National Audit Office

Report
by the Comptroller
and Auditor General

Department for Business, Energy & Industrial Strategy
Department for Education

Delivering STEM (science, technology, engineering and mathematics) skills for the economy

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National Audit Office

Department for Business, Energy & Industrial Strategy
Department for Education

Delivering STEM (science, technology, engineering and mathematics) skills for the economy

Report by the Comptroller and Auditor General

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This study examines whether the departments' approach to boosting participation in the science, technology, engineering and mathematics (STEM) education pipeline at all levels is likely to address the STEM skills challenge in a way that achieves value for money.

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Contents

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Key facts

£990m

spent on, or committed to, key STEM-specific interventions between 2007 and autumn 2017

442,000

undergraduate enrolments in STEM subjects in 2015/16

24%

of graduates in STEM subjects known to be working in a STEM occupation six months later

700,000	additional STEM technicians the Gatsby Charitable Foundation estimates will be needed to meet employer demand in the decade to 2024
112,000	STEM apprenticeship starts in 2016/17
8%	of STEM apprenticeships started by women in 2016/17, despite women accounting for over 50% of all apprenticeship starts
£80 million	government investment in national colleges, including in high-speed rail; nuclear; onshore oil and gas; and digital
2.6%	rise in the number of STEM A level examination entries in 2016/17 compared with the previous year
30.9%	fall in the number of enrolments in part-time undergraduate STEM degrees between 2011/12 and 2015/16
£200 million	government capital investment in higher education STEM provision in 2015/16

Summary

Background

1 STEM stands for science, technology, engineering and mathematics. In education, it means the study of these subjects, either exclusively or in combination. In employment, STEM refers to a job requiring the application of science, technology, engineering and mathematics skills or a qualification in a relevant subject, or located in a particular industry or sector. There is no universally accepted definition in either setting.

2 Since the early 2000s there has been growing concern, including from government, about how to achieve higher productivity and economic growth in an era of rapid technological change. Over time, this has generated the widely held belief that one of the UK's key economic problems is a shortage of STEM skills in the workforce. Most recently, the November 2017 policy paper, *Industrial Strategy: Building a Britain fit for the future*, stated that "…we need to tackle particular shortages of STEM skills. These skills are important for a range of industries from manufacturing to the arts". Some employers in STEM sectors have also suggested that exit from the European Union (EU) may affect the availability of people with the requisite STEM skills, but the precise impact is hard to predict.

3 People can develop formal STEM skills and knowledge in different ways, either in an educational setting or in the workplace. This can be seen as a 'pipeline', through which learners move in order to acquire more advanced abilities. The key routes for developing STEM knowledge and skills are: schools and sixth-form colleges; further education colleges; apprenticeships, which mix work with formal off-the-job training; and higher education institutions.

Government intervention

4 Responsibility for developing STEM skills involves a number of government departments, and is embedded across a number of non-STEM specific policy areas. The Department for Education (DfE) is responsible for the majority of STEM skills interventions. The Department for Business, Energy & Industrial Strategy (BEIS) has a cross-cutting role, including work on doctoral training and STEM inspiration, and setting the national framework for science and technology. Other departments, including the Department for Digital, Culture, Media & Sport and the Ministry of Defence, run individual STEM-related programmes and initiatives.

5 Aside from the core teaching of STEM subjects, some of the most significant initiatives in terms of spending are:

- providing higher education institutions with additional money to support their teaching of very high-cost STEM subjects;
- allocating capital funds to enhance higher education STEM teaching facilities; and
- running university technical colleges, which were set up to offer 14- to 19-year-olds a combination of technical, practical and academic learning.

Scope and approach

6 This report focuses on government's overall approach to enhancing STEM skills, and how each section of the STEM skills pipeline is performing, looking in particular at the development of STEM skills in those aged over 16. It covers the situation in England, in keeping with the responsibilities of the key government departments involved. Its main focus is on DfE and BEIS, but it also references a number of other departments that have responsibility. The report examines three main areas:

- government's understanding of the need for enhanced STEM skills in the workforce (Part 2);
- what the performance of the education pipeline shows about the effectiveness of past initiatives in delivering STEM skills (Part 3); and
- the opportunities and risks associated with the latest initiatives to enhance the development of STEM skills (Part 4).

Key findings

Government's understanding of the need for enhanced STEM skills in the workforce

7 Government does not currently gather robust intelligence on the STEM skills issues it has already started to address. The UK Commission for Employment and Skills (UKCES), the public body previously responsible for collecting and analysing labour market intelligence, and forecasting skills needs, closed in March 2017. Its research function was transferred to DfE in late 2016. DfE has since announced that it will develop Skills Advisory Panels to oversee skills needs at a local level, but it is too early to tell whether these will produce robust assessments of current and future skills needs. Currently, the case for intervening on STEM skills, as put forward in the November 2017 industrial strategy policy paper, is based on skills gap estimates from employer representative groups, and historic UKCES analysis (paragraphs 2.2 to 2.5 and 2.22).

8 **Current estimates of the STEM skills problem vary widely, and typically focus only on individual sections of the workforce.** Estimates of skills needs generated by sectoral and employer groups tend to be narrow in focus or too generalised to provide a sufficiently detailed understanding of overall STEM skills needs. We have produced our own analysis, which indicates that current and predicted shortages vary by skill level and also demonstrates the difficulty of producing reliable estimates using available data and methodologies. Modelling future needs is especially problematic due to the difficulty of predicting the effects of technological changes and future events (paragraphs 2.13, 2.14, 2.16, and Figure 3).

9 **Government does not have a stable and consistent set of definitions for STEM, in either an educational or a work context.** STEM is a complex and overlapping group of subject areas that can be defined in a number of different ways, depending on the criteria used. In a work context, Standard Industrial Classification (SIC) or Standard Occupational Classification (SOC) codes can be used to arrive at very different results when analysing 'STEM jobs' and identifying the nature and extent of any STEM skills shortage. Without a more stable, consistent set of definitions, government will be less able to understand the problem in a meaningful way, target initiatives effectively, or measure their overall success (paragraphs 2.10 to 2.12).

10 **Existing evidence indicates that there is a STEM skills mismatch rather than a simple shortage.** A mismatch can include many types of misalignment between the skills needed and those available in the labour pool. Our research indicates that there are particular shortages of STEM skills at technician level, but an oversupply in other areas, such as biological science graduates, who are then often underemployed in an economy in which they are not in high demand. There is also evidence to suggest that, at graduate level and above, the problem is sometimes one of quality rather than quantity, with people not having all of the employability or practical skills they need to enter the workforce (paragraphs 2.14, 2.15 and 2.17 to 2.21).

11 **Government is starting to improve coordination on STEM and address past incoherence.** Departments have begun taking steps to set out clearly what they are seeking to achieve and what success will look like. A single lead for STEM has been appointed within DfE and, at the end of our fieldwork in September 2017, DfE was developing more specific objectives. Relevant departments were also in the process of establishing new STEM governance boards to foster a joined-up approach. These measures should help to address historical issues of incoherence, but until they are fully implemented, there is a risk that the overall approach remains incohesive, that various strategies that support STEM will not be aligned, and that emerging issues will not be dealt with in a timely way (paragraphs 2.6 to 2.9).

12 **The impact of exit from the EU is difficult to predict, with some major science and engineering bodies believing that exit from the EU could reduce the availability of STEM skills in the short term.** BEIS and DfE are involved in cross-government work to assess the wider impacts of exiting the EU. This will be informed by the work of the independent Migration Advisory Committee (paragraphs 2.23 to 2.25).

The performance of the education pipeline in delivering STEM skills

13 **Some STEM initiatives have been effective but overall coordination has been lacking.** Some initiatives have had a positive impact, and those targeted at A levels saw entries grow by 3% between 2011/12 and 2016/17. However, overall these initiatives are not sufficiently coordinated at programme level to take full advantage of synergies, or to mitigate the risk of duplication. This is exacerbated by the absence of a dedicated evidence-gathering function, and the fact that robust evaluations have not been carried out on all initiatives so far to identify what works (paragraphs 2.2, 2.6, 2.8, 3.3 to 3.5, 4.8 to 4.10 and 4.12, and Figures 4, 5 and 10).

14 **Females are underrepresented in most STEM subject areas at every stage of the STEM skills pipeline.** In 2016/17, female students accounted for only 42% of all STEM A level exam entries, making up just 9.4% of examination entries in computing, 21.2% in physics, and 39% in mathematics. Females made up only around 8% of STEM apprenticeship starts in 2016/17, despite representing more than 50% of all apprenticeship starts overall, and around 38% of enrolments on undergraduate STEM courses, again despite accounting for more than 50% of all enrolments. There is also evidence of gaps on the basis of other characteristics, such as ethnicity and socio-economic background, but the information and analysis currently available on these characteristics is less comprehensive (paragraphs 3.6, 3.8, 3.19 and 3.23, and Figure 6).

15 **The number of people participating in STEM-related vocational courses has risen in some areas but not others.** Starts in STEM apprenticeships grew from 95,000 in 2012/13 to 112,000 in 2016/17. This was mainly driven by growth in apprenticeships covering: engineering and manufacturing technologies; and construction, planning and the built environment. The number of non-apprenticeship STEM further education learning aims being studied, however, remained at around 110,000 between 2011/12 and 2015/16 (paragraphs 3.8, 3.9 and 3.12, and Figure 7).

16 **However, enrolments in undergraduate STEM courses have fallen slightly since 2011/12, and in subjects where there has been growth this appears to reinforce reported skills mismatches.** Between 2011/12 and 2015/16, enrolments in full-time STEM degrees rose by 6.9% against an overall rise in all subjects of 1.1%. Enrolments in biological sciences saw the strongest growth, while enrolments in engineering and technology and physical sciences have grown less strongly. However, take-up of part-time undergraduate STEM courses fell by over 30% in the same period, from almost 98,000 to around 68,000, as part of a collapse in part-time degree enrolments that saw them fall by 47% overall (paragraphs 3.17, 3.18 and 3.22, and Figure 8).

17 According to longitudinal research, of the 75,000 people who graduated with a STEM degree in 2016, only 24% were known to be working in a STEM occupation within six months. Some of the remainder, including the 15,000 (19.9%) whose destinations are unknown and the 13,000 (17.6%) going on to further study, may end up in STEM occupations. Improvements are currently being made to the quality of the graduate outcomes data, including delaying the data collection point to between 12 and 18 months after graduation. This should help DfE do more to understand why the proportion of STEM graduates entering STEM occupations is so low, and what can be done to improve the situation (paragraph 3.20).

The latest initiatives designed to enhance the development of STEM skills

18 There are several new initiatives in further education, which will need to establish their position in an already complex landscape. Technical levels (T levels) are designed to improve vocational education by standardising qualifications, aligning syllabuses with employer demand, and establishing 15 clear 'routes' into careers. The national colleges programme aims to develop high-level technical skills in sectors important to the UK economy, four of which focus on STEM skills: high-speed rail; nuclear; onshore oil and gas; and digital. The business case for each college is supported by detailed projections of supply and demand for skills, so they are well-targeted at areas of need within their specific sectors (paragraphs 2.15, 4.3 and 4.4, and Figures 10 and 11).

19 The November 2017 industrial strategy policy paper re-stated a proposal for institutes of technology, which will target skills gaps at levels 4 and upwards, particularly in STEM areas. As new institutions being introduced into an already crowded provider marketplace, there is a risk that they may face challenges in establishing their position (paragraph 4.5).

20 In the schools sector, better training and attempts to attract former teachers back to the workforce show some positive results. Early stage research indicates that the £67 million maths and physics teacher supply package, aimed at recruiting an additional 2,500 teachers and improving the skills of 15,000 non-specialist teachers in these subjects, is having a positive impact. However, a recent National Audit Office report also found that elements of the programme have been less successful, with the return to teaching pilot, for example, recruiting 428 returning teachers, just over half of its target of 810, of whom 330 completed the training provided (paragraph 4.8).

Conclusion on value for money

21 DfE and BEIS face a complex challenge to improve the quality of teaching and student take-up in key STEM subjects. Some of their initiatives are achieving positive results but there remains an urgent need for a shared vision of what they are trying to achieve and coordinated plans across government. The absence of a precise understanding of the STEM skills problem means the efforts of DfE and BEIS are not well prioritised and a better targeted approach is needed to demonstrate value for money.

Recommendations

22 DfE should:

a **Configure the labour market intelligence generated by Skills Advisory Panels and other mechanisms so that it enables effective decision-making.** Currently, the case for increasing the supply of STEM skills is based on different pieces of research that provide insufficient insight into the nature of the challenge.

b **Provide departments with clarity on the different STEM definitions used in different contexts, and reasons for these different definitions.** Without this clarity, meaningful comparisons of progress across different policy areas will always be challenging.

23 BEIS should:

c **Strengthen its work to evaluate and identify what is effective in its activities to promote participation in STEM education and skills development, and ensure this is shared with its delivery partners.** A range of different entities oversee or deliver activities to promote STEM. BEIS should continue to share good practice among them.

d **Working with other departments, use data on skills mismatches resulting from EU exit to establish the position across relevant sectors and determine whether key capabilities are at risk.** At present, there are clearly conflicting views about the likely impact on the availability of skilled workers and the flow of higher education students.

24 DfE and other key departments should:

e **Take steps to influence the skills marketplace in priority areas where insufficient development of STEM skills is taking place.** Departments are starting to take positive steps towards establishing better mechanisms to identify priority areas, but this intelligence will only be meaningful if the departments have the ability to influence the marketplace to develop the necessary skills.

f **Fully embed a more structured approach to STEM across government.** DfE has recently re-started a cross-government group to consider STEM issues involving all the key departments. This group needs long-term continuity to ensure the individual policies and strategies that support STEM are aligned and cohesive, and do not duplicate effort.

Part One

Background

Definition

1.1 STEM stands for science, technology, engineering and mathematics. In education, it means the study of these subjects, either exclusively or in combination. In employment, STEM refers to work that:

- involves the application of science, technology, engineering or mathematics knowledge and skills; and/or
- requires an appropriate qualification in a STEM subject; and/or
- is located in a particular industry or sector, such as pharmaceuticals, construction or aerospace.

1.2 There is no universal definition of what should be counted as a STEM subject or job. For example, researchers sometimes include different subjects when calculating the number of STEM students. The situation with job classifications is much more complex, because many jobs within STEM sectors do not require STEM skills (for example, a human resources specialist in an engineering company), while some jobs in non-STEM sectors clearly do require STEM skills (for example, an IT support specialist in a law firm).

1.3 People can develop formal STEM skills and knowledge in different ways, either in an educational setting or in the workplace (**Figure 1** overleaf). This can be seen as a 'pipeline', through which learners move in order to acquire more advanced abilities.

Figure 1

Key routes for formal development of STEM knowledge and skills

Setting	Type of learning	Typical qualifications	Educational level
School or sixth-form college	Classroom-based	GCSEs and A levels	2–3
Further education college	Mainly classroom-based but with work experience in some cases	Vocational qualifications such as BTECs and NVQs	2–5
Apprenticeship	Work-based but with some formal off-the-job training	Apprenticeships (various levels, from GCSE-equivalent to master's degree)	2–7
Higher education institution	Mainly classroom-/ laboratory-based, but with work experience in some cases	Bachelor's or master's degree, PhD	6–8
Place of work	Workplace training and up-skilling	N/A	N/A

Source: National Audit Office

Concern about the supply of STEM skills in the workforce

1.4 Since the early 2000s, there has been a growing focus on how to achieve increased productivity and economic growth in an era of rapid technological change. Government concern goes at least as far back as the 2002 Roberts review, which considered the difficulties that employers faced in recruiting highly skilled scientists and engineers.[1]

1.5 This concern has generated a widely held belief that one of the UK's key economic problems is a broad shortage of STEM skills in the workforce. The November 2017 policy paper, *Industrial Strategy: Building a Britain fit for the future*, included 'people' as one of its five themes, and stated that "…we need to tackle particular shortages of STEM skills. These skills are important for a range of industries from manufacturing to the arts".[2]

1 Sir Gareth Roberts, *SET for success: the supply of people with science, technology, engineering and mathematics skills*, April 2002.

2 HM Government, *Industrial Strategy: Building a Britain fit for the future*, November 2017.

1.6 It is difficult to measure precisely the economic impact of STEM skills, but research in STEM-reliant sectors helps to illustrate their value. EngineeringUK has calculated that around 5.7 million people, or 19% of the UK workforce, work in engineering organisations and that engineering contributes around 26% of the UK's gross domestic product.[3] Similarly, in 2014, the Confederation of British Industry reported that the gross value added (a standard measure of the value of goods and services produced) per employee in the advanced manufacturing sector stood at £49,000 compared with a national average of £37,000.[4]

1.7 Exit from the European Union (EU) could affect the availability of people with the requisite STEM skills in the workplace. EngineeringUK has reported, for example, that the UK is "highly dependent" on attracting and retaining workers from overseas to meet the current shortfall of engineering graduates.[5] This makes the UK skills picture highly sensitive to any changes that might arise.

Government responsibility for STEM skills

1.8 There is no unified government STEM skills programme, and responsibility for different elements is spread across a number of departments (**Figure 2** overleaf). The Department for Education (DfE) is responsible for the main formal learning routes: schools, colleges, apprenticeships, and higher education institutions. It is also responsible for generating research on employers and skills needs.[6] The Department for Business, Energy & Industrial Strategy (BEIS) has overall responsibility for the industrial strategy, develops insights into key business sectors, and leads on doctoral training. It also leads a STEM inspiration programme, encouraging young people to consider STEM careers by running science and engineering activities, mainly within a schools setting.[7]

1.9 Other departments also play an important role. The Department for Digital, Culture, Media & Sport (DCMS) is concerned with the broad development of digital and cyber security skills, and encouraging businesses to take appropriate action to defend themselves and their customers from cyber attack. The Ministry of Defence has a large apprenticeships programme, mainly in STEM areas, and has a particular need for engineering skills. The Department for Transport is interested in skills among its workforce that support national infrastructure projects, such as building the High Speed 2 rail line. Most STEM definitions exclude medicine and dentistry, so we do not specifically consider the healthcare sector in this report.

3 EngineeringUK, *Engineering UK 2017: The State of Engineering*, February 2017.
4 Confederation of British Industry, *Engineering our future: Stepping up the urgency on STEM*, 2014.
5 See footnote 3.
6 This was a function carried out by the UK Commission for Employment and Skills until it closed in early 2017.
7 BEIS's STEM inspiration programme is delivered in conjunction with a number of partner bodies, including STEM Learning Ltd.

Figure 2
Main departmental responsibilities for STEM

Responsibility for funding, managing and delivering STEM skills is spread across a number of departments

Department for Education
- Schools
- Further education
- Higher education
- Apprenticeships
- Lifelong learning
- Careers strategy
- Labour market intelligence

Department for Business, Energy & Industrial Strategy
- Managing industrial strategy overall
- STEM outreach (eg STEM inspiration)
- Significant role in R&D policies and funding
- Labour market intelligence

Department for Digital, Culture, Media & Sport
- Digital skills
- Cyber security
- Digital strategy

Department for Transport
- Transport infrastructure skills strategy
- STEM apprenticeships programme

Ministry of Defence
- Defence STEM engagement programme
- STEM apprenticeships programme

Other departments
- HM Treasury
- Cabinet Office
- Home Office

Source: National Audit Office

Funding

1.10 Funding the development of STEM skills involves several departments, and is embedded across a number of non-STEM specific policy areas. Aside from the core teaching of STEM subjects, some of the most significant initiatives in terms of spending are:

- providing higher education institutions with additional money to support their teaching of very high-cost STEM subjects;
- allocating capital funds to enhance higher education STEM teaching facilities; and
- running university technical colleges, which were set up to offer 14- to 19-year-olds a combination of technical, practical and academic learning.

1.11 We estimate that total dedicated spending on key STEM initiatives from 2007 to 2017 amounts to around £990 million,[8] in addition to the mainstream educational funding that has been spent on STEM.

8 This includes the sum currently committed to existing STEM initiatives.

Scope of this report

1.12 This report focuses on government's overall approach to enhancing STEM skills, and on how each section of the STEM skills pipeline is performing, looking in particular at the development of STEM skills in those aged over 16. It expands on a number of issues covered by our recent report on the higher education market.[9] It covers the situation in England, in keeping with the responsibilities of the key government departments involved.[10] Although it is focused on DfE and BEIS, who have primary responsibility for STEM activities, the report references a number of other departments that also share responsibility for delivering STEM skills.

1.13 The report covers three main areas:

- government's understanding of the need for enhanced STEM skills in the workforce (Part Two);
- what the performance of the education pipeline shows about the effectiveness of past initiatives to enhance STEM skills (Part Three); and
- the opportunities and risks associated with the latest initiatives to enhance STEM skills (Part Four).

1.14 The report does not evaluate all the STEM programmes in place over recent years, but focuses on key initiatives in schools, apprenticeships, further education and higher education.

9 Comptroller and Auditor General, *The higher education market*, Session 2017-19, HC 629, National Audit Office, December 2017.
10 Some of the initiatives it considers, such as BEIS's STEM inspiration programme, are UK-wide.

Part Two

Government's understanding of the need for enhanced STEM skills in the workforce

2.1 This part examines:

- whether government maintains a high-quality evidence base to help define the STEM skills challenge, based on robust definitions;
- the leadership and success measures underpinning efforts to boost STEM skills;
- popular estimates of STEM skills shortages, and the evidence for a STEM skills 'mismatch' rather than universal shortages; and
- how government is dealing with the potential impact of exit from the European Union (EU).

The quality of the evidence base

2.2 Government does not currently have a robust, independent evidence base that defines the STEM skills problem. The industrial strategy green paper acknowledged this gap, noting that "part of the problem has been the lack of a single authoritative source" of evidence on skills needs, and that such a source needs to be established.[11]

2.3 The case for increasing the supply of STEM skills, as set out in the green paper and the November 2017 policy paper *Industrial Strategy: Building a Britain fit for the future*, is therefore built on research conducted by employer representative groups, including EngineeringUK and the Confederation of British Industry (CBI).[12] This research indicates an undersupply of people with the right STEM skills in general terms. However, it does not analyse the undersupply – for example, by sub-sector, region or skill level – in a way that can fully identify the problem. In addition, other pieces of skills research draw different conclusions. For example, a 2015 UK Commission for Employment and Skills (UKCES) report suggested that the problem, for 'high-level' STEM skills at least, relates to the quality rather than the quantity of people with qualifications in STEM subjects entering the workforce.[13]

11 HM Government, *Building our Industrial Strategy*, January 2017, p. 45.
12 HM Government, *Building our Industrial Strategy*, January 2017; HM Government, *Industrial Strategy: Building a Britain fit for the future*, November 2017.
13 UK Commission for Employment and Skills, *Reviewing the Requirement for High Level STEM Skills*, July 2015.

2.4 UKCES, the main body previously responsible for producing labour market intelligence and a strategic overview of skills supply, closed in early 2017. It published regular analyses of skill needs, including the 'Working Futures' reports, which provided 10-year projections of demand for skills across the whole economy.

2.5 As of November 2017, the Department for Education (DfE) was considering how it might develop an authoritative source of intelligence. Since early 2017, it has been developing plans for a network of Skills Advisory Panels. These are regional entities that will work with employers, education providers and other local partners to assess and manage skills needs in each region.

Leadership and measurement of impact

2.6 DfE takes the lead for the majority of STEM interventions, but the lack of formal coordination across government creates a risk that the overall approach is not cohesive, strategies that support STEM are not aligned, and emerging issues are not dealt with in a timely way. For example, while the Department for Business, Energy & Industrial Strategy (BEIS) is responsible for the industrial strategy, the Department for Digital, Culture, Media & Sport (DCMS) is responsible for the UK digital strategy and DfE, with input from other departments, leads on the careers strategy. This situation is further complicated by the number of additional stakeholders involved. The Royal Academy of Engineering, for example, has identified over 600 organisations, aside from employers and universities, involved in STEM education in some way.[14]

2.7 DfE has begun to address these issues. As of November 2017 it has appointed a single lead for STEM, and the Department is in the process of establishing a departmental STEM Programme Board, which aims to facilitate a joined-up approach to STEM within the Department and across government. The Department also plans to establish a cross-governmental STEM governance group. These are positive developments, but they will need to be properly embedded and maintained to ensure they function effectively. There have been previous attempts to establish cross-departmental STEM governance bodies or working groups, but none have lasted long enough to have a meaningful impact.

2.8 To date, the departments have not collectively set out precisely what they are seeking to achieve in their efforts to boost STEM skills, or what success will look like. Broadly, their approach is to encourage higher participation in STEM subjects at all levels of the pipeline, which is expected to increase the flow of people with appropriate STEM skills into the workplace. This approach is not surprising, given the lack of rigorous intelligence on the nature of the problem, and the challenges of predicting STEM skills needs into the future. The success of government initiatives can be measured only against the very general objective of increasing participation in STEM education.

14 Royal Academy of Engineering, *The UK STEM Education Landscape*, May 2016.

2.9 As of November 2017, DfE advised us that it was in the process of developing detailed success measures for its work to boost STEM skills. It is too early to draw any conclusions about these measures.

The definition of STEM subjects and jobs

2.10 Improving the evidence base is made more complex by the lack of consistent and well-understood definitions, both in an educational and labour market context. For example:

- identifying STEM subjects tends to be more straightforward in post-16 education, given the narrow range of A level subjects generally studied. In higher education, the Joint Academic Coding System (JACS) is commonly used to designate STEM subjects. However, researchers vary in the way they treat disciplines such as medicine and sports science, and many subjects conventionally regarded as non-STEM, such as geography or economics, include STEM elements; and
- in a work context, there is huge scope for different definitions of what makes up a STEM job. STEM jobs are typically identified by the industry or occupation in which they take place, based on Standard Industrial Classification (SIC) codes or Standard Occupational Classification (SOC) codes respectively, but each code covers hundreds of classes of industry and occupation.

2.11 This lack of consistent definitions can lead to starkly contrasting research findings, which in turn undermines government's ability to understand the problem and target its programmes effectively. For instance:

- in 2012, the Royal Academy of Engineering and EngineeringUK used the same UKCES data to estimate the demand for engineering skills between 2010 and 2020. The Royal Academy of Engineering concluded that 1.23 million science, engineering and technology workers would be needed over this period, while EngineeringUK concluded the figure was around 2.2 million.[15,16] The variation was mostly due to differences in the footprint of occupations each body identified as 'engineering', as per SOC code classifications; and
- in 2014, the Royal Society found that 50% of those working in STEM jobs were women, while researchers from the Women in Science and Engineering (WISE) campaign concluded the figure was around 13%.[17,18] This discrepancy was again due to differences in the occupations labelled as STEM by each body and, to a lesser extent, the different datasets used.

15 Royal Academy of Engineering, *Jobs and Growth: the Importance of Engineering Skills to the UK Economy*, September 2012.
16 EngineeringUK, *Engineering UK 2012: The State of Engineering*, 2012.
17 Royal Society, *A picture of the UK scientific workforce*, February 2014.
18 Women in Science and Engineering (WISE), *The Talent Pipeline from Classroom to Boardroom,* 2014. WISE has subsequently revised the definition to align itself with other bodies in the sector such as UKCES and EngineeringUK and has recalculated the 2014 figures, bringing the estimate up from 12.8% to 19.7%. In 2017, according to its most recent analysis, women made up 22.7% of the total number of people working in core STEM occupations.

2.12 In 2012, a House of Lords study recommended that "Government should work together with the Higher Education Statistics Agency, the research councils, higher education institutions, and professional bodies to formulate and apply a standard definition of STEM".[19] However, this broad piece of work has not been carried out. In early 2017, the Royal Society established a working group, with input from a number of organisations, to compile an exhaustive list of STEM SOC codes. It aimed to produce a standard taxonomy of STEM occupations by the end of 2017.

Estimates of the STEM skills problem

2.13 Broad estimates of the nature of STEM skills shortages vary widely according to which definition, dataset and methodology are used. Estimates tend to be based on employer surveys, along with modelling of educational and occupational data. Most surveys involve a relatively small sample of employers, and modelling is particularly problematic due to the unpredictable impacts of technological changes (which are especially relevant to many STEM occupations) and future events like exit from the EU.

2.14 Recent estimates of shortages have focused on particular sectors or disciplines, and include:

- in 2017, EngineeringUK estimated an annual shortage of around 45,000 people with engineering skills at levels 3 and above, based on estimated annual demand of 158,000 for skills at this level (or just over 1.5 million by 2024);[20]
- in 2014, the Gatsby Charitable Foundation estimated that up to 700,000 STEM technicians would be required over the next decade to meet employer demand;[21] and
- in 2013, the Social Market Foundation estimated an annual shortage of 40,000 STEM graduates each year to 2020.[22]

2.15 As part of its programme to set up national colleges, BEIS undertook detailed analysis of skills needs in a small number of specific sub-sectors. The business case for each college included a rigorous analysis of the current and projected supply and demand for skills for that industry. The business case for the National College for Nuclear, for example, was based on work by the Nuclear Energy Skills Alliance that examined individual occupations by region and skill level, and concluded that the industry will require an additional 2,200 full-time equivalent workers with high-level STEM skills each year.

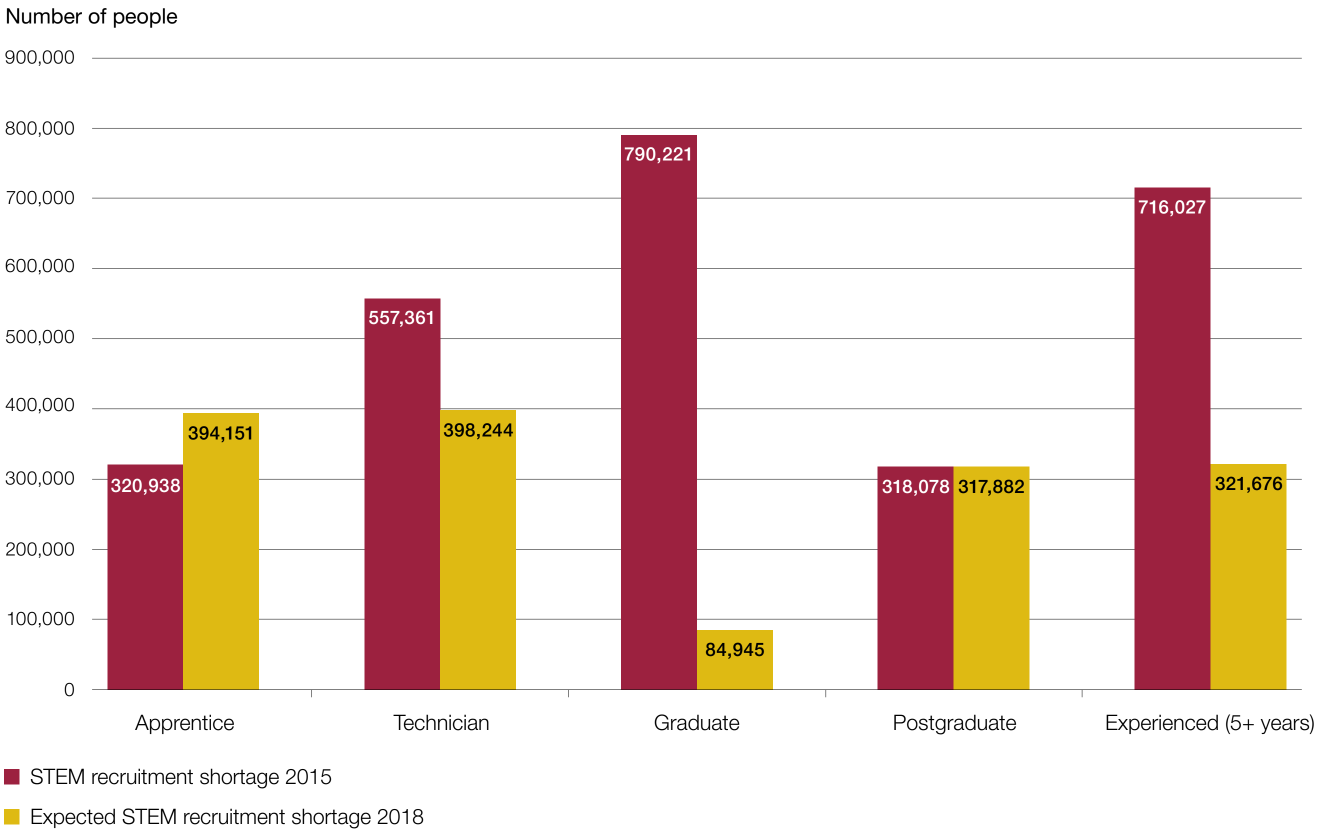
19 House of Lords Select Committee on Science and Technology, *Higher Education in Science, Technology, Engineering and Mathematics (STEM) subjects*, July 2012.
20 EngineeringUK, *Engineering UK 2017: The State of Engineering*, 2017.
21 Gatsby Charitable Foundation, *Our Work Supporting Technicians*, December 2014.
22 Social Market Foundation, *In the Balance: The STEM Human Capital Crunch*, March 2013.

2.16 In the absence of a definitive figure, we carried out our own analysis (see Appendix Two for a fuller explanation of our methodology). We estimate that, in 2015, employers in England experienced around 2.7 million STEM recruitment shortages, and they expected around 1.5 million in 2018 (**Figure 3**). Our estimate also suggests employers expect these shortages to fall in 2018, particularly at graduate level. Shortages in other areas are expected to persist, particularly for apprentices and technicians. This analysis also demonstrates the difficulty of understanding the true nature and extent of the STEM skills problem using sample-based survey methodologies and existing national-level datasets. By itself this would not provide a sufficiently detailed basis on which to intervene, and does not distinguish between problems with availability of skills and problems with employers' approaches to accessing those skills.

Figure 3

Estimate of employer-reported STEM recruitment shortages: 2015 and (expected) 2018

Estimated recruitment shortages vary substantially by level of STEM-qualified employee



Notes

1 We carried out this analysis by matching 2015 CBI education and skills survey responses (quoted in the industrial strategy green paper) with Office for National Statistics data on businesses in England.

2 We have weighted the estimate by size of CBI survey respondent, and have used a figure of 1% of each business's workforce (to a minimum of one person) to generate a numerical estimate.

Source: National Audit Office analysis of survey information from the Confederation of British Industry and data produced by the Office for National Statistics

2.17 Our fieldwork also identified recurring issues that point towards a wider STEM 'mismatch', in which there is oversupply of some skills and undersupply of others. This term covers various situations arising from a misalignment between the skills needed in the economy and those available in the labour pool, of which skills shortages are just one part.[23]

2.18 Recent research, along with the experience of many of the stakeholders we interviewed, suggests there is an acute shortage of technician-level STEM skills.[24] Interviewees attributed this shortage to an undersupply of people with level 3 to 5 vocational qualifications over the last 20 years, due to lower participation in vocational education.[25] This lack of new entrants has led employers to rely on an ageing workforce, many of whom are now reaching retirement age.

2.19 But there is also an oversupply of some STEM qualifications, particularly at degree level. For instance, there appears to be a surfeit of biological science graduates, a greater proportion of whom enter non-graduate roles compared to the STEM average. This is evidenced by the fact that more biological science graduates earn low salaries 40 months after graduation, compared to the STEM average, and the average for all subjects.

2.20 Both the oversupply of some graduate-level skills and the undersupply of technician-level skills can result in graduates occupying technician-level roles for which they are overqualified and under-skilled. This can lead to low morale and high staff turnover. Graduate-level skills may not align directly with those required in technician-level roles, particularly in engineering-related occupations, where technicians are likely to have expertise in particular processes or instruments that graduates may lack.

2.21 For some higher-level (e.g. graduate) roles, the issue is not a shortage of people with the relevant qualifications, but the skills these people hold. This includes particular technical skills that employers expect graduates to have, or 'softer' employability skills. This indicates that, in some areas, there are sufficient people with high-level STEM skills to meet demand, but these individuals do not possess all the skills required by employers. This problem is generally attributed to some higher education institutions not possessing the right equipment, courses being more focused on theoretical topics than vocational application, and a lack of work experience opportunities.

2.22 As of November 2017, DfE was setting up Skills Advisory Panels (SAPs) to work with Local Enterprise Partnerships (LEPs) at a regional and local level to better understand and address regional and local skills needs.[26] There is a risk that this will be hampered by differences in quality between SAPs, as our recent report found in relation to combined authorities, and of incoherence across regions.[27]

23 Government Office for Science, *Skills Demand, Training and Skills Mismatch: A Review of Key Concepts, Theory and Evidence,* 2016, p. 27.
24 Technical vocational skills below degree level. The 2014 Gatsby Charitable Foundation report *Our Work Supporting Technicians* noted the shortage of skills at this level.
25 This is corroborated by the 2016 *Report of the Independent Panel on Technical Education*, which noted that the post-secondary technical education sector in England is very small by international standards.
26 The DCMS-led Digital Skills Partnerships, set out in the industrial strategy policy paper, will perform a similar role for digital skills.
27 Comptroller and Auditor General, *Progress in setting up combined authorities*, Session 2017-19, HC 240, National Audit Office, July 2017.

The likely impact of exit from the EU

2.23 The impact of exit from the EU is hard to predict, but some major science and engineering bodies believe it could reduce the availability of STEM skills. Engineering the Future, an alliance of professional engineering bodies hosted by the Royal Academy of Engineering, for example, noted that the UK's existing engineering skills shortage could be exacerbated if access to the EU's engineering workforce is limited.[28] The CBI has also expressed concern about possible restrictions on the rights of non-graduate EU workers to work in the UK, which would include those with technician-level skills.[29]

2.24 Some science and engineering bodies also believe there could be a reduction in the numbers of EU and other international students coming to study STEM subjects at higher education level. For example, the Engineering the Future alliance has noted that it is reasonable to assume "many students from EU member states would see studying within the EU as a more attractive option", particularly if UK universities charge them tuition fees at overseas student levels.[30] In 2015/16 there were 438,000 international students in the UK (19% of the total student population), with 127,000 from the EU. A reduction in these numbers could have a dual impact, for instance:

- tuition fee income from EU-domiciled students could fall; and
- some postgraduate taught courses in STEM subjects rely on EU and overseas students to remain viable, so may have to be discontinued if they fail to attract enough non UK-domiciled students.[31]

2.25 As of November 2017, BEIS and DfE were involved in cross-government work to assess the wider impacts of exiting the EU. This work is being informed by the Migration Advisory Committee, the independent body responsible for advising government on migration issues.

28 Engineering the Future, *Engineering a future outside the EU*, October 2016.
29 Confederation of British Industry, *Making a Success of Brexit*, December 2016.
30 See footnote 28.
31 In 2015/16 EU-domiciled students made up one in 12 of all students in postgraduate taught courses. EngineeringUK has noted that "postgraduate taught courses and research programmes in engineering are highly dependent on international students for their viability". EngineeringUK, *Engineering UK 2017: The State of Engineering*, 2017.

Part Three

The performance of the education pipeline in delivering STEM skills

3.1 This part examines:

- the range of recent initiatives designed to enhance STEM skills in various parts of the education pipeline; and
- the performance of the pipeline in terms of trends in A levels, apprenticeships and further education, higher education and lifelong learning.

Recent key initiatives to enhance STEM skills

3.2 We estimate that, between 2007 and 2017, government spending on key initiatives designed to enhance STEM skills amounted to around £990 million (**Figure 4** overleaf). Skills-related spending is rarely broken down between STEM and non-STEM. Insofar as it can be broken down, expenditure on STEM initiatives has increased over recent years.

Figure 4

Key STEM initiatives, 2007–2017

Setting	Initiative	When	Department responsible	Total funding (£m)
Higher education (HE)	Very high-cost STEM subject top-up	2007 – present	DfE	236
HE	HEFCE STEM teaching capital funding	2016	DfE	200
Schools	University technical colleges	2010	DfE	192
Schools/further education	STEM inspiration	2007 – present	BEIS	103
All	National cyber security programme	2013 – present	Cabinet Office	33
Employers	Engineering skills fund	2014	Ex-BIS	30
Schools	Maths hubs	2014 – present	DfE	32
All	National HE STEM programme	2009–2012	Ex-BIS	20
Schools	Triple science support programme	2007–2016	DfE	23
HE	Quantum engineers training fund	2015	Ex-BIS	15
Schools	Further maths support programme	2009 – present	DfE	31
	Stimulating physics network	2009 – 2019	DfE	18
	Science learning partnerships	2004–2019	DfE	12
	Project ENTHUSE	2003–2018	DfE	10
	Core maths support programme	2014–2017	DfE	9
	Isaac physics	2013–2018	DfE	6
	Network of excellence	2012 – present	DfE	6
	Underground mathematics	2012–2017	DfE	5
	CyberFirst courses	2016–2018	DCMS	5
HE	CyberFirst bursary scheme	2015–2020	DCMS	4
				990

Notes

1 These initiatives are additional to routine public funding for STEM learning at all levels.

2 For programmes running for more than one year, the cost shown is the aggregate cost incurred since the inception of the programme, insofar as this can be precisely determined. These costs are expressed in cash terms and have not been adjusted for inflation during the period.

3 The costs shown in this table also include amounts currently committed to key existing initiatives.

4 The cost included for university technical colleges relates to set-up costs only.

5 The engineering skills fund comprised three separate initiatives worth £10 million each, established in response to Professor John Perkins' *Review of Engineering Skills* (November 2013): 'Developing Women Engineers', 'Improving Engineering Careers' and 'Improving Engineering Skills in Smaller Companies'.

6 STEM inspiration activities commenced in the 1990s, but only actual and committed expenditure since 2007 has been included.

7 The cost for the science learning partnerships relates to the 2016-19 contract only.

8 This list was correct as at the end of our fieldwork (September 2017).

9 BEIS = Department for Business, Energy & Industrial Strategy; DCMS = Department for Digital, Culture, Media & Sport; DfE = Department for Education; HEFCE = Higher Education Funding Council for England.

Source: National Audit Office

A levels

3.3 Between them, the Department for Education (DfE) and the Department for Business, Energy & Industrial Strategy (BEIS) oversee a large number of initiatives aimed at improving the take-up and delivery of STEM subjects at school. Further detail about these is set out in Appendix Three. Insofar as they have been carried out, evaluations of these programmes suggest that they have had some positive impacts (**Figure 5**).

Figure 5
Evaluation of school-focused initiatives

Initiative	Summary of evaluation(s) performed
Triple science support programme (TSSP)	The evaluation of the 2014-16 contract found that 90% of schools indicated that the programme helped improve their triple science provision. It enabled schools to provide more high-quality continuing professional development (CPD) and bespoke support to their staff than they otherwise would have, and helped the pace of development of triple science at target schools. Some aspects of the programme, such as the networking support and online resources, were found to be less effective.
Further maths support programme	Providers saw an increase or sustainment of the number of further maths students.
Science learning partnerships	69% of teachers participating in local CPD events reported greater motivation and engagement in lessons among pupils, and 43% noted improved progress in science. Teachers involved in CPD provided by STEM Learning Ltd are also more likely to remain in the profession than those who are not.
Stimulating physics network	The programme performed strongly against the key performance indicators evaluated, with 89% of teachers reporting increased pupil engagement in physics lessons, 96% of heads of science/physics reporting a positive impact on departmental culture and practice, and 62% of mentee teachers identifying a positive impact from their mentor support.
Project ENTHUSE	An evaluation of the ENTHUSE partnership strand found it had a very positive impact, with the majority of school leaders and teachers reporting it had increased pupils' engagement with, and attainment in, STEM subjects, and their awareness of STEM career paths.
STEM inspiration	The STEM ambassadors scheme was found to increase the number of young people who pursue STEM study post-16, and who go into STEM careers. Participants on CREST Silver Awards are more likely to take a STEM subject post-GCSE compared with the wider pupil population, but are self-selecting and tend to come from a more privileged socio-economic background and have stronger prior educational attainment.
Network of excellence	The evaluation noted the difficulty of precisely measuring the impact of the programme, but anecdotal evidence indicated elements of the programme, such as 'master teachers', were found to be very helpful for computer science teachers. CPD activities took place after school hours so some teachers struggled to engage with them, and it was found that the programme could not meet the needs of all schools.

Note

1 The TSSP merged with science learning partnerships in 2016.

Source: National Audit Office

STEM A level trends

3.4 STEM A level examination entries increased from 252,000 in 2011/12 to 259,000 in 2016/17, a 3% rise against a 4.8% fall in entries overall.[32] Provisional data indicate that participation in STEM subjects accounted for 34.9% of all A level entries in 2016/17 (up from 32.3% in 2011/12), having grown by 2.6% compared with the previous year following three years of faltering growth, although this masks persistent problems in some areas.

3.5 In 2016/17 physics, which is seen as a requirement for many STEM careers, grew particularly strongly after two years of decline in absolute and proportional terms (**Figure 6**). Biology and chemistry followed a similar pattern, but remain below 2013/14 levels in both absolute and proportional terms. In terms of attainment, outcomes in STEM subjects in 2016/17 were better than in non-STEM subjects. STEM subjects saw an average point score (APS) of 36.5, compared with an APS of 35.7 across all subjects.[33]

3.6 There is a consistent gender participation gap in most STEM subjects. In 2016/17, females made up 42% of all STEM A level examination entries, including just 9.4% of entries in computing, 21.2% in physics (Figure 6) and 39% in mathematics. Conversely, females made up 61.8% of A level biology entries. In terms of outcomes, females regularly outperform males in many STEM subjects and results overall are very similar. Female students had an APS of 36.3 in STEM subjects in 2016/17, compared with 36.6 for male students. This participation gap shows that young women represent a pool of potential STEM-skilled people that is currently being lost to the economy.

STEM teaching workforce

3.7 DfE has sought to improve the STEM teaching workforce and give STEM subjects more importance in the curriculum, but the challenges in these areas are considerable. Our 2016 report *Training new teachers* found that some STEM subjects suffer from acute teacher shortages.[34] For example, it found that the proportion of physics classes taught by a teacher without a relevant post A level qualification rose from 21% to 28% between 2010 and 2014, and that the leaving rates for mathematics and science teachers were above average. DfE offers increased payments to trainee teachers in a range of high-demand subjects. For 2018/19 DfE is offering up to £28,000 of additional funding for trainee teachers in physics, chemistry and computing, and up to £26,000 for trainees in biology. It has also introduced a total payment of up to £32,000 to mathematics trainees, consisting of training scholarships of up to £22,000 (or bursaries of £20,000) and a total of £10,000 in retention payments if they remain in teaching for 5 years post-qualification.

32 The A levels we have classified as STEM are: mathematics, further mathematics, biology, chemistry, physics, ICT, computing, other science and design and technology (D&T). The DfE definition of STEM A levels excludes ICT, other science and D&T on the grounds that these are neither 'facilitating subjects' as defined by the Russell Group (*Informed choices: a Russell Group guide to making decisions about post-16 education*, 2016), nor part of the English Baccalaureate qualification. The subjects DfE classifies as STEM performed especially strongly over the period, growing by 12.9% between 2011/12 and 2016/17, and 9.8% between 2015/16 and 2016/17. 2016/17 data are provisional and subject to change.

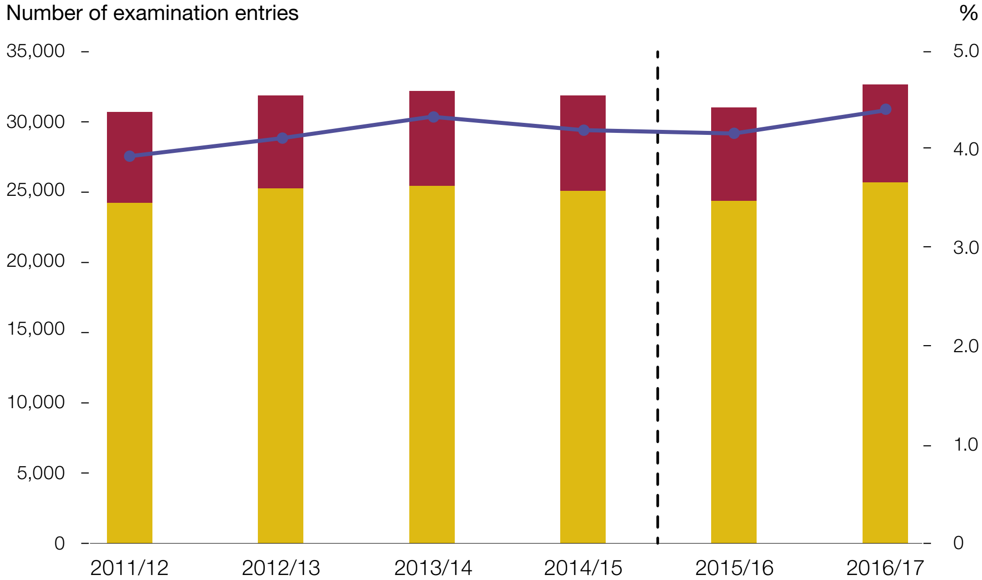
33 Average point score (APS) assigns a numerical value to each grade achieved, with an A* worth 60 points and an E worth 10 points. The APS for a group of subjects is calculated by totalling the score for each grade achieved and dividing by the number of examination entrants in those subjects.

34 Comptroller and Auditor General, *Training new teachers*, Session 2015-16, HC 798, National Audit Office, February 2016.

Figure 6

Trends in A level physics entries from 2011/12 to 2016/17 (provisional), by gender

Females typically make up only around a fifth of all entries in A level physics



	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Females	6,452	6,596	6,736	6,811	6,652	6,947
Males	24,297	25,312	25,490	25,113	24,396	25,750
Physics as a percentage of total A level entries	3.9	4.1	4.3	4.2	4.2	4.4

Note

1 The collection methodology changed slightly between 2014/15 and 2015/16, with a new data source being introduced. The impact of this change appears to be very small: when applied retroactively to 2014/15, for example, the total number of A level entries fell from 758,625 (using the previous methodology) to 758,565, but we have shown this change in methodology in the graph with the vertical dashed line.

Source: National Audit Office analysis of data gathered by the Department for Education

Apprenticeships and further education

3.8 The number of starts in STEM apprenticeships grew from 95,000 in 2012/13 to 112,000 in 2016/17, an increase of around 18%, when they accounted for 22.6% of all starts (compared to 18.5% in 2012/13).[35] This was mainly driven by growth in apprenticeships covering: engineering and manufacturing technologies; and construction, planning and the built environment. Starts in other STEM areas performed less well (**Figure 7**). However, there is a clear gender disparity, with females making up around 8% of STEM apprenticeship starts in 2016/17 despite representing over 50% of apprenticeship starts in total.

3.9 Our 2016 report on apprenticeships found that ongoing reforms to the apprenticeship system, such as the introduction of new standards, had been welcomed by employers. But many employers, particularly small and medium-sized enterprises, struggle to engage with the design process due to the resources required. Data suggest that while the overall number of apprenticeship starts fell by 2.8% in 2016/17 compared with 2015/16, the number of starts on higher apprenticeships rose from 27,000 to 37,000 over the same period, a 34.8% increase.

3.10 Some further education providers have reported difficulties accessing capital funding under the new funding system led by Local Enterprise Partnerships (LEPs), and are therefore disincentivised from taking on the financial risk involved in running costly STEM courses. Since 2015, responsibility for distributing DfE capital grant funding has been entirely devolved to LEPs, who distribute it on a competitive basis according to the priorities set out in their strategic economic plans. Some providers have faced difficulties accessing this funding, relying instead on cash reserves and private loans to finance investment in STEM facilities. Providers therefore need to take a strategic approach to educational provision in each area, in conjunction with stakeholders such as LEPs, local authorities and other providers, to ensure they realise maximum value from any investment. The recent area reviews of post-16 education and training, which focused on aligning provision locally, may help foster this coordination.

3.11 Other challenges in the provision of STEM training in further education include:

- funding following the pupil, so schools are financially disincentivised from encouraging pupils to opt for further education routes;
- the patchy nature of careers advice and work experience available at schools, which makes it more difficult for pupils to understand the full range of options open to them;[36] and
- providers struggling to offer some courses due to the absence locally of sufficient numbers of students and/or employers to make courses financially viable.

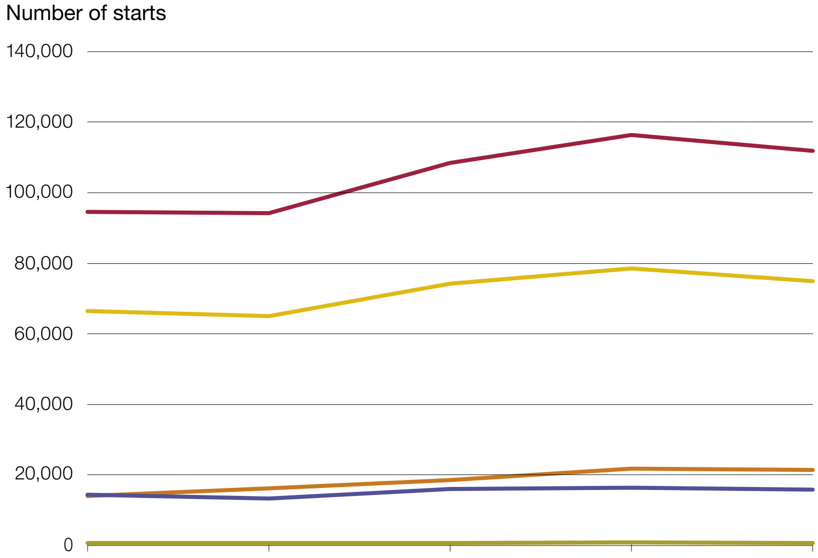
35 The four sector subject areas we have identified as STEM are: construction, planning and the built environment; engineering and manufacturing technologies; information and communication technology; and science and mathematics.

36 House of Commons Sub-Committee on Education, Skills and the Economy, *Careers education, information advice and guidance*, Session 2016-17, HC 205, July 2016. This report states that although schools have a statutory duty to provide independent careers guidance to pupils in years 8 to 13, in practice the guidance available is 'patchy and often inadequate'. The Department for Education published a new careers strategy in December 2017 containing a range of measures designed to improve the careers advice available to young people, but it is too early at this stage to determine what impact this will have.

Figure 7

STEM apprenticeship starts, 2012/13 to 2016/17

Starts grew overall between 2012/13 and 2016/17, but have declined over the past year



	2012/13	2013/14	2014/15	2015/16	2016/17
Total STEM	94,600	94,140	108,400	116,460	111,850
Engineering and manufacturing technologies	66,410	64,830	74,060	78,480	74,860
Construction, planning and the built environment	13,740	15,880	18,290	21,450	21,210
ICT	14,130	13,070	15,660	16,030	15,480
Science and maths	320	360	390	500	300

Notes

1 The sector subject areas identified as STEM are in line with those awarded STEM top-up funding by the Education and Skills Funding Agency.

2 All numbers are rounded to the nearest 10.

Source: National Audit Office analysis of Department for Education data

3.12 The industrial strategy green paper also pointed out that non-apprenticeship further education consists of a "bewilderingly complex array" of qualifications, including BTECs, diplomas, awards and certificates, delivered by a variety of provider types.[37] The number of qualification types available, and the lack of clear pathways through them, makes it difficult for learners, providers and employers to navigate and understand. The number of non-apprenticeship learning aims studied by learners at level 3 and above (excluding A levels) remained at around 110,000 between 2011/12 and 2015/16.[38]

37 HM Government, *Building our Industrial Strategy*, January 2017.

38 These figures are derived from the 'National Aims Report', as published by DfE in December 2016. This report lists all 'learning aims' (individual courses that are often combined to form different qualifications), and shows the number of learners enrolled on each by academic year. Individual learners can study multiple aims each year (e.g. as part of a qualification made up of multiple aims), so can be counted multiple times in the report. Also, the report excludes aims in years where there are fewer than 100 enrolments. The National Aims Report therefore provides an approximate indicator of levels of participation in non-apprenticeship, non A level FE study.

Higher education

STEM funding

3.13 In recent years, DfE has sought to change the higher education sector through reforms to funding and the abolition of the cap on student numbers. Funding reform means that institutions are now reliant on tuition fees for the majority of their student-related income, and the amount that the Higher Education Funding Council for England (HEFCE) allocates for teaching fell from around £4.3 billion in 2011/12 to around £1.3 billion in 2017/18.

3.14 HEFCE funding for each institution is based on measures including the number and characteristics of students and the subjects studied, recognising that STEM subjects typically involve higher delivery costs. The abolition of caps on student numbers gives institutions control over the number of places they offer. These reforms aim to make the system more demand-led, incentivising institutions to structure their mix of courses, and the number of places offered, to match demand from prospective students.[39]

3.15 HEFCE supports provision of some high-cost STEM subjects that have historically struggled to remain financially viable. Its 'very high-cost STEM funding' targets four subject areas: chemical engineering; chemistry; mineral, metallurgy and materials engineering; and physics. The funding began in 2007 when student demand for these subjects appeared to be in decline, and some departments faced closure. In 2016/17, HEFCE awarded around £24 million to 51 institutions on condition that they continue to maintain taught programmes in these very high-cost subjects. HEFCE also provides a high-cost subject top-up to institutions to offset the costs in excess of the £9,000 tuition fee associated with high-cost subjects, which includes most STEM subjects.[40] Between 2012/13 and 2015/16, the total amount paid to institutions under the high-cost subject top-up was around £1.5 billion.

3.16 In 2015/16, HEFCE also awarded around £200 million of capital funding to provide new or upgraded STEM teaching facilities to support the expansion of student numbers, including meeting increased demand from STEM graduates. This funding was allocated on the basis of a competition and match-funded by recipients, and is expected to increase student numbers on STEM courses by 10%.

39 The new Teaching Excellence Framework reinforces institutions' accountability to students for the quality of the educational experience offered, including the design and range of courses.
40 Mathematics is the only STEM subject not included in the high-cost subject top-up.

Undergraduate numbers in STEM subjects

3.17 Undergraduate enrolments in STEM subjects represent just under a third of enrolments in all subjects. Overall numbers fell slightly from around 448,000 in 2011/12 to 442,000 in 2015/16 (a 1.3% fall), against a 12.4% decline in overall enrolments across the same period, but this masks very different trends for full-time and part-time courses. Enrolments on full-time STEM courses grew by 24,000 (6.9%) against an overall rise of 13,000 (1.1%), while on part-time they fell by 30,000 (30.9%) against an overall fall of 214,000 (47%, **Figure 8** overleaf). Where there has been growth this appears to reinforce rather than address reported skills mismatches.

3.18 The highest growth has been in biological sciences, which may already have a surfeit of graduates, whereas enrolments in subjects where employer demand is higher, like engineering and technology or physical sciences, have either grown by less or fallen. Overall, students studying STEM subjects achieve higher grades than those in non-STEM subjects: in 2015/16, 92.4% of STEM students achieved at least a lower second-class degree, compared with 90.7% of non-STEM students, and 27.4% of STEM students achieved a first class degree, compared with 20.9% of non-STEM students.[41]

3.19 As with other stages of the pipeline, there is also a marked gender disparity in higher education, which reflects the pattern set down at A level. Gender breakdowns are only available for UK-wide figures, which show that in 2015/16 female students made up 38.3% of undergraduate STEM enrolments, despite accounting for 56.4% of enrolments overall. They predominate in biological sciences (61.2% in 2015/16), but are in the minority in most other STEM subjects, including in engineering and technology (14.9%) and mathematics (37.7%).

3.20 Large numbers of people leaving STEM courses do not progress to work in STEM occupations, particularly from higher education. Longitudinal research by the Higher Education Statistics Agency (HESA) indicates that, of the 75,000 people graduating in 2015/16 from full-time STEM degree courses, only just over 18,000 (24.2%) were known to be working in a STEM occupation within six months.[42] Some of the remainder, including the 15,000 (19.9%) whose destinations are unknown and the 13,000 (17.6%) going on to further study, may end up in STEM occupations. In early 2017, HESA began work to improve its data collection methodology, which will include delaying data collection until 12–18 months after graduation to take account of the lead-time for new graduates entering sustained employment. This improved data should become available from 2020, providing DfE with better information about the transition rates of STEM graduates into STEM occupations, and enabling it to do more to understand why the proportion of STEM graduates entering STEM occupations is so low, and what can be done to improve the situation.

41 Higher Education Statistics Agency data, showing first degree classes awarded on an FTE basis by English institutions.
42 National Audit Office analysis of Higher Education Statistics Agency data. If calculated as a percentage of only the 60,000 STEM graduates with *known* destinations, the figure rises to 30.2%. See Appendix Two for more information on how we calculated this figure.

Figure 8

Undergraduate STEM subject enrolments in England, 2011/12 to 2015/16

Trends in part-time enrolments are very different from trends in full-time enrolments

Subject area	2011/12 enrolments	2015/16 enrolments	Change (%)
Full-time			
Biological sciences	109,240	124,490	14.0
Veterinary sciences	3,325	3,815	14.7
Agriculture and related subjects	10,485	9,525	-9.2
Physical sciences	50,425	54,445	8.0
Mathematical sciences	24,910	26,405	6.0
Computer science	49,480	51,900	4.9
Engineering and technology	76,360	81,700	7.0
Architecture, building and planning	25,360	21,600	-14.8
Full-time total	**349,585**	**373,880**	**6.9**
Part-time			
Biological sciences	29,135	22,105	-24.1
Veterinary sciences	55	55	0.0
Agriculture and related subjects	5,170	3,260	-36.9
Physical sciences	11,455	5,530	-51.7
Mathematical sciences	8,060	4,580	-43.2
Computer science	13,990	10,520	-24.8
Engineering and technology	20,275	15,810	-22.0
Architecture, building and planning	9,790	5,805	-40.7
Part-time total	**97,930**	**67,665**	**-30.9**

Note

1 Numbers are rounded to the nearest 5.

Source: National Audit Office analysis of Higher Education Statistics Agency data

3.21 An independent evaluation of the 3-year, £20 million National Higher Education STEM Programme, which sought to enhance the recruitment and development of chemistry, engineering, mathematics and physics students, found it had met its aims overall, and noted that it coincided with a growth in participation in these subjects. However, it could not determine the impact of individual initiatives, or evidence any impact on the institutional culture at universities. The Department for Digital, Culture, Media & Sport-led CyberFirst bursary scheme offered a £4,000 bursary and work placements to students studying cyber security as a degree or degree apprenticeship, but the impact of this scheme is unclear at this point.

Lifelong learning

3.22 Overall participation in lifelong learning has fallen since 2011 (**Figure 9** overleaf), placing greater pressure on the education system to meet demand for STEM skills. Lifelong learning comprises in-work training (either formal or informal), apprenticeships and part-time learning. It enables people to transition into STEM occupations, progress within them, or maintain the skill levels required to keep pace with rapidly evolving STEM workplaces.[43] While STEM apprenticeship starts by people aged 25 and above have seen a slight increase since 2011/12, enrolments in part-time undergraduate STEM degrees fell from around 98,000 in 2011/12 to just over 67,500 in 2015/16, a 30.9% fall (Figure 8). This collapse in part-time STEM degree enrolments is part of an overall decline in part-time degree enrolments, which fell by 47% overall. Meanwhile, a 2015 report by the Department for Business, Innovation & Skills found that spending on in-work training by employers fell by £2.5 billion between 2011 and 2013, a 17% reduction per employee.[44]

Diversity

3.23 There is some evidence to indicate a participation gap on the basis of characteristics other than gender, including ethnicity and socio-economic background, at every stage of the post-16 education pipeline. The incidence and significance of these gaps are difficult to measure with precision due to there being less high-quality data and analysis available than for gender, but the quality of the available data is improving.[45] More detailed analysis has been done for some specific sectors. The 2016 Royal Academy of Engineering report *Employment outcomes of engineering graduates*, for example, identified consistently higher unemployment rates among black and minority ethnic engineering graduates than comparable white graduates, and also found that younger graduates do better in terms of entry to full-time employment than older graduates. There are also clear regional variations in levels of engagement with STEM learing and work, which relate closely to differences in the representation of other characteristics, such as socio-economic background. The November 2017 industrial strategy policy paper acknowledged the “significant regional variation” in the uptake of STEM subjects, and emphasised the need to tackle it effectively.[46]

43 In 2015/16, 86.8% of enrolments on part-time undergraduate STEM degrees in the UK were by people aged 21 and over, and 43.5% were by people aged 30 and over. A decline in those acquiring STEM skills via lifelong learning routes also has a negative impact on social mobility, due to the higher levels of remuneration commanded by STEM qualifications and skills.

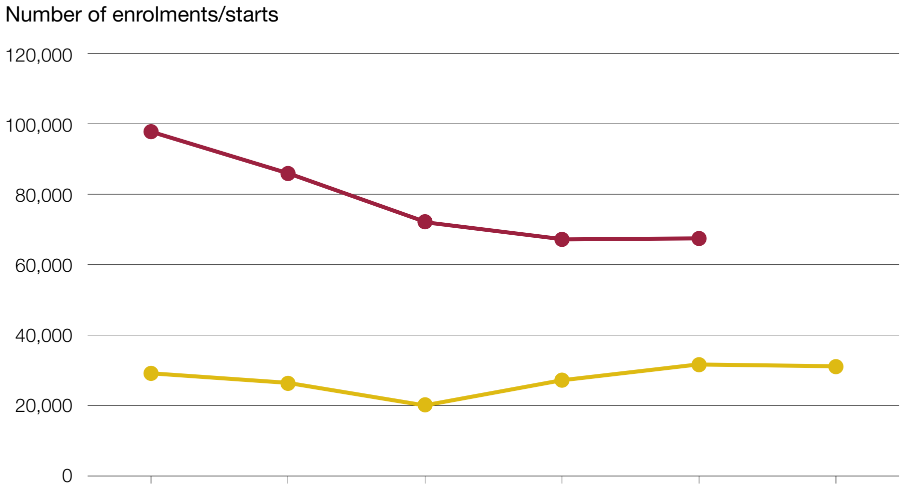
44 Department for Business, Innovation & Skills, *A dual mandate for adult vocational education*, March 2015. This analysis covers all employer training, so includes both STEM and non-STEM training.

45 Publicly available data on A level, apprenticeship and higher education entry and achievement rates (as published by DfE) now include characteristics such as age and ethnicity, but the data remain less detailed and extensive than those available for gender.

46 HM Government, *Industrial Strategy: Building a Britain fit for the future*, November 2017.

Figure 9
STEM lifelong learning in England, 2011/12 to 2016/17

Participation in STEM lifelong learning fell between 2011/12 and 2015/16



	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
● Enrolments in part-time STEM degrees	97,930	86,070	72,265	67,425	67,665	
● STEM apprenticeship starts by people aged 25+	29,220	26,500	20,100	27,170	31,660	31,200

Notes

1 The data available on part-time STEM degree enrolments only go up to 2015/16.

2 Part-time STEM degree numbers are rounded to the nearest 5. STEM apprenticeship start numbers are rounded to the nearest 10.

Source: National Audit Office analysis of DfE data

Part Four

The latest initiatives to enhance the development of STEM skills

4.1 This part examines:

- the nature of a range of new and proposed initiatives designed to enhance STEM skills; and
- the opportunities and risks that these initiatives present, in further education, apprenticeships, schools and higher education.

New and proposed initiatives

4.2 Government recognises that further action is necessary in order to maintain or improve the development of STEM skills, and the departments involved are in the process of developing and launching a number of new initiatives aimed at all main stages of the pipeline (**Figure 10** overleaf).

Further education

T levels

4.3 Technical levels (T levels) are designed to improve vocational education by standardising qualifications, aligning syllabuses with employer demand, and establishing 15 clear 'routes' into careers. Some routes will be clearly STEM-related, while others will contain some STEM elements (**Figure 11** on page 37), and the plan is for all 15 routes to include coverage of core mathematics, English and digital skills. Each route is expected to involve a mandatory three-month industry placement. While this is likely to enhance students' work-readiness, success will depend on employers' participation. T levels will also need to earn the recognition and trust of employers, parents and prospective students, through effective promotion and careers advice.[47]

47 *Careers strategy: making the most of everyone's skills and talents* was published by the Department for Education in December 2017. It set out a number of measures aimed at improving the careers information available about STEM options by the end of 2020, including: updating statutory guidance to include more 'STEM encounters' with employers and apprenticeships; targeting interventions at low-uptake areas; and developing a 'what works' toolkit to help providers improve their careers advice on offer.

Figure 10

Key early-stage and proposed STEM initiatives

Level	Initiative	When	Department responsible	Total funding (£m)
Further education (FE)	T levels	2020	DfE	500 (per annum)
FE/Higher education (HE)	Institutes of technology	2019	DfE	170
HE	1,000 new PhDs (85% in STEM subjects)	2017–21	BEIS	90
FE/HE	National colleges	2017	DfE	80
Schools	Maths and physics teacher supply package	2015–20	DfE	67
Lifelong learning	National retraining scheme	2018–21	DfE	64
Schools	Maths mastery	2016–20	DfE	42
HE	Institute of Coding	2017	DfE	20
Schools	Cyber schools programme	2017–21	DCMS	20
FE/Schools	Level 3 maths support programme	2018–20	DfE	16
HE	New Model in Technology and Engineering	2020	DfE	15
	Engineering conversion course scheme	2017	DfE	2 (pilot)
	Retraining in cyber security master's	2017	DCMS	1 (pilot)

Notes

1 These initiatives are in addition to routine public funding for STEM learning at all levels.

2 The cost of institutes of technology relates to set-up costs only.

3 The cost of maths mastery includes the Shanghai maths teacher exchange.

4 This table only shows key early-stage and proposed initiatives. Some existing initiatives will also continue to receive funding. Future amounts currently committed to these programmes are included in the amounts presented in Figure 4.

5 The information contained in this table was correct as at the end of our fieldwork (September 2017).

6 BEIS = Department for Business, Energy & Industrial Strategy; DCMS = Department for Digital, Culture, Media & Sport; DfE = Department for Education.

Source: National Audit Office

4.4 In May 2016, the then Department for Business, Innovation & Skills announced an £80 million national colleges programme, aimed at developing higher (levels 4 to 6) skills in five areas of high strategic demand: high-speed rail; nuclear; onshore oil and gas; digital; and creative and cultural. The first four of these are STEM sectors experiencing spikes in skills demand associated with specific infrastructure projects or industrial expansion. The business case for each college is supported by detailed projections of the supply and demand for skills in each sector, so they are well-targeted at areas of need. As these are brand new institutions, it is too early to judge their likely impact on skills or the extent to which this model could be applied in other sectors.

Figure 11
T level routes

Route	Classification
Agriculture, environmental and animal care	Some STEM
Business and administrative	Non-STEM
Catering and hospitality	Non-STEM
Childcare and education	Non-STEM
Construction	STEM
Creative and design	Non-STEM
Digital	STEM
Engineering and manufacturing	STEM
Hair and beauty	Non-STEM
Health and science	Some STEM
Legal, finance and accounting	Some STEM
Protective services	Non-STEM
Sales, marketing and procurement	Non-STEM
Social care	Non-STEM
Transport and logistics	Some STEM

Source: National Audit Office

Institutes of technology

4.5 The November 2017 industrial strategy policy paper restated a proposal for institutes of technology (IoTs), targeting skills gaps at levels 4 and upwards, particularly in STEM areas. These will be regional institutions set up through partnerships between local employers and education providers. Involvement of employers from the outset should help them align provision with local skills needs, and IoT status will be awarded competitively. However, recent plans to link the IoTs to universities has caused concern about whether they are further education or higher education providers. As new institutions being introduced into an already crowded provider marketplace, there is a risk they will fail to establish themselves in the education landscape.[48] The Department for Education (DfE) intends to review the sensitivity of each IoT bidder's business model to learner numbers, which may mitigate the risk of attracting insufficient learners. The involvement of existing providers in setting up and running IoTs may further mitigate the risk of their not finding their place in the landscape.

48 This was the case with university technical colleges many of which have failed to establish their position in the educational landscape and so have struggled to attract enough students.

Apprenticeships

4.6 Implementation of new employer-led apprenticeship standards is continuing. As at May 2017, around half of the 177 standards approved appeared to be in STEM areas, but DfE had not categorised them on this basis. The standards are designed, funded, delivered and assessed by employers, and in April 2017 the employer-led Institute for Apprenticeships became responsible for managing the quality of apprenticeships. While reforms to apprenticeships were generally welcomed by sector representatives we spoke to, standards take around a year to develop, and smaller employers may lack the capacity to engage in this process.

4.7 The new system of apprenticeships is funded by the apprenticeship levy, which came into effect in April 2017. Obliging large employers to finance the apprenticeships system is intended to encourage greater use of apprentices. However, the upper funding limit of £27,000 may not cover the cost of all STEM apprenticeships. At present it is unclear how employers are likely to react to the levy arrangements in the longer term.

Schools

4.8 In 2015, DfE launched the maths and physics teacher supply package, a £67 million programme to recruit an additional 2,500 teachers, and to improve the skills of 15,000 non-specialist teachers in these subjects.[49] Early stage research on this initiative shows some positive results, although a recent National Audit Office report also found that the return-to-teaching initiatives' first pilot recruited 428 returning teachers, just over half of its target of 810; of these, 330 completed the training provided.[50,51] The overall target is a challenging one, and the upskilling approach may not address the shortage of specialist teachers in these subjects.

4.9 DfE is also building on existing mathematics-focused interventions with £55 million of investment in maths hubs. This includes around £42 million for developing 'maths mastery' teaching in primary schools, assisted by a teacher exchange programme with schools in Shanghai. The £16 million level 3 maths support programme, which was launched in response to Adrian Smith's 2017 review of post-16 maths, is intended to combine the remits of the core and further maths support programmes and boost participation in level 3 maths, but the precise activities are yet to be confirmed.[52]

49 The package contains eight strands, including: paid internships for undergraduates in their penultimate year; return-to-teaching initiatives to attract former teachers back to the workforce; 'Maths and Physics Chairs', aimed at attracting post-doctoral researchers into teaching; and 'Teacher Subject-Specialism Training', which aims to improve the skills of non-specialist teachers in mathematics and physics.

50 Department for Education and National College for Teaching & Leadership, *Maths and physics teacher supply package*, Research report, March 2017.

51 Comptroller and Auditor General, *Retaining and developing the teaching workforce*, Session 2017-19, HC 307, National Audit Office, September 2017.

52 Department for Education, *Report of Professor Sir Adrian Smith's review of post-16 mathematics*, July 2017.

4.10 Other departments also have responsibility for school-focused programmes. The Department for Digital, Culture, Media & Sport (DCMS), for example, is responsible for the forthcoming cyber schools programme, a four-year extracurricular course aimed at equipping 5,700 14- to 18-year-olds with cyber security skills between 2017 and 2021. The National Cyber Security Council's CyberFirst scheme also offers grants of up to £4,000 for up to 1,000 students to study for a degree, do a placement or attend a summer school in the cyber security field.

Higher education

4.11 Fewer initiatives have been targeted at higher education, in line with the general consensus that there is no particular shortage of skills at this level. From early 2017, DfE was piloting a conversion course scheme to enable graduates to retrain in engineering and computer science. DCMS has also committed £500,000 to fund bursaries for adults wishing to retrain in a GCHQ-accredited master's degree. High-level STEM skills have been targeted by the announcement of a Department for Business, Energy & Industrial Strategy-led £90 million investment in 1,000 new PhD places, of which around 85% will be in STEM areas, and 40% will aim to boost collaboration between industry and academia. If successful, improving these links would help to align the skills learned in STEM qualifications with the requirements of the workplace.

4.12 The proposed Institute of Coding faces a challenge in establishing its place in the skills landscape. The Institute is due to receive £20 million of funding from government and matched funding from industry, and will aim to improve digital skills provision at levels 6 and 7. It will target a skills gap in digital skills, and involves collaboration between education providers and industry. However, there have been concerns from within the sector about its strategic fit within the digital skills landscape, particularly as it risks occupying a similar strategic position to the existing Alan Turing Institute, run by a collaboration of universities and a research council.

4.13 DfE's intention to close the gap between higher education and the needs of industry is also reflected in its support (up to £15 million over three years) for the forthcoming New Model in Technology & Engineering (NMiTE), a STEM-focused institution due to take its first full cohort of students in 2020. NMiTE will use an employer-centred curriculum, innovative learning methods and gender-balanced admissions to overcome barriers that prevent enough STEM undergraduates from developing the right skills. The creation of NMiTE seeks to address known problems in this sector but, as with new institutions in further education, its key challenges will be to establish itself and achieve financial viability.

Lifelong learning

4.14 The industrial strategy policy paper also contains proposals for initiatives aimed at boosting lifelong learning, many of which are targeted at STEM areas. The policy paper reaffirms the intention set out in the 2017 spring budget to spend £40 million on developing innovative approaches to helping adults up-skill and re-skill. It also sets out the new national retraining scheme, which aims to help adults re-skill in areas of need, and sets out an initial commitment of £64 million to develop skills in innovative digital and construction sectors.

Appendix One

Our audit approach

1 Our study is intended to evaluate current and past approaches to developing STEM skills in those aged over 16 in England, and to inform STEM skills policy going forward. The report evaluates three main areas:

- government's understanding of the need for enhanced STEM skills in the workforce;
- what the performance of the education pipeline shows about the effectiveness of past initiatives in delivering STEM skills; and
- the opportunities and risks associated with the latest initiatives to enhance the development of STEM skills.

2 We applied an analytical framework with evaluative criteria to consider what arrangements would be optimal in terms of the value achieved from the efforts being made to enhance STEM skills. By 'optimal', we mean the most desirable possible while acknowledging relevant restrictions or constraints.

3 Our audit approach is summarised in **Figure 12** overleaf. Our evidence base is described in Appendix Two.

Figure 12
Our audit approach

The objective of government

Government aims to enhance STEM skills among the workforce. Responsibility is spread across government departments. The Department for Education (DfE) is responsible for most interventions. The Department for Business, Energy & Industrial Strategy (BEIS) has a cross-cutting role, and sets the national framework for science and technology. Some other departments also run STEM-related programmes and initiatives.

How this will be achieved

Between 2007 and 2017, government spent around £990 million on key initiatives to enhance STEM skills. Government has also announced a number of new initiatives aimed at boosting the numbers acquiring STEM skills at all levels, including substantial reforms to technical education. Implementation of significant reforms in apprenticeships, including the introduction of standards and the levy, are ongoing, as are changes to skills funding more widely, which will have an impact. DfE has also announced its intention to create a new research function to assess and manage skills needs in each region of England, to provide authoritative data on skills needs.

Our study

This study examined whether the departments' approach to boosting participation in the STEM education pipeline at all levels is likely to address the STEM skills challenge in a way that achieves value for money.

Our evaluative criteria

Does government have a clear case for intervening to boost STEM skills?

Is government able to intervene in an effective way?

Does government have a clear and appropriate set of interventions?

Our evidence

(see Appendix Two for details)

We examined the robustness of the departments' understanding of the STEM skills shortage by:

- **interviewing** departmental officials and others;
- **reviewing** the literature on the STEM skills gap and STEM definition;
- **estimating the STEM skills shortage** using a combination of ONS and CBI employer survey data; and
- **interviewing and visiting** employers and employer representative bodies.

We reviewed how the departments are set up to take action and how the skills pipeline is currently performing by:

- **interviewing** departmental officials on cross-government working;
- **analysing** publicly available data sources on the numbers participating in the STEM pipeline; and
- **interviewing and visiting** oversight bodies, training providers, employers and stakeholder representative groups.

We evaluated current and proposed interventions by:

- **interviewing** departmental officials and other stakeholders;
- **reviewing previous NAO reports** on initiatives in the education and skills sector; and
- **reviewing** documents relating to existing and proposed interventions.

Our conclusions

DfE and BEIS face a complex challenge to improve the quality of teaching and student take-up in key STEM subjects. Some of their initiatives are achieving positive results but there remains an urgent need for a shared vision of what they are trying to achieve and coordinated plans across government. The absence of a precise understanding of the STEM skills problem means the efforts of DfE and BEIS are not well prioritised and a better targeted approach is needed to demonstrate value for money.

Appendix Two

Our evidence base

1 We reached our independent conclusions on whether the government's approach to delivering the STEM skills needed in the workforce represents value for money after analysing evidence collected between March and September 2017.

2 We used publicly available education and employment data to assess the numbers of students progressing through STEM education to STEM occupations.

3 We **interviewed training providers, stakeholders in education and business and other representative groups, as follows:**

- We conducted semi-structured interviews with the following oversight bodies:
  - Education and Skills Funding Agency;
  - Higher Education Funding Council for England; and
  - Institute for Apprenticeships.
- We conducted semi-structured interviews with the senior leadership team members of the following organisations:
  - Boeing;
  - Cascaid;
  - Larkfleet; and
  - Optimity.
- We visited further education training providers and conducted semi-structured interviews. We selected a diverse group of providers with specialisms in STEM provision. The training providers were:
  - Dudley College of Technology;
  - National College for High Speed Rail;
  - National STEM Learning Centre; and
  - Nelson and Colne College.

- We conducted semi-structured interviews with higher education stakeholder representatives, including academics specialising in education and skills:
  - King's College London;
  - Loughborough University;
  - Newcastle University;
  - UCL Institute of Education;
  - University of Derby;
  - University of Oxford;
  - University of Sheffield; and
  - University of Warwick.
- We conducted semi-structured interviews with other stakeholder representative groups:
  - Association of Colleges;
  - Association of Employment and Learning Providers;
  - Cogent Skills;
  - Confederation of British Industry;
  - EEF – the Manufacturers' Organisation;
  - EngineeringUK;
  - Federation of Small Businesses;
  - Gatsby Charitable Foundation;
  - Learning and Work Institute;
  - Royal Academy of Engineering;
  - Royal Society;
  - Trades Union Congress; and
  - University Alliance.

4 To estimate the size of the current and expected STEM staff recruitment shortage:

- We **identified sources of data and information** on the STEM skills gap, to ascertain the percentage of employers reporting current and future difficulties recruiting people with STEM qualifications and skills. We selected the Confederation of British Industry (CBI) education and skills survey 2015 as the most appropriate source of intelligence for this analysis. This survey organises the employers reporting difficulties by number of employees, to show the proportion of employers in each of the following groups reporting difficulties:
  - 0–49 employees
  - 50–249 employees
  - 250–4,999 employees
  - 5,000+ employees.

  The CBI survey also analyses these results by the level of STEM-qualified employee for which recruitment difficulties were reported.
- We **identified sources of data** on the numbers of employers in England. We selected the Office for National Statistics' Nomis dataset as the most suitable, and analysed and grouped these data into the same employee number categories.
- We **applied the percentage** of employers reporting difficulties recruiting people with STEM skills to the number of businesses in England, for each business size. To estimate the number of staff members affected in each business we used a figure of 1% of employees (to a minimum of 1). This gave us an estimated current and expected STEM recruitment shortage for each employee type and for each employer size.
- By **adding up the result for each** employer size and employee type we arrived at an estimate for the total current and expected STEM recruitment shortage.

5 To calculate the proportion of 2015/16 STEM graduates progressing into STEM occupations:

- For the purposes of our analysis, we identified the following Standard Occupational Classification (SOC) minor groups (three-digit SOC code) as STEM:

Minor group	Group title
112	Production managers and directors
117	Senior officers in protective services
121	Managers and proprietors in agriculture related services
211	Natural and social science professionals
212	Engineering professionals

Minor group	Group title
213	Information technology and telecommunications professionals
214	Conservation and environment professionals
215	Research and development managers
242	Business, research and administrative professionals
243	Architects, town planners and surveyors
246	Quality and regulatory professionals
311	Science, engineering and production technicians
312	Draughtspersons and related architectural technicians
313	Information technology technicians
351	Transport associate professionals
353	Business, finance and related associate professionals
355	Conservation and environmental associate professionals
511	Agricultural and related trades
521	Metal forming, welding and related trades
522	Metal machining, fitting and instrument making trades
523	Vehicle trades
524	Electrical and electronic trades
525	Skilled metal, electrical and electronic trades supervisors
531	Construction and building trades
532	Building finishing trades
533	Construction and building trades supervisors
811	Process operatives
812	Plant and machine operatives
813	Assemblers and routine operatives
814	Construction operatives
911	Elementary agricultural operations
912	Elementary construction operations
913	Elementary process plant occupations

- This selection is judgemental, and includes all minor groups with a majority of unit groups (four-digit SOC codes) that we determine to be STEM.
- To calculate the proportion of 2015/16 graduates entering STEM occupations, we calculated the number of graduates (from universities in England) in STEM subject areas who were known to be employed in one of these occupational groups within six months (18,220), using HESA's Destination of Leavers from Higher Education (DLHE) data. We then calculated the proportion of all the 75,295 STEM students who graduated in 2015/16 that this represented.
- Our list of STEM occupations is one of many possible taxonomies. There is no universally accepted definition of a STEM job. However, this reflects our understanding of the occupations that are most likely to be labelled as STEM, and is informed by the definitions of STEM by the Royal Society and Women in Science and Engineering (WISE) as referenced in the body of the report.
- This is also just one way of measuring the proportion of graduates going into STEM jobs. Other approaches are possible, such as one based on destination industry rather than (or in addition to) destination occupation.
- There are also limitations to the DLHE data in their current form. They only show outcomes six months after graduation, so many of the graduates not employed in a STEM occupation within this time period may subsequently enter a STEM job. This includes the 17.6% pursuing further study. The destination of 19.9% of graduates is also unknown. A two-year review of DLHE destinations and outcome data was completed in June 2017. This included the recommendation that the survey should take place 12–18 months after graduation, to align it more closely with common expectations regarding transition into a sustained pattern of activity following higher education.

Appendix Three

Key school-focused STEM initiatives

1 **Figure 13** sets out further detail about the school-focused STEM initiatives presented in Part Three of the report.

Figure 13
Key school-focused STEM initiatives

Initiative	Description
Triple science support programme	This initiative ran continuing professional development (CPD) for teachers, with the aim of supporting schools in the provision of GCSE triple science. Science learning partnerships now carry out this work.
Science learning partnerships	A national network of school-led providers that facilitate and deliver science CPD to schools at a local level, and provide support to schools to improve the take-up of GCSE triple science.
Further maths support programme	This programme provides support for maths and further maths at GCSE, AS and A level, through CPD activities for teachers, and a range of enrichment activities, support and tuition for students.
Core maths support programme	This programme comprised interventions intended to support providers in the promotion and delivery of core maths, including CPD activities for teachers and online teaching resources.
Project ENTHUSE	Partly funded by the Wellcome Trust and industry partners, this provides bursaries for science teachers to undertake CPD provided through the National STEM Learning Centre.
Stimulating physics network	This provides support to schools to improve progression to physics A level. It provides targeted support, including tailored CPD and pupil enrichment activities to qualified and trainee teachers, and activities specifically to increase the proportion of girls taking physics A level.
STEM inspiration programme	This programme aims to increase engagement in STEM subjects and aspiration in STEM careers by young people from primary school up to 19 years of age. It comprises a range of different activities, including the CREST awards, STEM ambassadors scheme, Inspiring science fund, and the polar explorer programme.
CyberFirst	This is made up of a range of residential and non-residential short courses for 11- to 17-year-olds, to introduce them to cyber security and inspire them to pursue it as a career.

Notes

1 The core maths support programme ended in July 2017, and will be replaced by the level 3 maths support programme, which is due to start in April 2018.

2 Core maths, which was launched in September 2014, is the category of level 3 mathematics qualification designed for students who have achieved grade C or above at GCSE but who do not progress to AS or A level mathematics. It is intended to develop mathematical thinking and application beyond GCSE level, and to help prepare students progressing to higher education courses with a distinct mathematical or statistical element, such as psychology.

3 STEM ambassadors is a scheme whereby volunteers from business and academia go into schools to lead STEM curriculum-related activities.

Source: National Audit Office

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