The teacher labour market in England

Shortages, subject expertise and incentives

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Foreword

The Education Policy Institute is an independent, impartial and evidence-based research institute which aims to promote high quality education outcomes for all, through analysis that both informs and influences the policy debate in England and internationally.

This publication sheds light on the state of the teacher labour market, which in recent years has begun to face a number of serious pressures. In particular it considers the scale and implications of growing teacher shortages in certain subject areas. There have been persistent problems over recent years in ensuring an adequate supply of teachers in some subjects – with teacher recruitment targets frequently missed, most notably in subjects such as mathematics and the sciences – core subjects which more pupils have been encouraged to enter in to as a result of recent school accountability reforms.

Ensuring that there are enough graduates attracted in to teaching is a further challenge. This is particularly a concern given that today, many graduates in "shortage" subjects are able to earn a greater income in other professions. Ensuring that there are sufficient numbers of subject-qualified teachers across all subjects at secondary school level should form a central part of the government's efforts to improve education standards.

Along with looking at which subjects are experiencing shortages, one of this report's major contributions is its assessment of how highly-qualified graduate teachers are represented in different areas, and in schools with pupils from varying socio-economic backgrounds.

It is well established that the level of teacher quality in educational settings plays a role in determining both the attainment, and life chances of a child. If policy-makers wish to deliver on commitments to enhance social mobility, it is essential that the right mechanisms are in place to ensure that schools in the most deprived areas in England are able to attract highly talented teachers. As this report demonstrates, at present there seem to be significant hurdles in the way of this objective, which demand urgent attention.

As always, comment on the analysis and conclusions of this report are very much welcome, and will help inform our future work in this area.

Rt. Hon. David Laws Executive Chairman, Education Policy Institute.

Executive Summary

The teacher labour market in England faces some significant challenges. More teachers are needed to meet the growing pupil population, but overall public sector pay levels have been squeezed since 2010. There are persistent problems in recruiting and retaining a sufficient number of maths and science teachers, where outside options for graduates in alternative careers tend to be lucrative. In this report, we make three key contributions. First, we detail the overall challenges facing the teacher labour market. Second, we look at the consequences for teacher quality by using the proportion of teachers with a relevant degree in the subject they teach as a predictor for teacher quality. We then examine socio-economic and area-level differences in the proportion of teachers with a relevant degree in the subject they teach. Third, we review the empirical evidence on the role of financial incentives to retain teachers in shortage subjects and attract them to high-poverty areas, and how such incentives could be applied in England.

Overall challenges for the teacher labour market

- Since 2010, teacher numbers have held steady whilst pupil numbers have risen by about 10 per cent. **As a result, the national pupil:teacher ratio has risen from 15.5 in 2010 to around 17 by 2018**.
- **Applications to teacher training were down by about 5 per cent in 2018** as compared with the same point last year. Training targets have been persistently missed in maths and science.
- **Exit rates have also crept up over time**, from 8 to 9 per cent in primary schools and from 9 to 10 per cent in secondary schools between 2011 and 2017. They rose even faster in special schools, from around 8 to 11 per cent.
- Exit rates are particularly high early in teachers' careers, **with only 60 per cent of teachers working in a state-funded school in England five years after starting training.** This 5-year retention rate is only 50 per cent for high-priority subjects like physics and maths.
- **The value of teacher pay scales declined by about 10 per cent in real-terms since 2010** as a result of various freezes and cap on public sector pay rises.
- **Graduate pay varies significantly by subject of study, but teacher pay varies little by subject taught**. This seems to be a major cause of why recruitment and retention differs by subject. Average salary levels for maths graduates are about £4,000 above the level for teachers in their late 20s, whilst average earning for graduates in English, history and biology are about £4,000-£5,000 below that for teachers in their late 20s.
- **The announcement of pay rises between 1.5 and 3.5 per cent for September 2018 will arrest this real-terms decline in teacher pay**. The fact that pay rises will be larger for early career teachers also creates an interest in how future pay awards should be targeted.

Differences in teacher quality across subjects and areas

- We treat whether teachers have a **relevant degree in the subject they teach as a predictor of teacher quality.** Empirical evidence suggests having a relevant degree is a good, though not perfect, predictor of teacher quality.
- The proportion of secondary school teachers with a relevant degree in the subject they teach varies by subject. **The lowest average levels are in maths and science subjects where**

there are significant recruitment and retention problems (e.g. 50 per cent of **physics** teachers and 46 per cent of **maths** teachers have a relevant degree) **and highest in subjects where there is less pressure on recruitment and retention** (e.g. 78 per cent of **biology** teachers have a relevant degree, as do 67 per cent of **English** teachers).

- **There is a significant socio-economic gradient in the proportion of teachers with a relevant degree in high-priority maths and science subjects**, with these socio-economic gradients much larger outside London.
- **At Key Stage 4, only 37 per cent of maths teachers and 45 per cent of chemistry teachers in deprived schools outside London have a relevant degree, whilst only 17 per cent of physics teachers have a relevant degree in deprived schools outside London**. These represent gaps of 14 percentage points for maths, 23 percentage points for chemistry and 35 percentage points for physics as compared with less deprived schools outside London.
- **Inside London, the proportion of maths and physics teachers with a relevant degree is generally higher**, at 40-50 per cent and mostly above 60 per cent for chemistry. There also appears to be less evidence of variation by deprivation inside London.
- **Many maths and science teachers do not have a degree in maths or science subjects**. **We find that 46 per cent of maths teachers and one third of physics teachers at Key Stage 4 do not have a maths or science degree.** These figures are lower at 20 per cent for biology and 12 per cent for chemistry.
- **Access to teachers with a relevant degree is also low for languages at Key Stage 4, at around 40-50 per cent**, with a small socio-economic gradient and little evidence of any London specific difference.
- **In other subjects, the proportion of teachers with a relevant degree is generally high**, at between 65 and 75 per cent for English, 60 to 70 per cent for biology and 70 to 80 per cent for history. In such subjects, there is a small socio-economic gradient, but little evidence of a London specific effect.
- **There are larger socio-economic gradients in the proportion of geography and art teachers with a relevant degree**, but the overall figures are generally high, at between about 65 and 85 per cent.
- **The proportion of technology teachers with a relevant degree is lower**, at around 50 to 60 per cent, but there are much smaller socio-economic differences and little evidence for a different picture in and outside of London.
- **We observe similar patterns for Key Stage 3**, except that the proportion of Key Stage 3 teachers with a relevant degree is generally lower.
- **There is a large amount of variation across local authorities too**. The proportion of teachers with a relevant degree is generally high in London and the South East of England, as well as some urban areas outside London, e.g. Bath and North East Somerset, Rochdale, and Darlington.
- **The proportion of teachers with a relevant degree is generally low** in South and West Yorkshire (e.g. Barnsley and Doncaster), the Welsh Borders, and the fringes of Birmingham, (such as Walsall and Dudley), East Anglia and the South Coast (Hampshire and Portsmouth in particular).

Role for financial incentives and salary supplements

- Empirical evidence from North Carolina and Florida **shows that salary supplements in maths and science subjects can reduce teacher exits**. A consistent finding seems to be that incentives worth about 5 per cent of gross salary can reduce teacher exits by about 10-20 per cent.
- Bonus payments in the order of $20,000-$25,000 have also been used successfully in California and other US states to attract high-ability teachers to deprived and hard-to-staff areas.
- Schools in England have the power and freedom to make such payments already. **However, they would have to do so from their existing budgets, which might be challenging in the present climate due to the squeeze on school finances**. Many of the US schemes have been centrally directed and funded; there is **therefore a good case for any salary supplement scheme in England being funded and run by the Department for Education**.
- A recent report for the Gatbsy Foundation argued that a **5 per cent salary supplement for early career maths and physics teachers would have eliminated shortages** within a few years had such a policy been introduced in 2010. **It would also have an annual cost of only about £37m, which is a small fraction of the overall teacher training budget** and about one quarter of the teacher training bursary budget (about £150m per year at present). These recruitment incentives have represented the government's main policy lever for reducing shortage subjects, but there is little good evidence that they are effective.
- The government is already making welcome steps here. It is piloting a student loan forgiveness programme in shortage subjects, though the recent increase in the student loan repayment threshold to £25,000 will mean this is of little benefit to new teachers.
- **The government is also trialling bonus payments of £5,000 for maths teachers** starting their training in 2018–19 who remain in the profession after three and five years, with extra bonuses if they are teaching in target local authorities.
- **Piloting new policy is almost always welcome, but the empirical evidence is very strong on the potential positive effects of salary supplements and incentives for maths and science subjects, and in attracting teachers to deprived areas**. Given the poor state of the teacher labour market in maths and science subjects, we believe that waiting for the results of a pilot has real costs too and the **government should now go further and faster on introducing salary supplements in hard-to-staff areas and subjects**.
- The government should seek advice from the School Teachers Review Body as to whether there is a case for extending these payments to other subjects.
- **The government should also review whether its scheme is targeted on an appropriate set of local authorities.** We show that several local authorities with low shares of teachers with relevant degrees are missed out, and several local authorities with high shares are included.

1. Introduction

It is now widely accepted that variations in teacher quality are an important driver of differences in pupil attainment and can even explain differences in pupils' later life earnings.[1] Work from the US further suggests that lower quality teachers tend to be located in poorer areas and differences in teacher quality could therefore form an important part of the explanation for the lower performance of pupils in poorer areas.[2]

This analysis from the US links data on teachers to the pupils they teach and measures teacher quality on the basis of the average value-added of the pupils for each teacher. One suspects that there are similar patterns in the UK in terms of access to high quality teachers, but it is currently not possible to replicate the US work due to the lack of a link between data on individual teachers and pupils. As a result, there is little understanding of the extent to which teacher quality varies across areas in England, including how it varies in relation to overall levels of deprivation and socio-economic background.

The teacher labour market in England also faces a number of major challenges. With caps on overall public sector pay rises in operation and average teacher pay declining by 10 per cent in real-terms since 2010, teaching has become less financially attractive over time. In the immediate aftermath of the Great Recession, this was less of a problem as private sector wages were also squeezed. Private sector earnings have, however, started to rise again. These changes have undoubtedly made it harder to recruit and retain high quality teachers.

For September 2018, early career teachers on the main pay scale have been awarded a larger pay rise of 3.5 per cent (which is likely to apply to about 40 per cent of teachers). Other classroom teachers were awarded a two per cent increase and school leaders a 1.5 per cent increase – both below the expected inflation of 2.3 per cent for next year. Whilst larger than the pay rises over the recent past, these increases will make little difference to the overall picture of real-terms declines in average teacher pay of the last decade. However, the settlement sets a precedent for pay rises above the one per cent cap in future years, and the targeted and varied nature of the pay award creates an interest in how to best structure future awards.

At the same time, the number of pupils is on the rise. Growth over the next decade is set to be dominated by an increase in secondary school pupil numbers of around 15 per cent between 2016 and 2026. This poses particular challenges for the teacher labour market as training providers have found it harder to meet recruitment targets for secondary school teacher trainees in recent years. Furthermore, the government has set the ambition for 90 per cent of GCSE pupils to be entered into the English Baccalaureate (EBacc) by 2025, as compared with 38 per cent at present. To be entered into the EBacc, GCSE students must be taking subjects that include English, maths, sciences, geography/history and a language. Achieving this aspiration will be difficult. Many of these subjects, such as physics, chemistry, maths and languages, have faced persistent recruitment and retention problems, likely because graduates in such subjects can generally command higher earnings outside of a career in teaching.

To date, there is a clear consensus that such problems of recruitment and retention exist. However, it is hard to track the consequences for pupils. If they cannot find a specialist teacher in individual subjects, schools will generally find a non-specialist, which to some extent covers up the problem.

There is also little understanding of the extent to which problems vary across areas, particularly whether access to specialist teachers in shortage subjects is even more acute in poorer areas. In their report for the Social Market Foundation's Commission on Inequality in Education, Allen et al. (2016) show that there exist socio-economic inequalities in terms of the proportion of teachers with a degree in the subject they teach, particularly in science and maths subjects.[3] However, this relates to 2013 and is, by now, slightly out of date.

In this report, we make three main contributions to understanding the state of the teacher labour market. First, we provide an update on the state of national labour market and differences by subject. Second, we analyse differences in teacher quality by subject and country area by using whether teachers have a degree in the subject they teach subject as proxy for quality. Although a degree in the subject you teach might not always be necessary, empirical evidence suggests it is a good predictor of teacher quality.[4] Specialist knowledge is also likely to be a key factor in determining teachers' ability to deliver the knowledge-rich curriculum the government is seeking to develop. We pay particular attention to socio-economic variations in access to high-quality teachers and whether this differs inside or outside London, given the very distinct labour market for graduates in London. Our third contribution is to review evidence on financial incentives that have been trialled in the US to address recruitment and retention problems across areas and subjects, and to consider how these could be developed within the English policy context.

The rest of this report proceeds as follows. Section 2 analyses overall trends in recruitment and retention. Section 3 presents our analysis of the distribution of teacher quality across areas and subjects. Section 4 reviews the evidence on financial incentives from the US. Section 5 concludes.

2. Overall trends in recruitment, retention and teacher pay

The teacher labour market in England is subject to a high level of churn. In 2017, just over 40,000 teachers left their jobs in state-funded schools in England, to be replaced by just over 40,000 new entrants. That makes for about one in 10 teachers replaced by a new teacher each year. This is higher than in other public sector occupations like nursing and policing.[5] And it is before we account for the further eight per cent of teachers who move school each year.[6] In this section, we set out some of the acute challenges facing the teacher labour market.

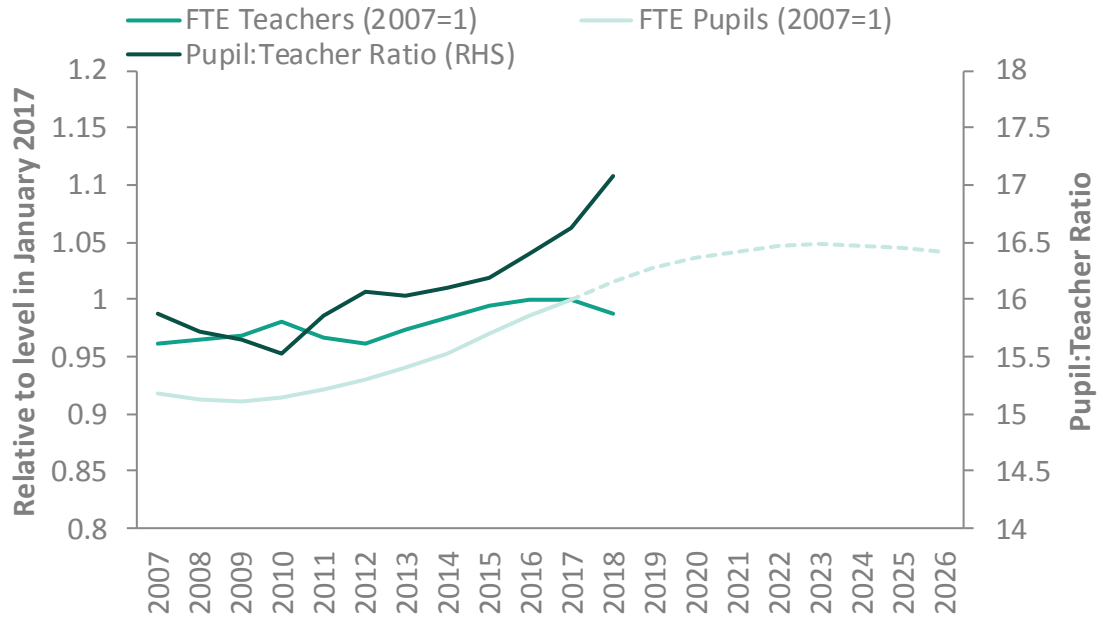
The number of pupils has been on the rise in recent years. Between 2007 and 2017, the number of pupils in state-funded schools grew by around six per cent. As shown in Figure 2.1, teacher numbers rose by around four per cent between 2007 and 2017. However, in the latest year of data (covering November 2017), teacher numbers actually fell by around 5,000, the first fall in teacher numbers since 2012. **Since teacher numbers have risen at a slower rate than pupil numbers, the national pupil:teacher ratio has risen from around 15.5 in 2010 to around 17 by 2018**. This increase in the pupil:teacher ratio has been evenly spread across primary and secondary schools.

Looking ahead, the overall number of pupils is expected to grow by a further four per cent between 2018 and 2026. All of this growth is expected to be driven by secondary schools, where pupil numbers are expected to rise by 15 per cent. This compares with an expected two per cent fall in primary school pupil numbers. To prevent class sizes from rising, the total number of teachers would also need to grow by a similar amount, with new entrants exceeding exits, rather than equalling them as they do at the moment.

There are some further challenges in secondary schools. The government has set the ambition for 90 per cent of GCSE pupils to be entered into the English Baccalaureate (EBacc) by 2025, as compared with 38 per cent at present[i]. To be entered into the EBacc, GCSE students must be taking subjects that include English language/literature, maths, sciences, geography/history and a language. Some rise in EBacc entry rates could be accommodated for by filling empty seats in some lessons, but increasing take-up from 38 per cent to 90 per cent will require a very significant rise in the number of teachers able to teach these subjects. For example, previous EPI analysis suggests that the number of modern foreign languages teachers would need to increase by 78 per cent in 2019–20 in order to meet government targets.[7]

[i] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/653532/SFR57_2017.pdf

Figure 2.1: Number of pupils and teachers over time, 2017=1



Sources and Notes: Pupil counts refer to pupils aged under 16 and measured in January each year and taken from DfE Pupil Projections, July 2018 (https://www.gov.uk/government/statistics/national-pupil-projections-july-2018). Teacher numbers are measured in January each year up to 2010 and then the preceding November from 2011 onwards. Teacher numbers taken from School Workforce Census Statistics, November 2017 (https://www.gov.uk/government/statistics/school-workforce-in-england-november-2017).

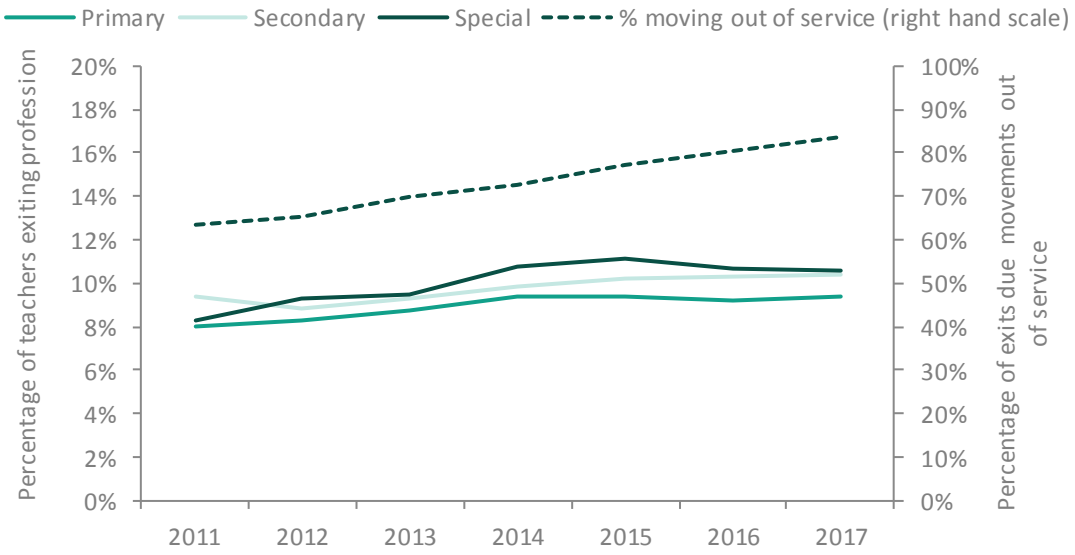
Unfortunately, there have some worrying signals from the teacher labour market. First, as shown in Figure 2.2, exit rates have been creeping up over time. Between November 2011 and 2016, exit rates increased from around eight per cent to 9.4 per cent in primary schools and from 9.4 per cent to 10.4 per cent in secondary schools. **In special schools, the increase in exit rates was even larger, from 8.3 per cent to 10.6 per cent.**

Even more concerning is the increase in the number of teachers choosing to cut short their teaching careers, with around 83 per cent of exits in 2017 due to movements out of service (e.g. other jobs or outside the state-funded sector in England) as compared with around two thirds in 2011. Unfortunately, these figures cannot be tracked back before 2011. The precise cause of this trend is uncertain. There are persistent complaints regarding a high and increasing workload for teachers, and teachers do work longer hours than other public sector occupations like nursing and policing (even after accounting for longer holidays).[ii, 8] However, high and increasing mobility of teachers may also be driven by a younger teaching workforce over time. Younger workers are well known to change jobs and occupations more frequently than older workers.

Exits also appear to be concentrated early in teachers' careers, with only 60 per cent of teachers working in a state-funded school in England five years after starting training.[9] **This five-year retention rate is only 50 per cent for high-priority subjects like physics and maths.**

[ii] https://www.tes.com/news/teacher-workload-unmanageable-dfe-study-finds

Figure 2.2: Percentage of teachers leaving state-funded schools in England over time



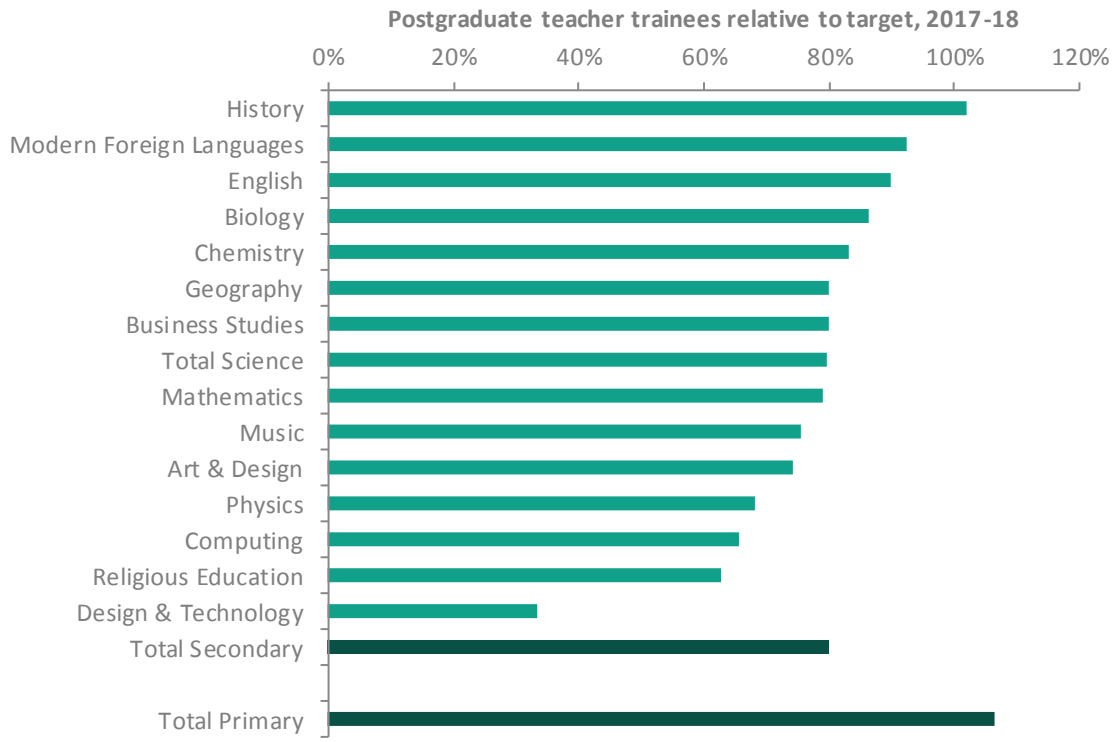
Notes and Sources: Figures taken from School Workforce Census Statistics, November 2017 (https://www.gov.uk/government/statistics/school-workforce-in-england-november-2017). Percentage moving out of service represents the share of exits not due to death or retirement each year.

Second, there are also worrying signs on entrants. Recent figures suggest applications to teacher training are down by around five per cent compared with previous years.[iii] This is much less than earlier in the year, when numbers looked to be down by about a third. Nevertheless, these trends still send a worrying signal about recruitment.

The problem also looks worse in secondary schools. Figure 2.3 shows the number of postgraduate teacher trainees recruited in 2017–18 relative to targets from the government's Teacher Supply Model. In 2017–18, training providers managed to fill targets for the number of primary school teacher trainees. However, only about 80 per cent of targets were filled for secondary school trainees, with the problem varying significantly by subject. Only about 70 per cent of training placement targets were filled in physics, about 80 per were filled in maths, chemistry and geography, whilst in English, biology and modern foreign languages it was about 90 per cent. Many of these problems have proved to be persistent over time, with targets missed year after year in many science subjects, particularly physics.

[iii] https://www.ucas.com/data-and-analysis/ucas-teacher-training-statistical-releases

Figure 2.3: Number of postgraduate teacher trainees relative to target, 2017–18



Sources and Notes: Department for Education, Initial Teacher Training Statistics 2017–18 (https://www.gov.uk/government/statistics/initial-teacher-training-trainee-number-census-2017-to-2018)

One potential explanation for the gradually worsening picture on teacher recruitment and retention is the squeeze on teacher pay. Since 2010, teacher pay has been subject to public sector pay freezes and caps. These measures froze pay until 2013 and have since restricted increases to one per cent, which has caused the real value of teachers' pay points to fall by around 10 per cent, relative to inflation (Consumer Price Index), since 2010.[iv] However, this followed from an increase in the estimated pay gap between public and private sector workers during the Great Recession, when private sector earnings fell and public sector earnings were largely protected. This gap has gradually dissipated over time, such that it was back at pre-recession levels by around 2016–17 and is now probably close to levels last seen in the late 1990s when there were widespread recruitment difficulties across the public sector.[10] This poses severe challenges for the teacher labour market at precisely the time when recruitment needs to rise to meet the growing pupil population, and it needs to rise faster in secondary schools where recruitment problems have been more problematic in recent years.

For September 2018, early career teachers on the main pay scale have been awarded a larger pay rise of 3.5 per cent (which is likely to apply to about 40 per cent of teachers). Other classroom teachers were awarded a two per cent increase and school leaders a 1.5 per cent increase – both below expected inflation of 2.3 per cent over the next year. Whilst larger than pay rises over much of the recent past, these increases will make little difference to the overall picture of large real-terms

[iv] National Education Union, 'Teacher Pay: The Problems and the Solutions', Submission to the School Teachers' Review Body, January 2018, para. 32, https://www.teachers.org.uk/sites/default/files2014/neu-submission-to-the-strb-january-2018-final_0.pdf.

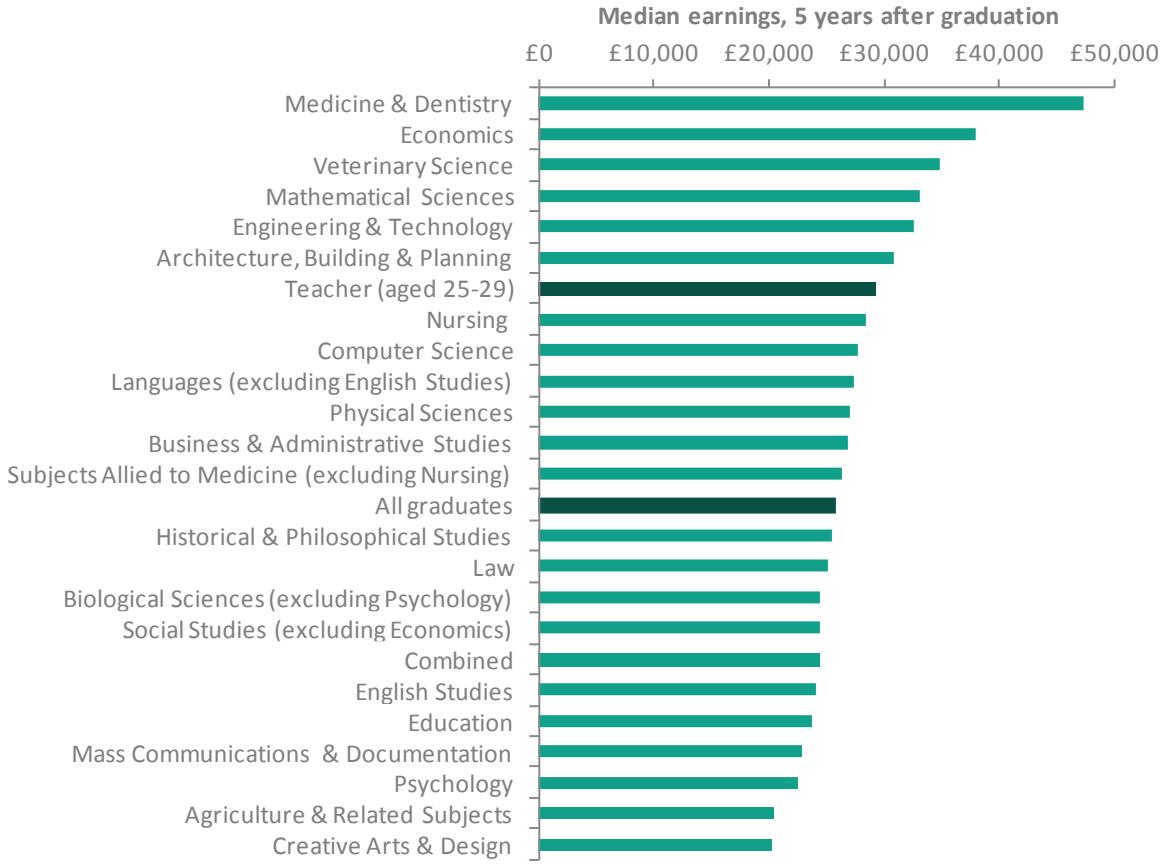
declines in average teacher pay over the last decade. However, the settlement sets a precedent for pay rises above the one per cent cap in future years, and the targeted and varied nature of the pay award creates an interest in how best future awards should be structured.

A comparison with wages in alternative graduate professions reveals greater differences. In 2015, secondary teachers in the UK earned 21 per cent less than similarly educated graduates, according to the OECD. While it is common across the OECD for teachers to earn less than the average graduate, the comparisons also show that, while UK secondary teachers with 15 years of experience earn five per cent more than the OECD average, starting salaries in the UK are 14 per cent lower than average. [11] This suggests that pay increases faster with experience in England than in other OECD countries and may make teaching a less attractive initial career option than is the case in other countries. The targeting of the September 2018 pay rise towards early career teachers may correct some of this difference.

Most empirical evidence suggests teacher salaries vary little by subject taught. Empirical evidence from 2013 shows that the average salary of science, maths, English and languages teachers are all within about £1,000 of the average teacher pay level of £33,000 in 2015, a pattern which hardly changed at all since 2010.[12]

In contrast, overall graduate pay varies considerably depending on which subject they studied at university. Figure 2.4 shows the average (median) graduate salary five years after graduation according to which subject they studied. For comparison, we also show the average (median) teacher salary level for individuals aged 25–29, as a close approximation to five years after graduation. In this case, the average teacher salary level is above the average level of graduate earnings, though this is partly because the measure for teachers includes individuals more than five years after graduation. What this also reveals is that differences in graduate earnings correlate very strongly with problems in teacher recruitment. Average salary levels for maths graduates are about £4,000 above the level for teachers in their late 20s, whilst average earnings for computer science, languages and physical science graduates are about £2,000 below. Average earning for graduates in English, history and biology – subjects where there is much less evidence of a recruitment problem - are about £4,000-£5,000 below that for teachers in their late 20s.

Figure 2.4: Graduate earnings five years after graduation by subject of study, 2015–16



Sources and Notes: Department for Education, Graduate Outcomes (LEO): 2015–16 (https://www.gov.uk/government/statistics/graduate-outcomes-2015-to-2016). School Workforce Census, November 2015.

In summary, the overall teacher labour market faces some severe challenges over the next few years. Just as teacher numbers need to grow to meet the growing pupil population, recruitment and retention are gradually getting worse over time. Furthermore, such problems look worse in secondary schools, where pupil numbers are expected to grow most, and in subjects where numbers will need to grow to meet the government's aspirations for 90 per cent entry rates to the EBacc and a knowledge-rich curriculum (e.g. physics, maths, languages).

3. Differences in teacher qualification levels by subject and area

In this section, we show how the proportion of teachers with degree-level qualifications in the subject they teach varied across secondary schools in different parts of the country in 2016. We look across a range of subjects and focus on differences by the socio-economic make-up of the school (i.e. proportion of pupils eligible for free school meals). Given the higher level of graduate labour market opportunities for potential teachers and the much higher educational performance of children in London, we examine how this socio-economic gradient varies inside and outside of London.[13] We also look at more disaggregated differences across local authorities. This allow us to build upon and extend the work of Allen et al. (2016), who looked at socio-economic differences across England as a whole in 2013.[14]

We treat differences in the proportion of teachers with a degree in the subject they teach as predictive of differences in teacher quality across areas. A degree-level qualification might not be necessary nor sufficient to be a great teacher. However, empirical evidence does suggest that prior educational attainment and having a degree in the subject you teach are some of the few teacher characteristics that can predict teacher quality. The relationship tends to be modest, on average, but is stronger for maths and science subjects.[15] A more recent study focused on maths teachers found that both cognitive and non-cognitive ability have a statistically significant effect on teacher quality.[16] Although the relationship between teacher quality and subject knowledge tends to be modest, one might also see teachers having a degree in the subject they teach as a desirable trait in itself, particularly when policymakers are clearly focused on delivering a knowledge-rich curriculum.[v]

Methodology

To undertake the analysis, we make use of the School Workforce Census for November 2016 and apply similar methods to those used in Allen et al. (2016) and Allen and Sims (2018).[17] Linking the various datasets together allows us to calculate the proportion of teaching hours in each subject that are taught by a teacher with a degree-level qualification or higher in that subject. We focus on subjects with sufficient sample sizes, namely: maths, English, chemistry, biology, physics, combined/general science, geography, history, languages, art, and design and technology. For brevity's sake, we refer to the proportion of teaching hours taught by a teacher with a degree-level qualification in that subject as 'the proportion of hours taught a by a subject specialist.' We show the proportion of hours taught by a subject specialist separately for Key Stage 3 and Key Stage 4.

Appendix A provides more details on how we link the data together and which types of qualifications/subjects are treated as degree-level qualifications in each subject. This always excludes PGCEs or other teaching qualifications.

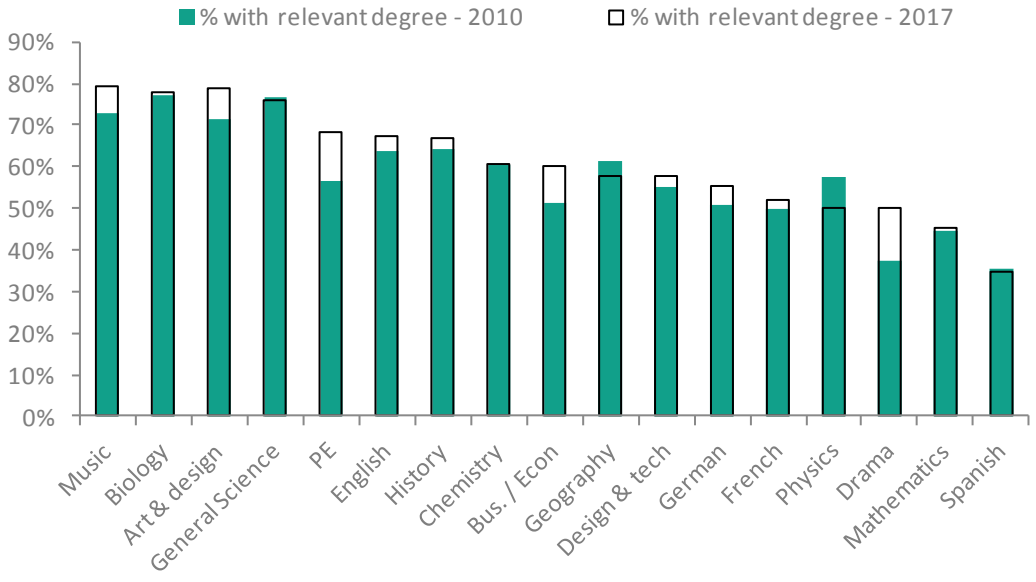
Figure 3.1 shows that the proportion of teachers with a relevant degree has increased over time across most subjects. However, there is also quite a lot of variation across subjects. In many non-EBacc subjects, for example in music, arts, drama, PE and business/economics, the proportion of teachers with a degree in that subject has risen over time, which makes sense as schools can be more selective in their hires given the greater number of teacher trainees each year relative to target. In EBacc subjects there is a bit of a mixed picture, with broadly steady levels or slight rises in

[v] https://www.gov.uk/government/speeches/nick-gibb-the-importance-of-knowledge-based-education

maths, English, chemistry, biology, languages and history. The two subjects where there has been a decline are physics and geography, both EBacc subjects and where recruitment targets have been missed over time.

Figure 3.1 is based on Department for Education statistics for the headcount of teachers with a relevant degree for 2010 and 2017. In Appendix A we compare our national calculations for the proportion of hours taught by a subject specialist with those reported by the Department for Education. In general our average figures tend to be slightly lower, but the differences across subjects are very similar. Our lower figures seem likely to result from missing qualification and curriculum data. The Department for Education is partly able to correct for this by using historical data to fill in missing information and by making use of non-response weights. Given this, we present 95 per cent confidence intervals around our figures and place more attention to the socio-economic differences across quintiles, rather than the absolute levels.

Figure 3.1: Percentage of teachers with a relevant degree in the subject they teach, 2010 and 2017



Source: Author's calculations using School Workforce in England (various years), https://www.gov.uk/government/collections/statistics-school-workforce

We show differences across schools based on the socio-economic background of pupils at each school. We divide schools into five equally sized quintiles according to the proportion of pupils eligible for free school meals (FSM), with the first quintile having the lowest proportion of pupils eligible for FSM and the fifth quintile having the highest proportion. We show these differences separately for schools inside and outside of London, given the very different graduate labour market and higher population density in London. We define quintiles based on the full sample of schools across England as a whole.

The proportion of teachers with missing data tends to be slightly higher in more deprived schools, with teacher qualifications data missing for 18 per cent of lessons in the least deprived set of schools and about 28 per cent of lessons in the most deprived set of schools.[vi] It should, however, be noted

[vi] A lesson here refers to a teacher reported as teaching a non-zero amount of hours in a specific subject to a specific year group, e.g. 8 hours of physics to year 7.

that we drop cases of missing data, rather than assuming they have no qualifications. Our estimates of the socio-economic differences therefore assume that the missing lessons are taught by teachers that are similarly qualified relative to the lessons we observe across quintiles.

We also show differences across local authorities. To ensure sufficient sample sizes, we group subjects classified as high-priority for recruitment purposes by the Department for Education (maths, physics, chemistry, combined/general science, languages) and other subjects.[vii] We can then show local authority differences across these two groups of subjects.

Key Stage 4 analysis

We start by showing the proportion of Key Stage 4 hours taught by subject specialists. In Figures 3.2 and 3.3, we show how this varies across subjects by quintile of deprivation (Q1 being least deprived and Q5 being most deprived) and in and outside of London (London shown in green and the rest of England in pink). Figure 3.2 shows the patterns for high-priority subjects (maths, physics, chemistry, science, languages) and 3.3 the same for other subjects (English, biology, geography, history, art & design, design & technology), together with 95 per cent confidence intervals. Figure 3.4 then shows the gap between the top and bottom quintiles for each subject inside and outside London, as well as the confidence interval for these differences. Again, one should note that the quintiles are defined across the whole of England, and not London and the rest of England separately.

As we have already seen, there are pronounced differences across subjects in terms of the proportion of hours taught by subject specialists. What we now see is that there are also differences by school deprivation, particularly for high-priority subjects, and that these socio-economic gradients are sharper outside of London. There are much wider confidence intervals for the quintiles inside London, reflecting the lower sample sizes. However, a number of clear patterns do emerge.

Starting with high-priority subjects in Figure 3.2, we see sharp socio-economic gradients in terms of access to subject specialists in maths, physics and chemistry, but less evidence in languages. In particular, we see:

- **Maths**: In London, 56 per cent of maths teaching hours are taught by a subject specialist in the least deprived schools, compared with 45 per cent for the most deprived set of schools, leaving a gap of around 11 percentage points. Outside of London, 51 per cent of Key Stage 4 maths hours are taught by subject specialists in the least deprived schools , but only about 37 per cent in the most deprived schools, a gap of around 14 percentage points, which is statistically significant.
- **Chemistry**: Inside London, the share of Key Stage 4 chemistry hours taught by a subject specialist is generally above 60 per cent across all quintiles and tends to be lower for the more deprived quintiles. However, the confidence intervals around each estimate are sizeable, suggesting a large amount of statistical uncertainty about the true value. Outside of London, 68 per cent of hours are taught by subject specialists in the least deprived set of schools, about the same level we see for the most deprived schools in London. This compares with 45 per cent in the most deprived schools outside of London, a gap of 23 percentage points. In contrast, the confidence intervals are relatively narrow outside London

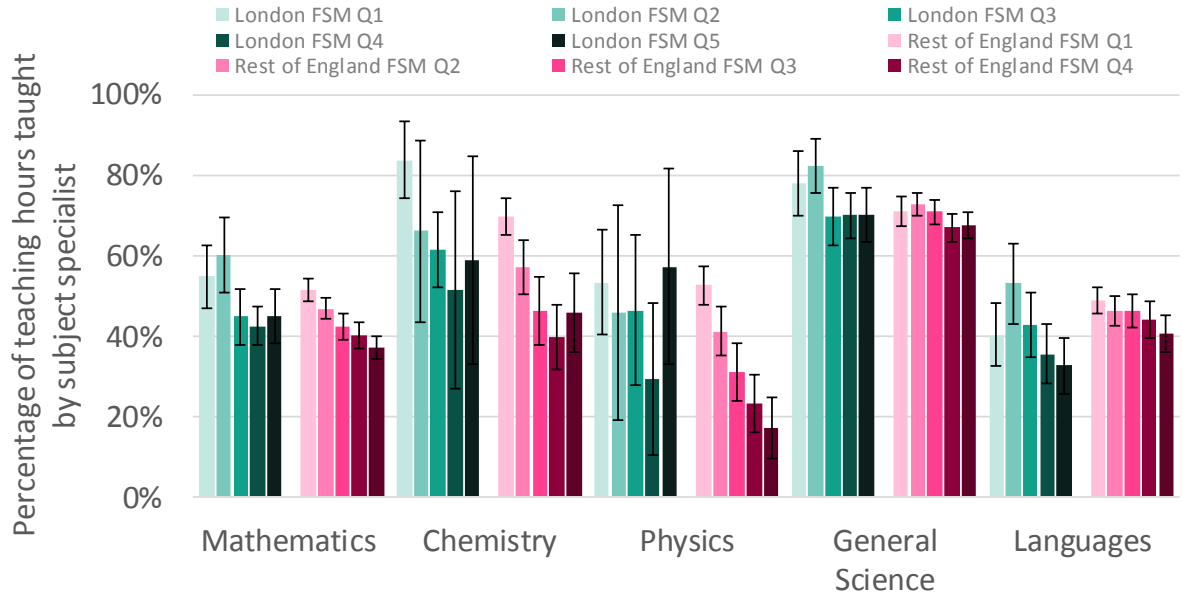
[vii] https://www.gov.uk/guidance/funding-initial-teacher-training-itt-academic-year-2017-to-18

due to larger sample sizes, confirming the existence of a large, statistically significant socio-economic gap outside London.

- **Physics**: Inside London, the proportion of hours taught by subject specialists is about the same across all quintiles, at just over 50 per cent. However, as with Chemistry, the confidence intervals are relatively wide. Outside London, about 52 per cent of hours are taught by subject specialists in the least deprived schools outside of London and then only 17 per cent in the most deprived schools outside of London, a gap of 35 percentage points. Again, the confidence intervals are relatively narrow outside London and suggest that we can be confident about the low access to subject specialists in physics in deprived schools outside London.
- **Combined/general science**: There are slightly higher levels of access to subject specialists inside London (70-80 per cent) than outside London (around 70 per cent). In both London and the rest of England, however, there is no strong evidence of a socio-economic gradient.
- **Languages**: there is some evidence of a small socio-economic gradient outside London, but the overall levels are actually slightly higher outside of London than inside. For the least deprived schools, about 40 per cent of hours are taught by subject specialists inside London compared with 48 per cent outside of London. For the most deprived schools, these numbers are 34 per cent for London and 39 per cent outside of London.

To sum up, there are clear socio-economic gradients in terms of access to subject specialists in high-priority subjects. With the exception of languages, the overall levels of access to subject specialists are generally lower, and the socio-economic gradient sharper, outside of London. **Recruiting physics graduates to deprived schools outside of London appears to be a particular problem.**

Figure 3.2: Socio-economic differences in the proportion of teachers with a degree in a relevant area by subject taught, high-priority subjects

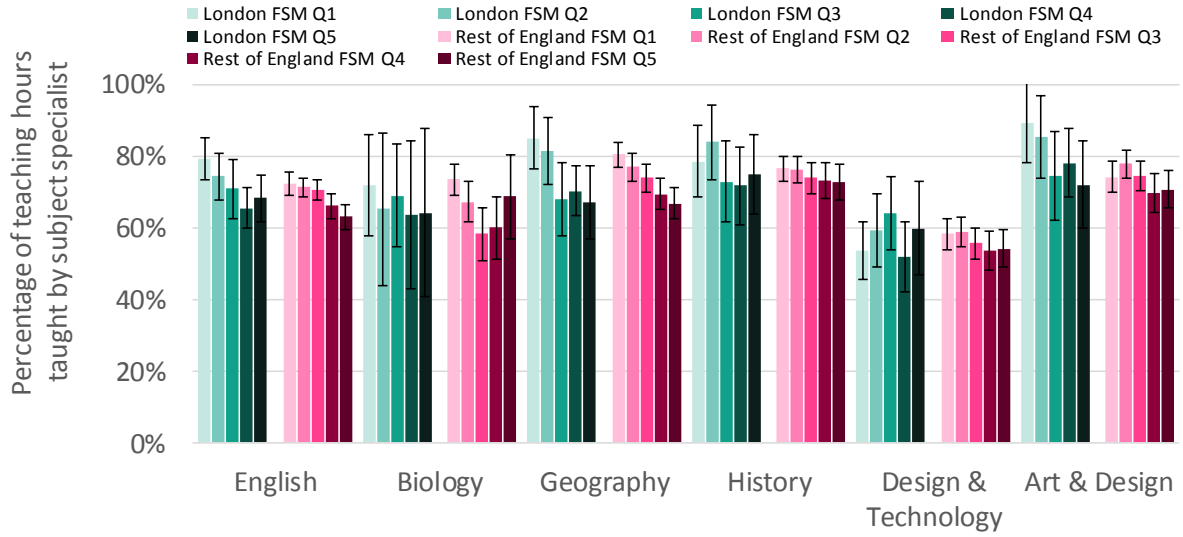


Sources and Notes: Author's calculations using School Workforce Census, November 2016 and Pupils, Schools and their Characteristics, January 2017. Errors bars show 95 per cent confidence intervals.

Figure 3.3 shows the equivalent figures for other subjects. Here, we see a greater proportion of hours taught by subject specialists, much smaller socio-economic gradients and less difference inside and outside of London. In particular, we see:

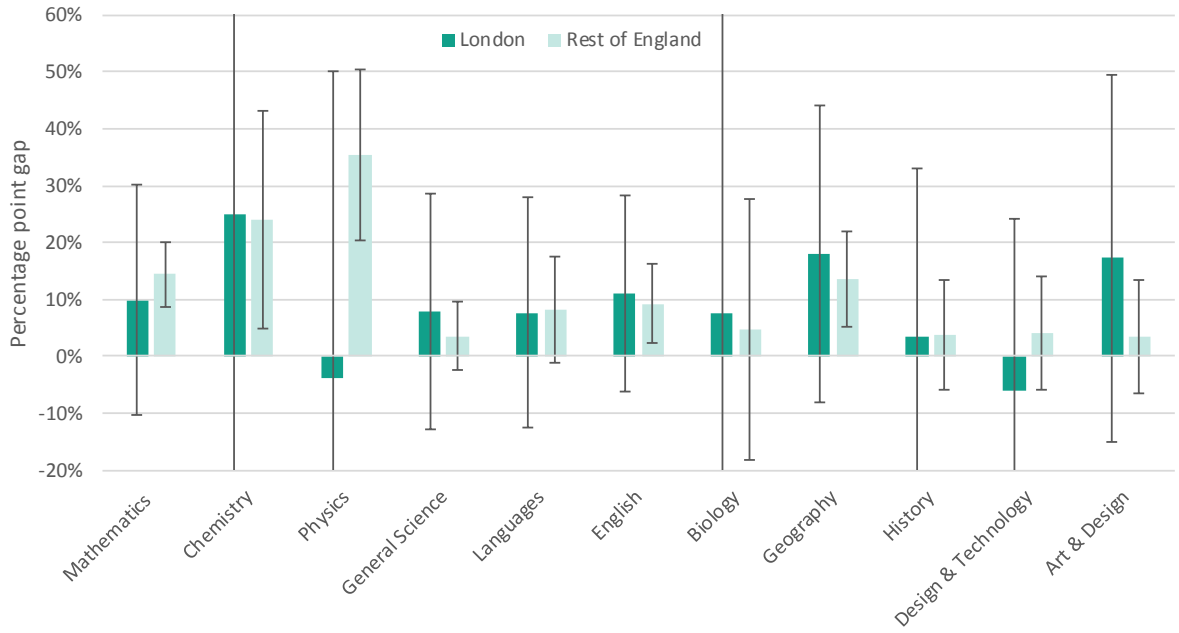
- **English**: 77 per cent of Key Stage 4 hours are taught by subject specialists in the least deprived schools in London compared with about 68 per cent in the most deprived schools. For the rest of England, the respective figures are slightly lower, at about 72 per cent for the least deprived schools and 63 per cent for the most deprived schools. Although both sets of figures suggest a small and similarly sized socio-economic gap, the differences across quintiles are not statistically significant for London due to smaller sample sizes.
- **Biology**: There is no evidence of large socio-economic gaps inside or outside London. Around 70 per cent of Key Stage biology hours are taught by subject specialists across quintiles, though there is a large amount of statistical uncertainty in all cases.
- **History:** There is no evidence of a socio-economic or London effect for history. The proportion of Key Stage 4 history hours taught by a subject specialist is generally around 70-80 per cent in all cases.
- **Geography:** There is evidence of a statistically significant socio-economic gap for geography, but no evidence of a London effect. In both London and the rest of England, the proportion of Key Stage 4 geography hours taught by subject specialists was about 80 per cent for the least deprived schools and 70 per cent amongst the most deprived schools.
- **Art and design**: Inside London, the estimated proportion of hours taught by a subject specialist varies by deprivation but is generally high, at between 70 and 90 per cent. Outside London, figures are slightly lower at around 70 per cent and there is less evidence of a strong socio-economic divide.
- **Design and technology**: There is little evidence of a socio-economic divide or London effect, with the proportion of hours taught by a subject specialist generally around 60 per cent.

Figure 3.3: Socio-economic differences in the proportion of teachers with a degree in a relevant area by subject taught at Key Stage 4, other subjects



Sources and Notes: Author's calculations using School Workforce Census, November 2016 and Pupils, Schools and their Characteristics, January 2017. Error bars show 95% confidence intervals.

Figure 3.4: Socio-economic gap between the most and least deprived quintiles in the proportion of teachers with a degree in a relevant subject in subject taught at Key Stage 4



Sources and Notes: See Figures 3.2 and 3.3. Errors bars show 95 per cent confidence intervals.

In summary, we see evidence of lower levels of access to subject specialists in high-priority subjects. Access to subject specialists is lower in more deprived schools and outside of London. The socio-economic gradient is also a lot sharper outside of London. Access to subject specialists in deprived schools outside of London appears to be particularly a problem in physics, as well as maths and chemistry to a slightly lesser extent. A larger share of hours is taught by subject specialists in other subjects, such as English, biology, history, geography and art. There is still a socio-economic gradient in such subjects, just not as large as is the case of high-priority subjects and little difference in and out of London.

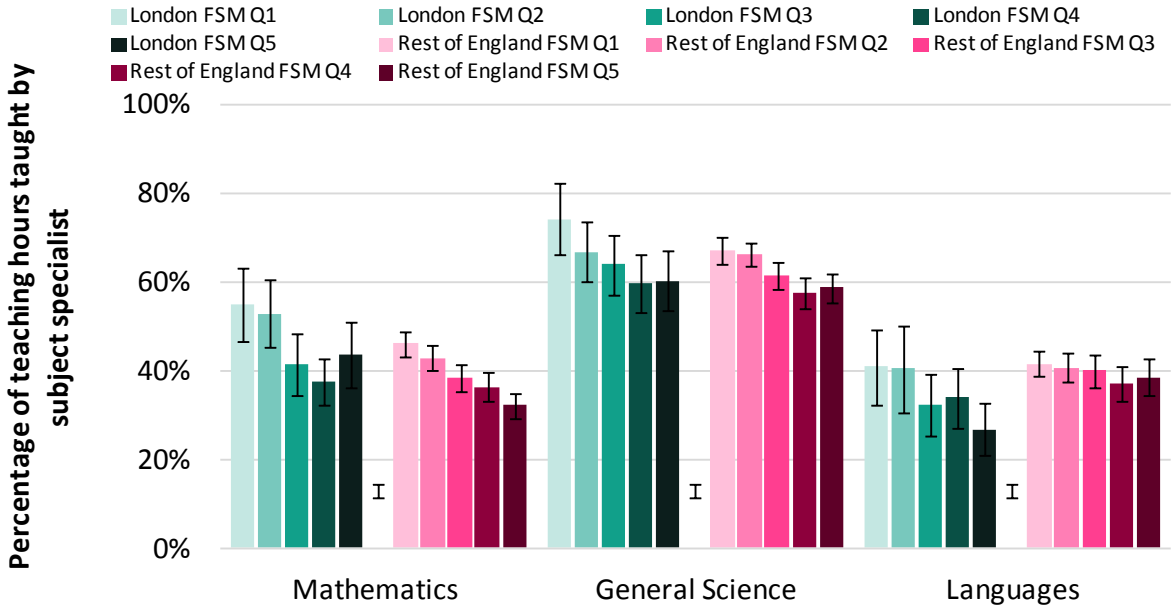
Key Stage 3 analysis

In Figures 3.5, 3.6 and 3.7, we show the equivalent analysis for subject hours taught at Key Stage 3. As one would expect, the proportion of teaching hours taught by a subject specialist is generally lower at Key Stage 3. However, many of the same socio-economic and geographic patterns emerge as we saw for Key Stage 4.

- **Maths:** As at Key Stage 4, we see large socio-economic gradients inside and outside London, with generally lower levels of access to subject specialists outside of London. For example, one third of Key Stage 3 maths hours are taught by a subject specialist in the most deprived schools outside of London, which compares with 44 per cent in the most deprived schools in London. The gap between the most and least deprived schools is slightly larger outside London (14 percentage points) than inside London (11 percentage points). The gap is only statistically significant for outside London though, reflecting the lower sample sizes and higher standard errors inside London.
- **Science:** There are small socio-economic gaps in access to specialist science teachers inside and outside London. The overall levels vary between about 60 and 75 per cent, which are lower than one might have expected given that a science teacher with a relevant degree can have a degree in either biology, chemistry or physics.

- **Languages:** There is less evidence of a socio-economic gradient and London effect in terms of access to specialist languages teachers at Key Stage 3, with the proportion of teacher with a relevant degree around 30-40 per cent in all cases.

Figure 3.5: Socio-economic differences in the proportion of teachers with a degree in a relevant area by subject taught at Key Stage 3, high priority subjects

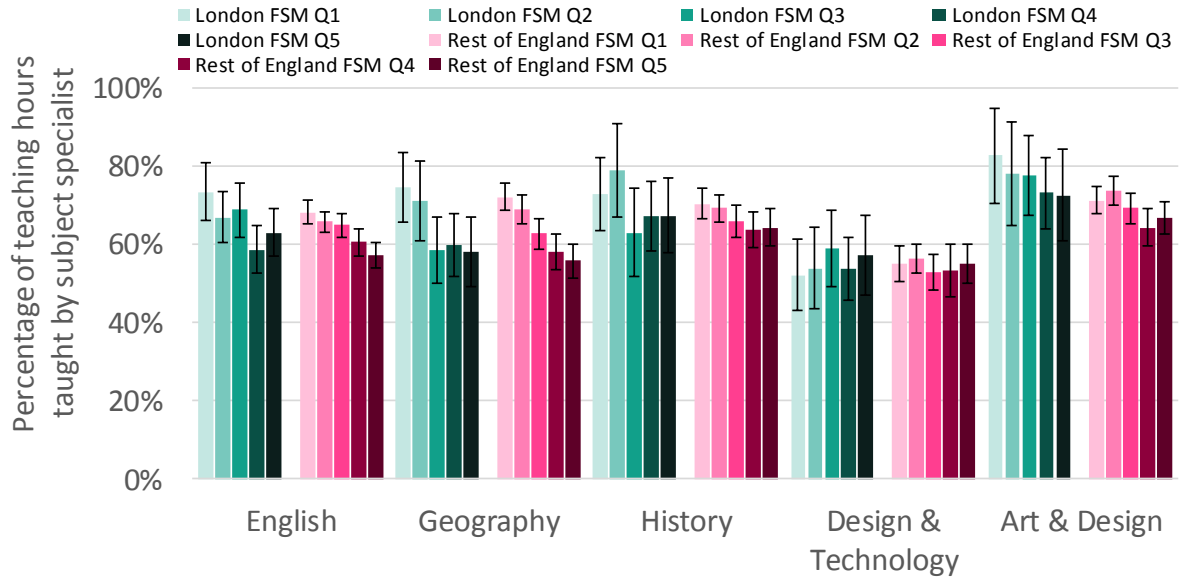


Sources and Notes: Author's calculations using School Workforce Census, November 2016 and Pupils, Schools and their Characteristics, January 2017. Errors bars show 95% confidence intervals.

Figure 3.6 shows the equivalent set of results for other subjects, which shows many of the same patterns we saw for Key Stage 4:

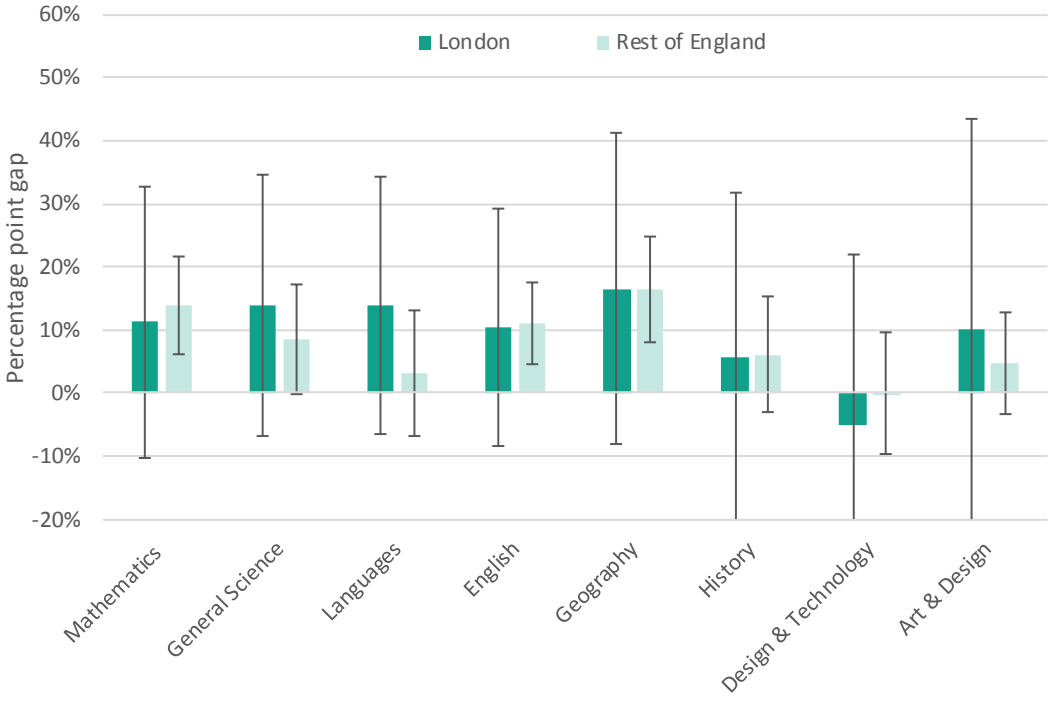
- **English**: There is a small socio-economic gradient inside and outside London, with the lowest levels of access to subject specialists in deprived schools outside of London (57 per cent). In both London and the rest of England, the gap between the most deprived and least deprived schools is around 10 percentage points, with the gap statistically significant outside London.
- **History**: Access to subject specialists is generally high at between 60 and 70 per cent in most cases. There is little evidence of a strong socio-economic gradient or a London effect.
- **Geography**: There is more evidence of a socio-economic gradient than for history, with a gap of around 16 percentage points between the most and least deprived sets of schools. There is, however, little evidence of a London effect.
- **Art and Design:** Access to subject specialists is generally high, with a small socio-economic gradient and London effect. Inside London, the proportion of art teachers with a relevant degree is generally between 75 and 88 per cent (though there are relatively large confidence intervals), and between 65 and 75 per cent outside London.
- **Design and Technology:** The proportion of design and technology Key Stage 3 hours taught by a teacher with a relevant degree is generally around 50-60 per cent. There is, however, little evidence of a socio-economic gap or London effect.

Figure 3.6: Socio-economic differences in the proportion of teachers with a degree in a relevant area by subject taught at Key Stage 3, other subjects



Sources and Notes: Author's calculations using School Workforce Census, November 2016 and Pupils, Schools and their Characteristics, January 2017. Errors bars show 95 per cent confidence intervals.

Figure 3.7: Socio-economic gap between the most and least deprived quintiles in the proportion of teachers with a degree in a relevant subject in subject taught at Key Stage 3



Sources and Notes: See Figures 3.5 and 3.6. Errors bars show 95 per cent confidence intervals.

In summary, the trends for Key Stage 3 largely match those seen for Key Stage 4. There is evidence of a socio-economic gap in terms of access to subject specialists across maths, science, English, geography and art. With the exception of languages, access to subject specialists is generally lowest for the most deprived schools outside of London.

Degree background of science and maths teachers

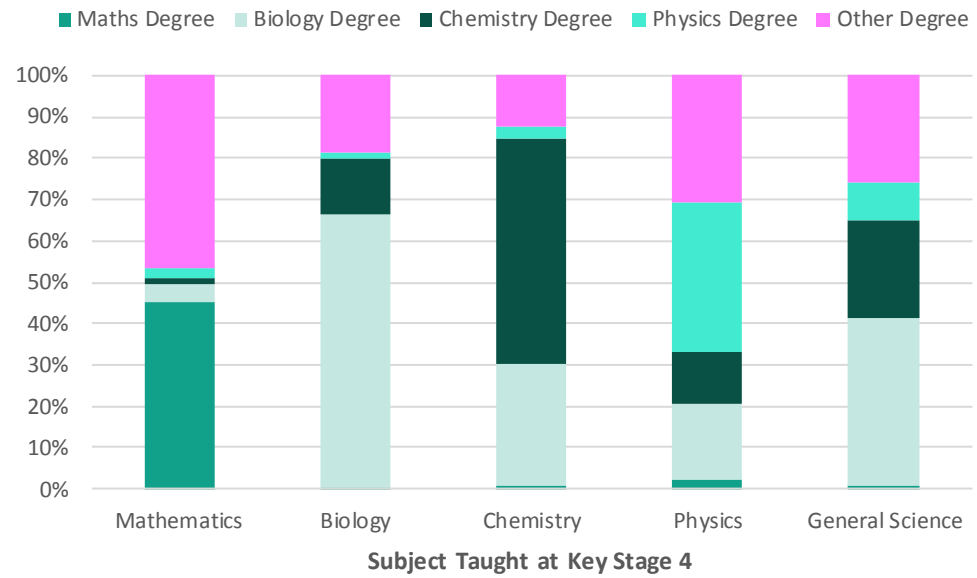
Given the low proportion of science and maths lessons taught by teachers with a relevant degree, the obvious question is 'what the degree background is of such teachers?'. One might be less concerned about the figures if, for instance, chemistry lessons were taught by those with a degree in biology or maths lessons by a physics graduate.

To help shed light on this, Figure 3.8 shows what proportion of maths, biology, chemistry, physics and science teachers have degrees in each of these subjects, along with the remainder who have degrees in other subjects. We see that:

- **Maths:** The proportion of Key Stage 4 maths hours taught by teachers without degrees in maths or science subjects represents about 46 per cent, which is more than the hours thought by teachers with an actual degree in maths.
- **Biology:** The proportion of Key Stage 4 biology hours taught by a teacher with a science or maths degree is around 80 per cent, with the remainder taught by a teacher without a science or maths degree.
- **Chemistry:** Similar to biology, around 88 per cent of Key Stage 4 chemistry hours are taught by teachers with a science or maths degree, and around 12 per cent by teachers without a science or maths degree.
- **Physics:** In contrast to biology and chemistry, only about 70 per cent of Key Stage 4 physics hours are taught by teachers with a science or maths degree. Around one third are taught by teachers without such degrees.
- **Science:** Looking at general science, we see that around a quarter of hours are taught by teachers without a science or maths degree.

In summary, for chemistry and biology, the proportion of lessons taught by teachers without a maths or science degree is less than 20 per cent. It is notably higher for general science and physics at between 25 and 30 per cent, whilst almost half of all Key Stage 4 maths lessons are taught by teachers without a science or maths degree.

Figure 3.8: Degree background of science and maths teachers at Key Stage 4



Sources and Notes: Author's calculations using School Workforce Census, November 2016 and Pupils, Schools and their Characteristics, January 2017. Percentage relates to proportion of Key Stage 4 hours taught.

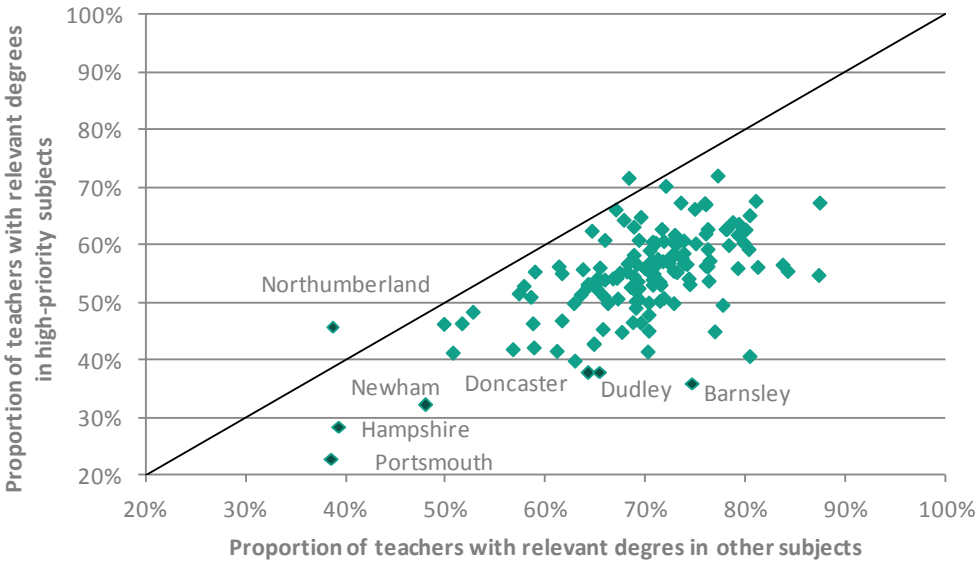
Local Authority analysis

We now extend our analysis to examine local authority-level differences in access to specialist teachers. To overcome small sample sizes, we group subjects into high-priority subjects (maths, physics, chemistry, science, languages) and other subjects (English, biology, geography, history, art and design, design and technology). Figure 3.9 shows the proportion of Key Stage 4 hours taught by teachers with relevant degrees in high-priority subjects against the proportion teaching in other subjects. We also show a 45-degree line, which is what we would expect to see if there was no difference by subject grouping within each local authority.

This shows that there is significant variation across local authorities in terms of access to teachers with relevant degrees in the subjects they teach and lower levels of access to subject specialists in high-priority subjects. Across high priority subjects, the proportion of teachers with relevant degrees ranges from about 40 per cent to about two thirds for the majority of local authorities, and from around 50 to 80 per cent for other subjects.

There is also significant heterogeneity around this average picture, with a number of local authorities standing out as having particular problems in access to high-priority subjects. For example, in Doncaster, Barnsley and Dudley, the proportion of Key Stage 4 hours taught by subject specialists is well below 40 per cent, despite having close to average levels of subject hours taught by specialist teachers in other subjects (between 60 and 70 per cent). In other cases, such as Hampshire and Portsmouth, access to teachers with relevant degrees appears low across the board. One unusual case is Northumberland, which has close to average proportions of teachers with relevant degrees in high-priority subjects, but below average proportions in other subjects.

Figure 3.9: Proportion of Key Stage 4 hours in high-priority subject taught by a teacher with a degree in a relevant subject across local authorities, November 2016



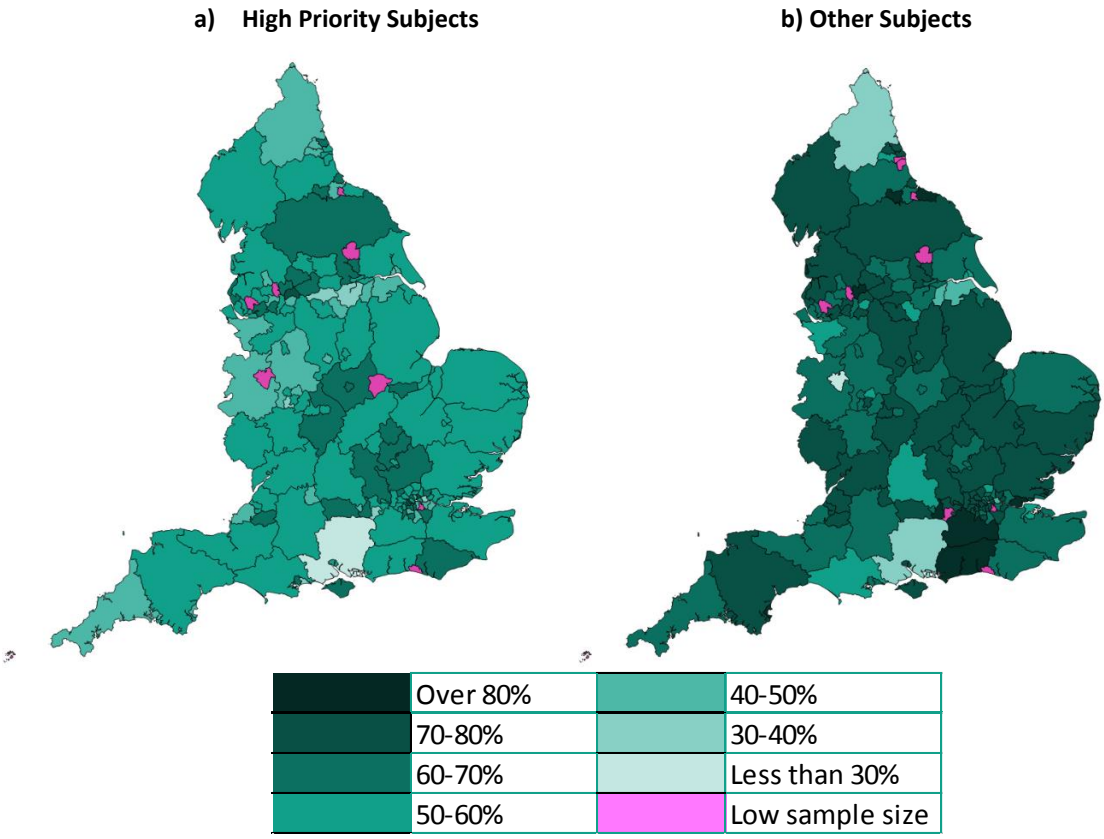
Sources and Notes: Author's calculations using School Workforce Census, November 2016 and Pupils, Schools and their Characteristics, January 2017. Percentage relates to proportion of Key Stage 4 hours taught.

Figure 3.10 expands on this by showing maps of how the proportion of teachers with relevant degrees varies across local authorities, with high-priority and other subjects shown separately. The same scale is used on both maps, with darker shades of green indicating high proportions of teachers with relevant degrees in the subjects they teach.

This shows that access to specialist teachers tends to be highest in London and adjoining counties, particularly in other subjects. However, there are also other areas of the country with high levels of access to teachers with relevant degrees. For example, the proportion of teachers with relevant degrees is higher than 60 per cent for high-priority subjects and above 75 per cent for other subjects in all of the following local authorities outside London and the South East: Bath and North East Somerset; Peterborough; Calderdale; Sefton; North Yorkshire; Hartlepool; Rochdale; Trafford; and, Darlington.

Access to teachers with relevant degrees tends to be lowest in a number of different pockets, including: East Anglia; the south coast, particularly around Hampshire; the Welsh Borders and fringe areas of Birmingham, such as Walsall and Dudley; and, south and west Yorkshire, e.g. Barnsley and Doncaster.

Figure 3.10: Proportion of Key Stage 4 hours in high-priority and other subjects taught by a teacher with a degree in a relevant subject across local authorities, November 2016



Sources: Author's calculations using School Workforce Census, November 2016

Table 3.1: Local authorities with the lowest and highest proportion of teachers with relevant degrees in high-priority subjects

Less than 40%	Above 65%
Portsmouth	Wokingham
Hampshire	Poole
Newham	West Berkshire
Barnsley	Bromley
Doncaster	Bath and North East Somerset
Dudley	North Tyneside
Bracknell Forest	Rochdale
Bournemouth	Darlington
	Oldham
	Kensington and Chelsea
	Hackney

4. Review of evidence on the role of financial incentives

Our analysis in the previous section demonstrated that there are clear differences across subjects in terms of the proportion of teaching hours taught by a teacher with a relevant degree. The problem appears worst in high-priority subjects like physics, chemistry and maths, where graduates can generally command higher earnings outside of teaching. There is also strong evidence of socio-economic gradients, with lower levels of access to subject specialists in the most deprived schools, particularly in high-priority subjects. Such differences are most pronounced for deprived schools outside of London.

What options exist for policymakers to mitigate the problems? To date, a lot of attention has been paid to increasing recruitment, with bursaries of up to £30k (tax-free) in some subjects. However, there is no evidence these have led to an uptick in recruitment, where problems have persisted.[18] Less attention has been paid to improving retention or incentivising teachers to move to hard-to-staff areas of the country. With approximately 8 per cent of teachers leaving the profession each year for reasons other than retirement and 10 per cent of teachers switching schools each year, there are potentially big gains here. Furthermore, teacher bursaries have not, to date, been conditional or targeted at increasing recruitment to schools in more deprived areas, where access to subject specialists is clearly much lower.

Recently, Teach First has played an important role in attracting high-performing graduates in shortage subjects to more deprived schools. However, to date, a large element of the programme has been focused on schools in London, with about half of all Teach First trainees over time placed in London.[viii] This may help explain the lower socio-economic gradients in access to subject specialists in London.

Problems in recruiting maths and science teachers, and to more deprived schools in particular, are not specific to the UK. The US and other countries have seen persistent problems here too.[19] This has led a number of US states to trial different types of financial incentives to encourage existing teachers to move to more deprived schools and retain teachers in key areas. In this section, we review this evidence and its relevance to policymakers in England.

Retention Incentives in Shortage Subjects

Between 2001 and 2004, maths, science and special education teachers working in high-poverty or low test score secondary schools in North Carolina qualified for a bonus of $1,800 per year. This represented about four per cent of the average teacher salary across the state at that time. The bonuses were funded and paid by the state's centralised payroll system. Clotfelter et al. (2008) analyse the effects of this scheme and found that the bonus reduced average teacher turnover rates by around 17 per cent amongst eligible teachers.[20] Given average turnover rates of around 30 per cent for qualifying teachers in eligible schools, which includes teaching moving to different schools, this equates to a reduction in turnover of around five percentage points. They also found larger effects for maths teachers and for more experienced teachers. The authors further suggest their estimates represent only short-run estimates of the impact of the bonuses and probably do not include any effects from improved recruitment of new teachers to eligible schools. They quote

[viii] https://www.teachfirst.org.uk/sites/default/files/2017-09/teach_first_impact_report.pdf

survey evidence that suggests many teachers believed the bonuses were only temporary. Given that the programme was abolished in 2004, these expectations turned out to be well founded. Nevertheless, the evidence generated by this study clearly suggests that centrally funded, modest bonuses for teachers in shortage subjects in high-poverty schools can have notable, positive impacts on retention.

Between 1984 and 2011, Florida ran a scheme called the Florida Critical Teacher Shortage Programme (FCTSP). Each year, the state would identify shortage subjects and teachers in these subjects could then potentially qualify for three different types of financial incentives. First, existing teachers who took additional training to become certified in a shortage subjects could receive tuition reimbursements of around $700 per year (or up to about $2,800 in total). Second, individuals teaching shortage subjects were eligible for student loan forgiveness of up to $2,500 a year for undergraduate loans and $5,000 for graduate loans (up to a lifetime total of around $10,000). Third, one-time retention bonuses of up $1,200 were paid for teachers in shortage subjects in the year 2000.

Feng and Sass (2017) analyse the effects of these different financial incentives. In terms of the loan forgiveness programme, they find that the effects vary by subject.[21] For maths teachers, they find that the scheme reduced attrition by about 11 per cent and by about nine per cent for science teachers. Given the average annual award was about $1,200, these results are fully in line with the effects estimated in North Carolina. For foreign language teachers, they found that the scheme reduced attrition by about 11 per cent, but found little evidence of any effect on special education teachers. Interestingly, however, they find even larger effects of the one-time bonuses of $1,200 in 2000, which reduced attrition by up to 25 per cent. The tuition reimbursements were also found to be effective in terms of boosting the probability of eligible teachers to become certified to teach in shortage subjects.

Therefore, from both Florida and North Carolina we see consistent evidence that modest financial incentives (of around four-five per cent of average salaries) in the shortage subjects of maths and science can reduce attrition amongst existing teachers in shortage subjects. The fact that the North Carolina scheme was explicitly targeted at more deprived schools shows how financial incentives can be used effectively to reduce the socio-economic gradient in terms of subject specialists that we see in England.

Financial incentives to teach in high poverty areas

Between 2000 and 2002, California implemented a scheme called the 'Governor's Teaching Fellowship', which aimed to attract more high ability graduates to teach in high poverty schools. The scheme was competitive, with a selection panel reviewing applications from trainee teachers. Applicants had to submit transcripts, letters of recommendation, essays and were interviewed on the phone. If successful, fellows were then eligible for a payment of $20,000 if they committed to teach in high poverty schools for four years (such payments were not confined to teach specific subjects though). If they did not fulfil this commitment for the full four years, individuals had to repay $5,000 for each year missed, invoking some element of loss aversion. Steele et al. (2009) studied the effect of this scheme and found that it increased participants' willingness to teach in such high-poverty schools by around 28 per cent.[22] Financial incentives are therefore relatively effectively in attracting high-ability teachers to high-poverty schools.

In Washington state, teachers were awarded a $5,000 bonus if they were board-certified (an extra qualification to recognise accomplished teachers) and taught in a high-poverty school. Cowan and Goldhaber (2016) find that these bonuses increased the number of board-certified teachers at high-poverty schools, both through existing teachers seeking board certification and from board-certified teachers moving to high-poverty schools.[23]

Glazerman et al. (2013) evaluate the impact of a multi-state randomised controlled trial (the 'Talent Transfer Initiative') that paid $20,000 to highly rated teachers (according to their value-added) if they transferred to a low-test score school.[24] They find that the scheme was very successful. It attracted high-performing teacher to fill 90 per cent of targeted vacancies. Once transferred, these highly rated teachers displayed similar levels of retention to existing teachers. The scheme was also found to improve student test scores by around 0.1-0.25 standard deviations.

Therefore, there is clear evidence that financial incentives can be highly effective in encouraging high-performing teachers to move to and stay at high-poverty schools.

Applicability to England

To date, a significant amount of resources has been devoted to implementing high-value bursaries for teachers with high degree classifications in shortage subjects. The annual cost of these is currently estimated to be around £150m.[25] Unfortunately, there is little good quality evidence to suggest that such recruitment incentives are effective at encouraging more teachers to join the profession. That is not to say that the evidence finds them to be ineffective, but that there is scant evidence. In contrast, the US evidence referred to above is quite clear that modest salary bonuses in the order of about five per cent can be sufficient to reduce teacher attrition in shortage subjects and high-poverty areas. Given that teacher attrition in England is a particular problem in both shortage subjects and high-poverty areas, it seems a shame that more attention has not been paid to such incentive schemes.[26] The US evidence also finds large bonuses (around $20,000-$25,000) have been effective in encouraging existing or trainee teachers to move to high-poverty schools.

In light of the above, a recent report commissioned by the Gatsby Foundation argued that targeted salary supplements (of about five per cent) for physics and maths teachers in the first five years of teaching would have eliminated the shortage of physics and maths teachers within a small numbers of years had such a policy been introduced in 2010.[27] Assuming that these salary supplements are paid to all maths and physics teachers in the first five years, they estimate that the annual cost would be around £37m, about one quarter of the teacher bursary budget and about five per cent of the total teacher training budget. Given the lack of evidence on the effectiveness of recruitment incentives and the strong evidence on retention incentives, switching more of the teacher training or bursary budget towards retention incentives could provide a greater chance of improving teacher numbers in shortage areas.

At present, schools are already free to pay such salary supplements if they chose. Schools have been able to pay recruitment and retention payments since the mid-1990s. Since 2013, they have also gained the autonomy to implement their own teacher pay scheme. However, as we have already seen, there is very little evidence of differences in teacher salaries by subject. Pay does vary slightly by school deprivation levels, with the difference in average teacher pay between the most and least deprived secondary schools at about £1,400 in 2013 (controlling for individual characteristics, such

as experience, and region).[28] Whatever the difference, however, such extra pay has clearly not been sufficient to reduce differences in access to subject specialists across areas.

Why have schools not implemented salary supplements in shortage subjects or high-poverty areas to a significant extent? First, schools may believe they would be ineffective. The evidence suggests this is not the case. Second, they may be averse or face political constraints in creating more variation in pay amongst teachers. Third, and probably most importantly, they must fund any salary supplements from within their existing budgets. In the US examples, salary supplements and incentives were paid centrally and did not affect the rest of the schools budget. In England, if schools wanted to pay salary supplements, they would need to reduce spending elsewhere. In recent years, the overall squeeze on teacher pay and school budgets would have made it difficult to make such payments.

The one important exception to this is the introduction of the Pupil Premium in 2011. Although average school funding per pupil was frozen in real-terms between 2010–11 and 2015–16, schools with more deprived intakes would have experienced a real-terms rise in funding as a result of the introduction and rise of the pupil premium over time. There is, however, no evidence yet to suggest that this rise in funding translated into significantly higher salaries for teacher

Schools use of pay freedoms therefore suggests that the introduction of salary supplements in shortage subjects or in high-poverty areas would need to be centrally funded. As we have already seen, such schemes need not be that expensive and represent a fraction of the amount spent on teacher training and bursaries.

Geographical targeting of such incentives could further reduce the costs, which could be of additional benefit given the geographical variation in access to specialist teachers across England seen in our analysis. The US evidence is also reasonably clear that salary differentials can encourage teachers to move to schools in high-poverty areas. Geographical targeting would, however, bring additional complexity and require some central direction of which areas most merited such salary supplements (and how long they persisted for). Geographical targeting could thus bring added benefits, but must be weighed against the added complexity.

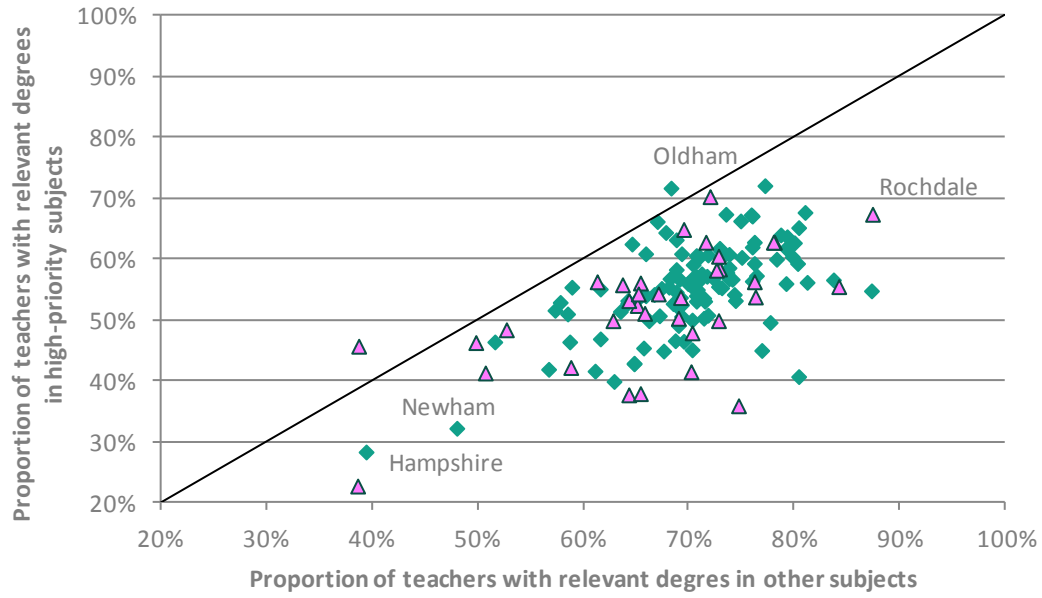
There is some suggestion that the government is moving closer towards such policies. First, the government has announced that early career maths teachers will be eligible to receive £5,000 payments if they remain in teaching three and five years after qualifying (this will only be available to teacher finishing training from the 2018–19 academic year. They are also eligible for a further £2,500 uplift if they are teaching in certain target local authorities. Such a policy is similar in spirit to those trialled in the US and that recommended by Sims (2018).[29] Further analysis will be required as to whether these incentives are set at the right level, e.g. whether they should be paid in all five years, but also whether they should be extended to other subjects. On the latter point, the above empirical evidence is already quite clear that such an extension would be desirable. The School Teachers Review Body would be well placed to advise on which subjects showed the most problems, and thus may merit salary supplements.

Further consideration should also be given to whether the target local authority uplifts are effective. Figure 4.1 repeats Figures 3.9 by showing the per cent of teachers with relevant degrees in high priority and other subjects across local authorities, but now with local authorities targeted by the new maths payments coloured in pink. This shows that many of the local authorities targeted by the

new scheme are indeed those with low shares of teachers with relevant degrees. However, there are several local authorities (e.g. Hampshire and Newham) with low shares of teachers with relevant degrees who are left out of the scheme and several with high shares who are included (e.g. Rochdale and Oldham).

The Department for Education says that the additional bonus payments are targeted at 'challenging areas'. Although we do not know the precise details, this is likely to include a mix of pupil attainment and deprivation. Some differences against our measure of areas with teacher recruitment and retention problems are only to be expected therefore. Given the level of missing data, our precise figures may also be partly driven by measurement error. However, the general point of imperfect targeting seems likely to hold. Given that salary supplements represent a policy lever for tackling teacher recruitment and retention problems, it would be more desirable to directly target these supplements on local authorities that demonstrate these problems (e.g. using a basket of indicators such as the share of teachers with relevant degrees, pupil attainment in shortage subjects and/or teacher vacancies).

Figure 4.1: Proportion of Key Stage 4 hours in high-priority subject taught by a teacher with a degree in a relevant subject across local authorities and areas targeted by new maths early-career payments



Sources and Notes: Author's calculations using School Workforce Census, November 2016 and Pupils, Schools and their Characteristics, January 2017. Percentage relates to proportion of Key Stage 4 hours taught. Department for Education (https://www.gov.uk/guidance/mathematics-early-career-payments-guidance-for-teachers-and-schools)

Second, policymakers are piloting a student loan reimbursement programme for early career teachers in shortage subjects in some local authorities in England. However, it is a complicated scheme with teachers making the student loan contributions first, and then filling out a range of paperwork and submitting payslips to claim them back. It would have been preferable, and presumably more effective, if eligible teachers just did not have to make the payments in the first place (as was the case in the loan forgiveness programme in Florida). Also, given changes to student loan repayments, this policy is likely to have little effect on early career teachers, when exit rates are

highest. With the exception of teachers in London, most new teachers will not make any student loan contributions as the starting salary for a teacher is currently £23,000 (below the new £25,000 threshold for starting to make any student loan contributions).

5. Conclusion

The overall teacher labour market in England is in trouble. The squeeze on teacher pay probably had little effect when private sector earnings were also squeezed. However, the recent recovery in private sector earnings is making teaching a less attractive financial option for young graduates and is probably behind the negative trends in recruitment and retention in recent years. Moreover, the projected growth in pupil numbers means teacher numbers will need to rise in order to prevent class sizes from rising further, rather than staying steady as they have done in recent years. There was therefore a good case for breaking the one per cent pay cap, as the government has recently done by announcing pay rises ranging from 1.5 per cent for school leaders to 3.5 per cent for early career teachers. This arrests the real-terms declines in teachers' earnings seen in recent years and its targeted nature creates an interest as to how future pay awards should be structured.

The teacher shortage problem appears worse in subject where graduates can earn most outside of teaching, with persistent problems recruiting and retaining sufficient numbers of physics, maths, chemistry and languages teachers. This appears to translate into differences in teacher quality in such subjects, with fewer teachers possessing a relevant degree in the subject they teach. Less than half of maths teachers have a degree in a relevant area.

We add to this evidence by showing that there is a significant socio-economic gradient in the proportion of teachers with a relevant degree, particularly for high-priority subjects like physics and maths. The figures are generally lower and the socio-economic gradient stronger outside of London, where there are fewer and less varied graduate labour market opportunities. In the case of maths and physics, less than 20 per cent of physics teachers and less than 40 per cent of maths teachers in the most deprived schools outside of London possess a relevant degree. More generally, there appears significant geographic variation in access to specialist teachers across the country, with low levels across the south coast, Welsh Borders and South and West Yorkshire in particular.

Such differences would be less of a concern if teachers were drawn from related areas. In the case of biology and chemistry, we see that this is mostly the case, with over 80 per cent of teachers possessing a degree in a science or maths subject. However, one third of physics teachers and about one half of maths teachers don't have a degree in a maths or science subject. Such figures are likely to be a substantial concern to policymakers focused on developing a knowledge-rich curriculum.

To date, the Department for Education has focused most of its attention on high-value bursaries for teacher trainees in shortage subjects with high-degree classifications in relevant subjects, with the annual budget for such bursaries totalling around £135m. However, retention in both shortage subjects and high-poverty areas is a substantial problem. Tackling this problem may also be more cost-effective given the high-cost of training teachers.

There is also now a very strong body of evidence from the US that suggests modest salary supplements in maths and science subjects (around five per cent of gross salary) can be highly effective in reducing teacher attrition. More generous bonuses (around $20,000-$25,000) have been found to be effective in incentivising existing teacher to move to high-poverty areas. Schools in England already have the freedom to make such salary supplements, but have been rarely making use of them to date. This is probably because schools would have to self-fund them at a time when school budgets are already severely squeezed.

We believe that there is a good case for introducing salary supplements in shortage subjects for all early career teachers. To be effective, such a policy would need central funding and direction. A recent report for the Gatsby Foundation concluded that had five per cent salary supplements for all early career teachers (first five years of teaching) in maths and science teachers been introduced in 2010, then the teacher shortages in such subjects would have been eliminated in just a few years. The annual cost of such a policy is not that expensive either, estimated at around £37m. This represents a small fraction of the overall teacher training budget and about one quarter of the teacher training bursary budget. If additional money is not available, the funding for salary supplements could be found from within the teacher training bursary budget. The evidence for the effectiveness of salary supplements is strong and clear, whilst there is scant evidence on the effectiveness of recruitment incentives. Given the strong geographic variation in access to specialist teachers (i.e. those possessing a relevant degree), particularly outside of London, there is probably a good case for geographic variation too.

The Department for Education is already starting to go down this route. Maths trainees taking their teacher postgraduate teacher training in 2018–19 will be eligible for payments of one payment of £5,000 after their third year of teaching and another one after their fifth year of teaching, with an extra £2,500 bonus paid in target local authorities. This is a welcome policy. However, given the strength of the US evidence and extent of problems in England, we would encourage the government to go further and faster.

Policymakers should strongly consider extending this scheme to other shortage subjects like physics. To further formalise such a scheme, the government could seek regular advice from the School Teachers' Review Body as to which subjects show most problems in terms of teacher recruitment and retention, and thus merit additional salary supplements.

The bonuses for target local authorities should also be reviewed, particularly as the US cases generally used bonuses of around $20,000 to $25,000 to attract teachers to high-poverty areas. At present the bonuses are targeted at "challenging" local authorities. Although we do not know the precise details of how the set of local authorities was chosen, we have shown that several local authorities with low shares of teachers with relevant degrees are missed out, and several local authorities with high shares are included. Given that salary supplements represent a policy lever for tackling teacher recruitment and retention problems, it would be more desirable to target these supplements directly on local authorities that demonstrate these problems (e.g. using a basket of indicators such as the share of teachers with relevant degrees, pupil attainment in shortage subjects and/or teacher vacancies).

In this report, we have focused almost entirely on pay and financial incentives. Overall workload and conditions are clearly also very important for determining levels of recruitment and retention, and merit significant attention. However, the variation in recruitment and retention problems by subject are almost certainly linked to the variation in outside graduate labour market opportunities, and it therefore makes sense for any policy prescription here to focus on financial incentives.

Appendix A – Methodology for using School Workforce Census

We link together three different files from the School Workforce Census. First, the contracts file allows us to identify which individuals were employed as classroom teachers in November 2016. Second, the curriculum file provides information on how many hours teachers spend teaching different subjects each week, on average, to different year groups. Unfortunately, curriculum data is missing for a large of teachers. Of the approximately 207,000 secondary school teachers we observe, curriculum data was missing in about 65,000 or 31 per cent of cases. We necessarily drop these individuals. Third, the qualifications data provides information on teachers' prior educational qualifications, including their level/type and subject. Data is missing or of poor quality in a further 32,000 cases and degree of subject is missing in a further 24,000 cases. This leaves us with a main sample of about 86,000 secondary school teachers, about 60 per cent of secondary school teachers where we observe curriculum data and about 40 per cent all secondary school teachers observed.

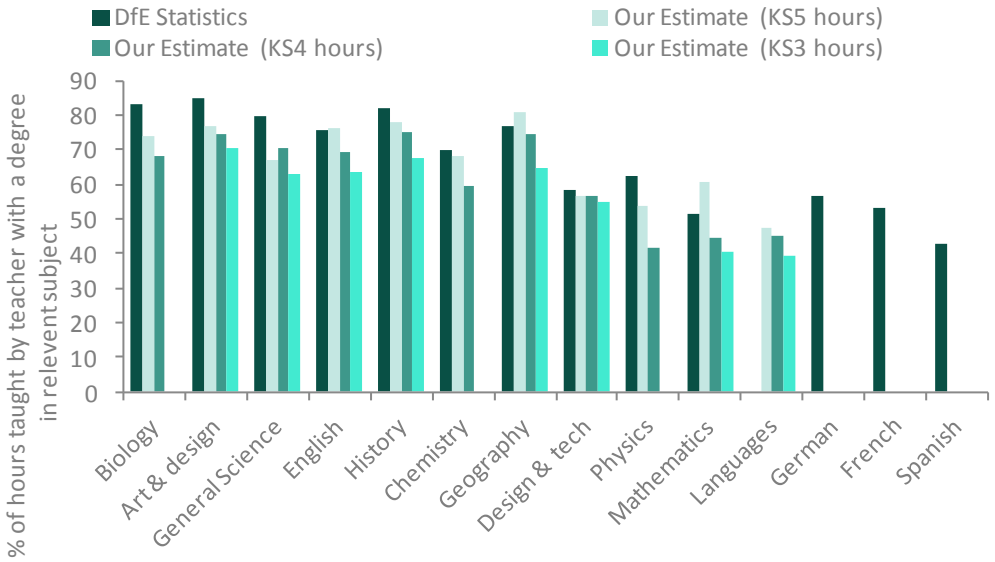
Teachers are classified as having a degree in the subject they teach if they possess a degree-level qualification in a subject classified as relevant by the Department for Education.[ix] For combined/general science, we assume that a teacher has a degree in the subject they teach if they have a relevant degree to teach biology, chemistry or physics, matching the assumption made in Department for Education statistics. For Key Stage 3, only a small number of schools report teaching individual sciences. We therefore group individual science lessons into the combined general science category at Key Stage 3.

Figure A.1 shows our estimates of the proportion of Key Stage 3 and Key Stage 4 hours taught by a subject specialist, and how this compares with Department for Education statistics for November 2016. One should note that DfE statistics relate to Key Stage 3 through to Key Stage 5, whilst we show the numbers broken down by individual Key Stage.

In most subjects, our estimates are slightly below DfE statistics. The exact source of this difference is uncertain, but it seems likely to result from the problems caused by missing curriculum and qualifications data. It is also notable that the proportion of hours taught by a subject specialist are generally lower at lower Key Stages. Such patterns are not surprising as one might expect schools to target specialist teachers at higher levels of learning and at points close to externally assessed examinations. It is further noteworthy that these differences are particularly pronounced for geography, English, history and maths.

[ix] https://www.gov.uk/government/statistics/school-workforce-in-england-november-2016

Figure A.1: Percentage of hours taught by teacher with a degree in a relevant subject, November 2016



Sources and Notes: Author's calculations using School Workforce Census, November 2016

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