points, with an increase compared to the earlier cohort (17 percentage points). A similar table for all higher education subjects is shown in the Appendix Table A2. This shows very little change in the gender gap between the earlier and later cohorts when considering individual subjects.

Tables 4 and 5 show regressions for some of these outcome variables with and without controls (i.e. demographics, achievement at primary and secondary school, as well as secondary school fixed effects) for the more recent cohort. The gender gap in Panel A (not being observed in education at age 18 and being classified as NEET) is fully accounted for by including these controls (about half is accounted for by achievement at the end of primary school and half by achievement at the end of secondary school, with little additional role for institutional-level variables).

The gender gap in whether the individual achieves at least a Level 3 qualification goes from about 10.7 percentage points without controls to about 4.6 percentage points with controls. The gap which can be accounted for is mostly evenly split between individual achievement at the end of primary school and at the end of secondary school. In contrast, the gender gap in the probability of being enrolled to an apprenticeship (of 3.6 percentage points) is almost invariant to inclusion of controls.

Turning attention to tertiary education, the very small gender gap in enrolment to Level 4 or 5 qualifications is not influenced by observable variables. The gender gap in university participation at age 19 is reduced by more than half after including controls (again mostly accounted for by primary and secondary school attainment). For this

Table 4: Regressions for post-16 outcomes

	(1)	(2)
Panel A. Drop out from education at age 18		
Not observed in education		
Male	0.030***	0.005***
	(0.001)	(0.001)
NEET		
Male	0.019***	–0.002***
	(0.001)	(0.001)
Panel B. Further education (16–19)		
Achieved Level 2 or more		
Male	–0.048***	–0.003***
	(0.001)	(0.001)
Achieved Level 3 or more		
Male	–0.107***	–0.046***
	(0.001)	(0.001)
Enrolled in apprenticeship		
Male	0.036***	0.034***
	(0.001)	(0.001)
Panel C. Tertiary education up to age 19		
Enrolled Level 4 or 5		
Male	–0.001***	0.000
	(0.000)	(0.000)
Enter university (Level 6 or more)		
Male	–0.080***	–0.034***
	(0.001)	(0.001)
Controls	no	yes

Notes: *p<0.10, **p<0.05, ***p<0.01. Robust standard errors in parenthesis. Controls include: demographic and socio-economic information (i.e. ethnicity; whether English is spoken as a first language; and whether the student is eligible to receive free school meals), achievement at primary and secondary school. They also include KS2 school characteristics (the % of females in KS2 year group and the rank in the school in terms of total KS2 points) and secondary school fixed effects. N=642776.

particular outcome, there is more of a role for the school attended in making a difference to the gender gap over and above achievement.[13]

Table 5 reports analysis of what men and women do in further and higher education. It shows the gender gap in STEM and the extent to which this can be accounted for by including controls.

The raw gender gap in all these outcome variables favours males except for STEM in academic further education (A-levels), where there is almost no gender gap.[14] Gaps for the other variables are large and explained to a much more limited extent by included variables compared to the more general achievement outcomes shown in Table 4. The gender gap in the probability of undertaking a STEM aim in vocational (further) education is 15.2 percentage points (favouring boys) without any controls and changes to 13.4 percentage points when including controls. The gender gap in STEM in higher

[13] After controlling for attainment measures, institutional measures reduce the gender gap from 4.2 to 3.4 percentage points.

[14] We measure this by whether individuals have any STEM aim of a given type within further education. A recent paper by McDool and Morris (2020) examines gender gaps with a more refined subject breakdown than we do here.

Table 5: Regressions for STEM outcomes

	(1)	(2)
Panel A. Any STEM in further education		
Male	0.107***	0.089***
	(0.002)	(0.002)
Panel B. Any STEM vocational (further education)		
Male	0.152***	0.134***
	(0.001)	(0.001)
Panel C. Any STEM academic (further education)		
Male	0.012***	–0.003*
	(0.002)	(0.001)
N (for Panels A, B, and C)	409,794	409,442
Panel D. STEM in higher education (conditional on entry)		
Male	0.204***	0.165***
	(0.002)	(0.003)
N	177,386	177,244
Controls	no	yes

Notes: *p<0.10, **p<0.05, ***p<0.01. Robust standard errors in parenthesis Controls include: demographic and socio-economic information (i.e. ethnicity; whether English is spoken as a first language; and whether the student is eligible to receive free school meals), achievement at primary and secondary school. They also include KS2 school characteristics (the % of females in KS2 year group and the rank in the school in terms of total KS2 points) and secondary school fixed effects.

education is 20.4 percentage points without any controls and changes to 16.5 percentage points after including controls (most of which is accounted for simply by controlling for attainment at the end of primary school).

The limited role of prior educational achievement in explaining the gender gap in STEM is consistent with much of the literature (Kahn and Ginther, 2018). Recent studies for Ireland and Canada by Card and Payne (2017) and Delaney and Devereux (2019) respectively, have found a much larger role for college preparedness in relation to the probability of STEM degree choices. In both cases, course-taking in upper secondary education is the most important driver of this and it might be that if we were to control for post-16 courses taken in a more detailed way, we would also be able to explain more of the variation in the gender gap. The main insight from our analysis—like much of the international literature—is that the gender gap in STEM-taking is unlikely to be much influenced by further relative improvement in female educational achievement at school, whether overall or in particular subjects.

III. Results in international context

The findings presented above show that girls vastly outperform boys in literacy from primary school onwards. The gender gap in maths favours boys, especially in the upper part of the distribution. However, this is much smaller and no longer evident in GCSE results at the end of secondary school. By this time, girls outperform boys overall and especially in English. Girls are more likely to attend university but less likely to pursue STEM subjects.

These broad findings display some commonalities with those seen in other OECD countries for recent years. Data from the OECD's Programme for International Student Assessment (PISA 2018) shows that 15-year-old girls' performance in literacy exceeds that of boys in every country and the gap is considerable. For science and maths, the gender gap is much smaller. Where there is a difference, it usually favours boys in maths—although not for all countries. For science, the picture is more mixed—sometimes favouring boys and sometimes favouring girls. In the UK, boys outperform girls in maths and (to a lesser extent) in science. The difference between the (small) gender gap in maths at GCSEs (which favours girls in the years considered here) and in PISA (favouring boys) might be explained by differences in what is tested in GCSE and the PISA maths test. PISA measures the application of knowledge in everyday situations. Another international study (Trends in International Mathematics and Science Study, TIMSS 2015) is more curriculum-based and closer to what is measured at GCSE. This shows teenage girls in England to slightly outperform boys in maths. In this survey, there is no distinct pattern in average gender differences in maths across countries: in some countries the gap favours girls and in others it favours boys. The difference is small.

With regard to tertiary education, the results reported here are also in line with international evidence. Specifically, in most OECD countries, the share of females in tertiary education is between 50 and 60 per cent.[15] However, boys are more likely to enter maths-intensive science fields (science, technology, engineering and maths or STEM) in upper secondary and tertiary education (e.g. see the review paper by Kahn and Ginther, 2018).

IV. Discussion and policy implications

(i) Boys' underachievement

Should policy-makers make boys' underachievement a target for policy? As discussed by Pekkarinen (2012) it is not obvious that policies need to focus specifically on the gender gap if the underlying issue is poor performance rather than something that is intrinsic to gender itself. On the other hand, there is a reason to focus on males specifically if the negative externalities from low male attainment are large—of which there is some evidence.[16]

There has been a debate on the extent to which gender gaps in numeracy and literacy arise from nature or nurture. As set out by Lavy and Sand (2018), this debate is based on limited credible scientific evidence because it is difficult to disentangle the impact of biological gender dissimilarities from environmental conditions and also because it is difficult to measure stereotypes and prejudices and test their causal implications. A review of the literature by Spelke (2005) finds that while there are some differences in intrinsic cognitive abilities, they are small and do not consistently favour either sex in a way that would make men or women cognitively more adept for schoolwork. Of course, this does not prevent stereotypical attitudes and bias that might lead to gender

[15] https://ec.europa.eu/eurostat/statistics-explained/index.php/Tertiary_education_statistics

[16] Pekkarinen (2012) cites evidence from Lochner and Moretti (2004) on the effect of education on male criminality and from Autor (2010) that declining male educational attainment is at least partly responsible for the fragile state of lower-income families in the US.

inequality. For example, Terrier (2020) finds evidence that teacher bias has a role to play in why boys lag behind girls.

According to the OECD (2015), important reasons for the gender gap are to be found in students' attitudes towards learning, their behaviour in school, their use of leisure time, and their self-confidence. There is also a literature showing clear and consistent gender differences in the incidence of behavioural problems that imply differences in non-cognitive abilities and are likely to show up in educational attainment (Pekkarinen, 2012). For instance, in the literature surveyed by Buchmann *et al.* (2008), males are overrepresented in populations with reading disabilities, antisocial behaviour, mental retardation, attention disorders, dyslexia, stuttering, and delayed speech. There is also evidence that adolescent girls score higher in tests measuring non-cognitive skills such as attentiveness, organizational skills, and self-discipline. Bertrand and Pan (2013) find evidence that boys' deficit in noncognitive skills is not purely biological but is subject to strong environmental influences, particularly from the home. Specifically, they find that boys' behaviour is more strongly affected by parental inputs than girls'. On the other hand, Lundberg (2017) finds that girls and boys react differently to school and family problems but not in a way that leads to a gender gap in college graduation rates. She finds that whereas boys react through behavioural problems, girls are more likely to react through anxiety and depression. Both types of problem lead to poor outcomes in the longer term.

The gender gap in achievement and college going has not always favoured females. This took several decades to emerge. As shown by Goldin *et al.* (2006) in relation to the US, the improvement in female performance over time has been driven by increases in girls' expected economic returns to college as well as being influenced by long-standing behavioural and developmental differences between boys and girls (discussed above). Bertocchi and Bozzano (2019) review the literature on explanations for gender gaps over time. They note that from the 1980s to the 2000s, the role of post-secondary expectations was a major driver of the relative increase in girls' high school grade point average in the US (Fortin *et al.* 2015). Furthermore, since 1980 the probability of working in a high-wage occupation has risen for college-educated women relative to men due to a greater increase in the demand for social skills in such occupations relative to others.

Pekkarinen (2012) emphasizes the role of the effort costs of education as a reason for why girls' achievement has risen, in the context of increasing returns to education that are evident for both men and women. This relates to the differences in non-cognitive abilities referred to above (e.g. as demonstrated by the difference in behavioural problems between boys and girls). In a data set of US high school graduates, Jacob (2002) finds that non-cognitive behavioural factors do a good job in explaining the gender gap in entry to college. In a study about England, Aucejo and James (2016) find that verbal skills play a substantially greater role in explaining university enrolment than maths skills. As this is an area of strong comparative advantage for girls (in most countries), the relative effort cost of the application of such skills in university is probably also lower for girls.

The different development trajectories of girls and boys may increase the role of effort costs. Buchmann *et al.* (2008) note that girls tend to mature more quickly. This has relevance to education systems in Europe because as noted by Pekkarinen (2012), many boys are going through adolescence at the age of 15/16 at which some countries (including the UK) are tracking students to different pathways—and this is a potential explanation for why gender gaps in attainment are lower in countries that track students at an earlier age.[17] The exam at age 16 in England is very high stakes and perhaps that was understandable in the 1950s when O-levels (the predecessor of GCSEs) were set up as it was common for individuals to enter the labour market after this time. But in recent times, the norm is to stay in education at least up until age 18. In fact, it is now compulsory to stay in some form of education/training until that age, even though in practice a small proportion drop out before then. Yet, despite changing expectations of education and increased demand for education in the labour market, the high-stakes exam in England is still at age 16 (GCSEs) and much rests on success in this exam. Machin *et al.* (2020) show that marginally failing to get a 'good grade' in GCSE English has a large effect on the probability of progression within education and the probability of dropping out of education and/or becoming NEET. Boys are more likely to be in this group as they are disproportionately represented in the number of students who get grades below a Grade C/4. The results reported in the above sections suggest that reforms to make standards higher (whether through reforming the curriculum or grading standards) makes it more difficult for students of lower ability to pass the threshold. This is an obvious effect of raising standards but here it is interesting to see what this means for the gender gap. Raising standards is not necessarily a bad thing if increased effort is applied to help marginal students to get to the higher threshold. But it could have unintended consequences if it has a discouragement effect and/or if it increases barriers to receive more respected post-secondary qualifications.

Perhaps high-stakes testing at age 16 would not be so bad if post-16 routes were better developed in England. While the academic route (A-levels and university) works well for those able to access it, the other half of the cohort has a far more mixed experience. The system of vocational education in England is complex, with many different qualifications. It is difficult to make sense of, and to foresee progression pathways (as documented by Hupkau *et al.* 2017). The lack of upper vocational education is also of concern. For example, the Augar Review (2019) notes that in England only 4 per cent of 25-year-olds hold a Level 4 or Level 5 qualification as their highest level, whereas in Germany these qualifications make up 20 per cent of all higher education enrolments. As males are not going to university to study degrees in such high numbers, they may be expected to benefit disproportionately from reforms to expand higher-level vocational education. Current research evidence suggests that the returns from doing so may be high, especially in the fields that appeal more to males, such as STEM subjects (Espinoza and Speckesser, 2019).

There are few studies that evaluate policies that specifically target the gender gap in achievement when the issue is poorly performing boys. However, there are plenty of studies of policies that target poorly performing students and some of these disproportionately affect boys such as increasing school resources or effective literacy interventions (e.g. Machin and McNally, 2008). As boys tend to have lower non-cognitive skills than girls, they would also be expected to benefit disproportionately from interventions that influence such skills. As noted by Bertrand and Pan (2013), much research shows that non-cognitive skills are not fixed but are in fact quite malleable and can be shaped by early intervention programmes.

[17] Of course, there are disadvantages to early tracking as well. For example, there is evidence to suggest that tracking students earlier leads to greater educational inequality (Hanushek and Woessmann, 2006).

(ii) Girls and STEM

The fact that females are much less likely to enter STEM fields in tertiary education is problematic because these areas are seen to be very important for productivity and they are also high-earning. A shortage of women potentially holds back productivity and is certainly one of the explanations for the gender wage gap.[18]

Although the gender differences in maths scores are relatively modest compared to literacy scores, there is a huge literature attempting to explain the gender differences in the former. Many studies find that girls have relatively lower self-efficacy in maths at all stages of education, even among those who are equally competent to boys (Cheryan *et al.*, 2017). This can be accentuated by teachers' gender stereotypes which have been found to affect gender differences in measured performance in maths and science and in STEM-related choices within high school and beyond (Lavy and Sand, 2018; Lavy and Meglokonomou, 2019; Terrier, 2020).

Some of the same reasons why males have higher performance in maths in many countries have also been found relevant as reasons why females do not enter STEM fields at university. These include personal attributes that differ between males and females such as confidence, self-efficacy, and competitiveness, which are related to each other. The results of laboratory experiments suggest that men are more likely to enter competitive arenas than women because of higher confidence (Gneezy *et al.*, 2003; Niederle and Vesterlund, 2007). This also (negatively) influences female performance in high-level maths tests (Niederle and Vesterlund, 2007). As noted by Shi (2018), insofar as students perceive STEM majors to require technical mastery, gender gaps in beliefs about one's own ability can lead men and women to sort into different academic tracks. It might also influence why women drop out of STEM majors at much higher rates than men (as found by Astorne-Figari and Speer, 2018).[19] In a study for the Netherlands, Buser *et al.* (2014) find that gender difference in competitiveness can account for 20 per cent of the gender gap in the prestige and maths and science intensity of the chosen academic track in upper secondary education, controlling for grades and perceived mathematical ability. However, gender differences in success in different subjects and interest in pursuing them at post-compulsory level also have to do with preferences and expectations which are in turn influenced by the cultural environment and stereotypes (e.g. as reviewed by Cheryan *et al.*, 2017).

Policy challenges lie in how to encourage more girls to pursue STEM fields which are in high demand. There are a huge range of interventions specifically trying to encourage female interest in STEM fields but these are often not evaluated. Nonetheless there is a vast academic literature on these subjects and several good reviews (including Cheryan *et al.* (2017) and Kahn and Ginther (2018)). With regard to STEM preparedness and choices, girls are sensitive to the 'female friendliness' of their educational environment both at school and in tertiary education. This manifests itself in a dislike of competitive environments and a positive response to female role models.[20] There are recent high-quality studies on the positive effects of female role models, especially for individuals of higher ability (Carrell *et al.*, 2010; Bottia *et al.*, 2015; Canaan and Mouganie, 2019; Mouganie and Wang, 2019). Given the strong effects of role models across most of the literature, it would seem to be important

[18] See, for example, Machin and Puhani, 2003; Blau and Khan, 2017; Card and Payne, 2017; Francesconi and Parey, 2018.

[19] They also find that men are more likely to switch out of college than women in general. However, the rate of women switching out of STEM majors is far higher than the male drop-out rate from college.

[20] Interestingly, girls respond less negatively to competitiveness when males are not part of the group and this also varies between cultures (see Booth (2009) and studies cited in Buser *et al.* (2014)).

to address that both in schools and in tertiary education. This is also a conclusion of Zafar (2013) who finds that most of the difference in STEM at the tertiary level is driven by gender differences in tastes and preferences. He concludes 'a possible policy implication . . . is to encourage policies that increase the representation of females in academic science and engineering, since these female professors may change female students' beliefs and preferences toward STEM coursework and careers'. Cheryan *et al.* (2015) emphasize the importance of diversifying the image of computer science and engineering. They argue that girls are currently exposed to an unrealistic image of these fields that depicts all computer science and engineering cultures as fitting a narrow profile. They argue that as more women and girls are welcomed into these fields, the process of cultural change will likely build on itself. A large international project 'The Relevance of Science Education (the ROSE project)' suggests that females might be more prepared for STEM education if comprehensive education programmes wisely exploited knowledge about differences in the interests of girls and boys when designing school curricula (Sjøberg and Schreiner, 2010).[21]

V. Conclusion

In England, the gender gap in school achievement favours girls, especially in literacy, and this follows through to tertiary education. However, girls are much less likely to pursue STEM subjects within post-16 vocational and tertiary education. They are also less likely to pursue apprenticeships. Whereas there has been some evolution of the gender gap in recent years in educational achievement (i.e. improving boys' performance), there has been much more stability with regard to the participation of girls in STEM subjects and apprenticeships. Moreover, the gender gap in these areas is not strongly influenced by the gender gap in achievement at school.

Considering changes over time, there had been a narrowing of the gender gap in achievement in secondary school, and to some extent in primary school, up to the point when standards were raised in England. The raising of standards is associated with an increase in the achievement gender gap favouring girls. It is not surprising to see that the lower performing group (boys) are disproportionately affected by the raising of standards. This is not necessarily a bad outcome if it leads to increased attention on the group of students who fail to meet the standard. However, because educational progression within the English system is so contingent on performance at GCSE, there may be unintended consequences for the weaker group if this has implications for what courses they pursue within post-16 education.

Finally, because boys are more likely to enter vocational education and higher-earning options within that (like STEM subjects), they are likely to benefit disproportionately from efforts to improve the vocational education system in England. The perceived shortage of individuals with a STEM education could also be addressed by encouraging more girls to pursue these fields. This is likely to require improvements in the perceived 'female friendliness' of educational environments where STEM is taught. One aspect of this with a good evidence base is the need for more female role models in the form of peers, mentors, and teachers.

[21] For example, boys were found to be interested in explosives and engines, whereas girls were more interested in the environment and healthy living: https://www.roseproject.no/publications/english-pub.html

Appendix

Table A1: Summary statistics of educational outcomes and gender gaps by group

	Overall			FSM			Black			Asian		
	Males	**Females**	***Gender gap***	**Males**	**Females**	***Gender gap***	**Males**	**Females**	***Gender gap***	**Males**	**Females**	***Gender gap***
Key Stage 2 (KS2)												
Target achieved in KS2 reading	0.83	0.88	*–0.05*	0.71	0.79	*–0.07*	0.81	0.87	*–0.06*	0.83	0.87	*–0.04*
Target achieved in KS2 writing	0.79	0.89	*–0.10*	0.65	0.79	*–0.14*	0.78	0.88	*–0.10*	0.82	0.89	*–0.07*
Target achieved in KS2 maths	0.85	0.85	*0.00*	0.74	0.74	*0.00*	0.81	0.83	*–0.02*	0.86	0.85	*0.01*
Achieved L5+ in KS2 reading	0.41	0.48	*–0.07*	0.25	0.30	*–0.05*	0.33	0.42	*–0.09*	0.37	0.42	*–0.05*
Achieved L5+ in KS2 writing	0.23	0.38	*–0.14*	0.11	0.21	*–0.10*	0.19	0.33	*–0.14*	0.25	0.37	*–0.12*
Achieved L5+ in KS2 maths	0.43	0.39	*0.04*	0.26	0.23	*0.04*	0.35	0.34	*0.01*	0.47	0.42	*0.06*
Key Stage 4 (GCSEs)												
5+ A*–C GCSEs or equivalents	0.8	0.86	*–0.07*	0.65	0.74	*–0.09*	0.8	0.86	*–0.07*	0.84	0.90	*–0.06*
5+ A*–C GCSEs	0.51	0.63	*–0.12*	0.27	0.37	*–0.11*	0.47	0.62	*–0.15*	0.57	0.69	*–0.12*
A*–C English GCSE	0.61	0.76	*–0.15*	0.39	0.55	*–0.16*	0.6	0.76	*–0.15*	0.64	0.78	*–0.13*
A*–C maths GCSE	0.71	0.72	*–0.01*	0.5	0.51	*–0.01*	0.67	0.7	*–0.03*	0.76	0.77	*–0.01*
A*–A maths GCSE	0.19	0.19	*0.00*	0.07	0.07	*0.00*	0.14	0.15	*–0.01*	0.28	0.27	*0.01*
A*–A English GCSE	0.11	0.21	*–0.10*	0.03	0.08	*–0.04*	0.07	0.16	*–0.09*	0.11	0.22	*–0.10*
Post-16												
Not observed in education at 18	0.13	0.1	*0.03*	0.2	0.17	*0.03*	0.1	0.06	*0.03*	0.09	0.06	*0.02*
NEET at 18	0.07	0.05	*0.02*	0.13	0.11	*0.02*	0.07	0.04	*0.03*	0.06	0.05	*0.01*
Achieved Level 2 or more	0.9	0.94	*–0.04*	0.79	0.86	*–0.07*	0.91	0.95	*–0.04*	0.92	0.95	*–0.03*
Achieved Level 3 or more	0.63	0.74	*–0.11*	0.43	0.54	*–0.11*	0.72	0.83	*–0.11*	0.75	0.84	*–0.09*
Apprenticeship	0.2	0.16	*0.04*	0.15	0.15	*0.00*	0.09	0.07	*0.02*	0.08	0.07	*0.00*
University degree or more	0.22	0.31	*–0.08*	0.12	0.18	*–0.06*	0.29	0.42	*–0.13*	0.36	0.45	*–0.09*
Subject choice												
Any STEM in FE	0.70	0.60	*0.10*	0.65	0.54	*0.11*	0.67	0.64	*0.03*	0.84	0.77	*0.07*
Any STEM vocational (FE)	0.29	0.13	*0.16*	0.35	0.16	*0.19*	0.29	0.16	*0.13*	0.37	0.20	*0.16*
Any STEM academic (FE)	0.55	0.55	*0.00*	0.44	0.46	*–0.02*	0.51	0.57	*–0.06*	0.68	0.70	*–0.02*
STEM for those in HE	0.47	0.25	*0.22*	0.47	0.24	*0.23*	0.44	0.23	*0.21*	0.45	0.27	*0.19*
N	291,210	280,341		43,357	41,859		13,637	13,806		25,100	23,966	

Notes: Data come from the National Pupil Database, Individual Learner Records, and Higher Education Statistics Agency datasets. The data for KS2 and KS4 are for academic year 2013. The post-16 data and subject choice in further education (FE) are measured by age 19. Higher education (HE) outcomes are measured at age 19. They both refer to the cohort of students that sat their GCSEs (i.e. were at the end of KS4) in 2013.

Table A2: Subject choice in higher education

	2003		Gender gap, 2003	2013		Gender gap, 2013	Change in Gender gap (2013–2003)
	Males	Females		Males	Females		
Panel A. STEM subjects							
Biological sciences	0.08	0.10	–0.02	0.12	0.16	–0.04	–0.02
Physical sciences	0.06	0.03	0.03	0.08	0.05	0.03	0.00
Mathematics	0.03	0.01	0.02	0.05	0.02	0.03	0.01
Computer science	0.08	0.01	0.07	0.09	0.01	0.08	0.01
Engineering and technology	0.10	0.02	0.08	0.12	0.02	0.10	0.02
Panel B. Non-STEM subjects							
Medicine and dentistry	0.02	0.03	–0.01	0.02	0.02	0.00	0.01
Subjects allied to medicine	0.03	0.10	–0.07	0.03	0.09	–0.06	0.01
Architecture, building and planning	0.01	0.01	0.00	0.00	0.01	–0.01	–0.01
Agriculture and related subjects	0.04	0.01	0.03	0.02	0.01	0.01	–0.02
Social studies	0.08	0.08	0.00	0.11	0.12	–0.01	–0.01
Law	0.04	0.06	–0.02	0.03	0.06	–0.03	–0.01
Business and administrative studies	0.15	0.10	0.05	0.13	0.09	0.04	–0.01
Mass communications and documentation	0.03	0.04	–0.01	0.03	0.03	0.00	0.01
Languages	0.05	0.09	–0.04	0.04	0.10	–0.06	–0.02
Historical and philosophical studies	0.06	0.05	0.01	0.05	0.05	0.00	–0.01
Creative arts and design	0.08	0.11	–0.03	0.07	0.11	–0.04	–0.01
Education	0.06	0.14	–0.08	0.01	0.05	–0.04	0.04
Other	0.01	0.02	–0.01	0.00	0.00	0.00	0.01
N	67,936	85,426		77,822	99,564		

Notes: Data come from the Higher Education Statistics Agency datasets linked to the National Pupil Database. The data refer to the academic year 2005–6 (2015–16) for the cohort of students that sat their GCSEs (i.e. at the end of KS4) in 2003 (2013).

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