KEY INDICATORS IN STEM EDUCATION

UPDATED 2018

GATSBY

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BY DAVID SAINSBURY
TO REALISE HIS CHARITABLE OBJECTIVES.
WE FOCUS OUR SUPPORT ON A LIMITED
NUMBER OF AREAS:

PLANT SCIENCE RESEARCH
NEUROSCIENCE RESEARCH
SCIENCE AND ENGINEERING EDUCATION
ECONOMIC DEVELOPMENT IN AFRICA
PUBLIC POLICY RESEARCH AND ADVICE
THE ARTS

OUR EDUCATION PROGRAMME FOCUSES
ON STRENGTHENING SCIENCE AND
ENGINEERING SKILLS IN THE UK WORKFORCE
THROUGH A RANGE OF INNOVATIVE
PROGRAMMES AND PARTNERSHIPS.

INTRODUCTION

This is the fourth edition of Key Indicators in STEM Education, bringing together key data relating to Science, Technology, Engineering and Mathematics (STEM) education. It focuses on trends in the numbers of individuals studying STEM subjects at GCSE, A level and undergraduate degree levels. Data comparing uptake of apprenticeships, vocational qualifications and diversity within STEM subjects are also included. We expect this leaflet will be of use to policymakers, members of the STEM education community, employer groups and others involved in discussing policy interventions in this area.

When drawing together data that span many years, some issues of consistency can arise. For example, as the apprenticeship system continues to transition away from 'frameworks' towards 'standards', data on the uptake of both need to be considered in tandem. Notwithstanding such issues, we have satisfied ourselves that the data included in this leaflet fairly represent the major trends in STEM education. We have also identified the source for each dataset used.

GCSEs

While separate GCSEs in Biology, Chemistry and Physics (referred to as 'Triple Science' when all three are sat together) have been available for many years, the majority of the cohort have taken combined science GCSEs, either as a single or double award, or more recently as Core Science, Additional Science and Further Additional Science. In 2016, a new double award Combined Science was introduced, as part of a wave of reforms to curriculum content, assessment and grading.

The most striking trend in the last decade has been the rise in Triple Science, with entries increasing threefold in the decade to 2013. This rise can be traced to government policy announced in 2006, which required all maintained schools to make Triple Science available to their students.

Computing GCSE was reformed for 2014 and is slowly taking the place of what was previously ICT GCSE. However, with only a 7% increase in numbers between 2016 and 2017, other factors such as teacher availability may be affecting uptake of Computing GCSE.

Design and Technology GCSE numbers have dropped by 50% since 2008, in a relatively steady fashion, and with no single factor responsible for its decline.

> DESIGN AND TECHNOLOGY NUMBERS HAVE DROPPED BY 50% SINCE 2008

Year	Triple Science			Computing	Single Science	Double Science	Core Science	Additional Science	Further Science	Maths	Design & Technology
	Biology	Chemistry	Physics								
2007	63,208	59,216	58,391		98,485	478,028	57,316				
2008	85,521	76,656	75,383		4,445	8,433	537,606	433,468		738,451	332,787
2009	100,905	92,246	91,179		3,954	7,594	493,505	396,946		754,738	305,809
2010	129,464	121,988	120,455		4,060	7,497	449,697	352,469		762,792	287,701
2011	147,904	141,724	140,183				405,977	306,312		772,944	253,624
2012	166,168	159,126	157,377				552,504	289,950		675,789	240,704
2013	174,428	166,091	160,735				451,433	283,391		760,170	219,931
2014	141,900	138,238	137,227	16,773			374,961	323,944		736,403	213,629
2015	139,199	133,618	133,610	35,414			395,484	332,960	23,389	761,230	204,788
2016	144,148	141,245	139,805	62,454			408,569	368,033	17,409	757,296	185,279
2017	143,340	141,867	141,977	66,751			295,889	376,347	14,606	770,034	165,815

Table 1: Entries to science, maths and technology GCSEs in the UK (all ages). Source: JCQ

A LEVELS

Recent reforms to A level content do not seem to have had a significant impact on A level entries in the sciences. Maths, Further Maths, Chemistry and Physics all saw increases in the number of entries, whist there was a very small drop in the Biology numbers.

This was the first year that some practical skills in science A levels were assessed using a separate teacher endorsement.

The 99% pass rate (average across Biology, Chemistry and Physics) for this teacher endorsement contrasts with the significant numbers of science students who got less than a C grade in their A level. It must be noted that not all students entered for the A level were also entered for the endorsement.

> MATHS, FURTHER MATHS, CHEMISTRY AND PHYSICS ALL SAW INCREASES IN THE NUMBER OF ENTRIES

Year	Maths	Further Maths	Physics	Chemistry	Biology	Computing	Design & Technology
2007	60,093	7,872	27,466	40,285	54,563	5,610	
2008	64,593	9,091	28,096	41,680	56,010	5,068	
2009	72,475	10,473	29,436	42,491	55,485	4,710	
2010	77,001	11,682	30,976	44,051	57,854	4,065	
2011	82,995	12,287	32,860	48,082	62,041	4,002	18,249
2012	85,714	13,223	34,509	49,234	63,074	3,809	17,105
2013	88,060	13,821	35,569	51,818	63,939	3,758	15,641
2014	88,816	14,028	36,701	53,513	64,070	4,171	13,691
2015	92,711	14,993	36,287	52,644	63,275	5,383	13,240
2016	92,163	15,257	35,344	51,811	62,650	6,242	12,477
2017	95,244	16,172	36,578	52,331	61,908	8,299	12,415

Table 2: Entries to science, maths and technology A levels in the UK. Source: JCQ

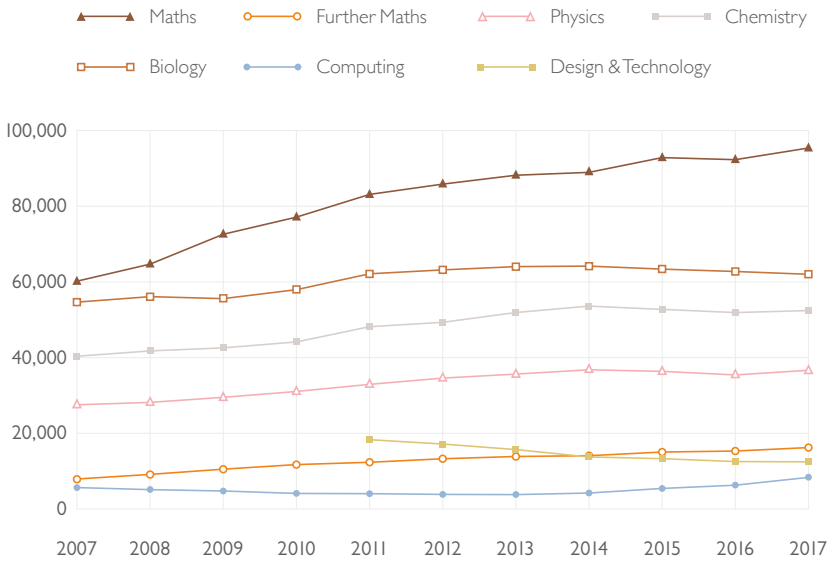

Chart 1: Entries to science, maths and technology A levels in the UK. Source: JCQ

VOCATIONAL QUALIFICATIONS

It is important to understand that there are a very large number of vocational qualifications available to young people and adults at a range of levels. Over the years there has been considerable churn in the qualifications offered and in the way that they have been classified.

Table 3 and Chart 2 show information on the number of certificates issued in England for vocational qualifications and others (e.g. basic skills and functional skills) regulated by Ofqual. The number of certificates has been summed over the four quarters of an academic year. These data do not include Advanced Extension Award, GCSEs, AS or A level qualifications.

Table 3 shows the proportions of learners on vocational qualifications at different levels. Consistently over the years most certificates have been awarded at Level 2 (GCSE grades A*–C equivalent). More certificates have been awarded at or below Level 2 than at or above it, although there have been some welcome increases in the numbers at Level 3 (A level equivalent).

	Percentage of certifications				
	2012/13	2013/14	2014/15	2015/16	2016/17
Entry Level	10.4%	11.4%	12.3%	12.4%	11.8%
Level 1	26.3%	25.2%	23.3%	21.8%	21.1%
Level 1/2	0.7%	2.3%	6.6%	11.6%	10.0%
Level 2	48.2%	45.2%	40.1%	35.5%	36.3%
Level 3	13.0%	14.6%	16.2%	16.9%	18.8%
Level 4	0.8%	0.7%	0.7%	1.0%	1.0%
Level 5	0.4%	0.4%	0.5%	0.6%	0.7%
Level 6+	0.2%	0.2%	0.2%	0.3%	0.3%
Total student numbers	8,500,310	7,972,500	7,564,250	7,151,315	6,508,930

Table 3: Proportion of certificates in vocational qualifications by level in England.
Source: Ofqual Vocational Qualifications Dataset

Chart 2 shows that participation in vocational qualifications has generally declined over time. The subjects of vocational qualifications are classified using Sector Subject Areas (SSAs). Most vocational qualifications have been taken in the SSA "Preparation for Life and Work", the majority of which are at Entry Level and Level 1. These qualifications therefore account for much of the lower level provision shown in Table 3. It must be noted that there are more than 3,400 qualifications in the Preparation for Life and Work SSA.

Beyond this the most popular SSAs are as follows, with the most popular qualification within each SSAs in brackets: Health, Public Services and Care (Level 2 Award in Emergency First Aid at Work); Arts, Media and Publishing (Level 1 Award in Graded Examination in Music Performance); and Languages, Literature and Culture (Level 1 Certificate in English).

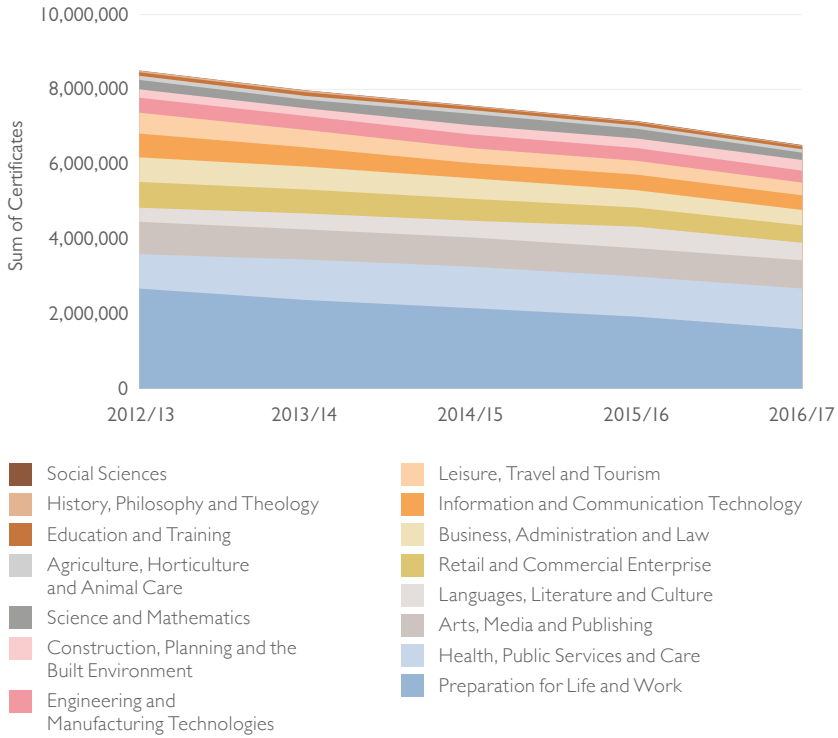

Chart 2: Proportion of certificates in vocational qualifications by Sector Subject Area in England.
Source: Ofqual Vocational Qualifications Dataset

APPRENTICESHIPS

Following the Richard Review of apprenticeships there was a move from apprenticeship 'frameworks', which contained several sector-based qualifications, to 'standards', which are driven by an end-point assessment.

The 2017 data on apprenticeships contain information on people starting apprenticeship frameworks and others starting on apprenticeship standards, making any detailed analysis more complicated.

Nonetheless it is still possible to look at broad trends over the last ten years. The data shown in Table 4, Chart 3 and Chart 4 are based on people starting apprenticeships, not on number of apprenticeship completions.

One of the most significant changes was the huge growth in people over the age of 25 starting apprenticeships in 2010/11. This, and the growth of apprenticeships in the 19–24 range, means that 16–18 year olds now make up only around a quarter of the total number of apprenticeship starts.

> 16–18 YEAR OLDS MAKE UP ONLY AROUND A QUARTER OF THE TOTAL NUMBER OF APPRENTICESHIP STARTS

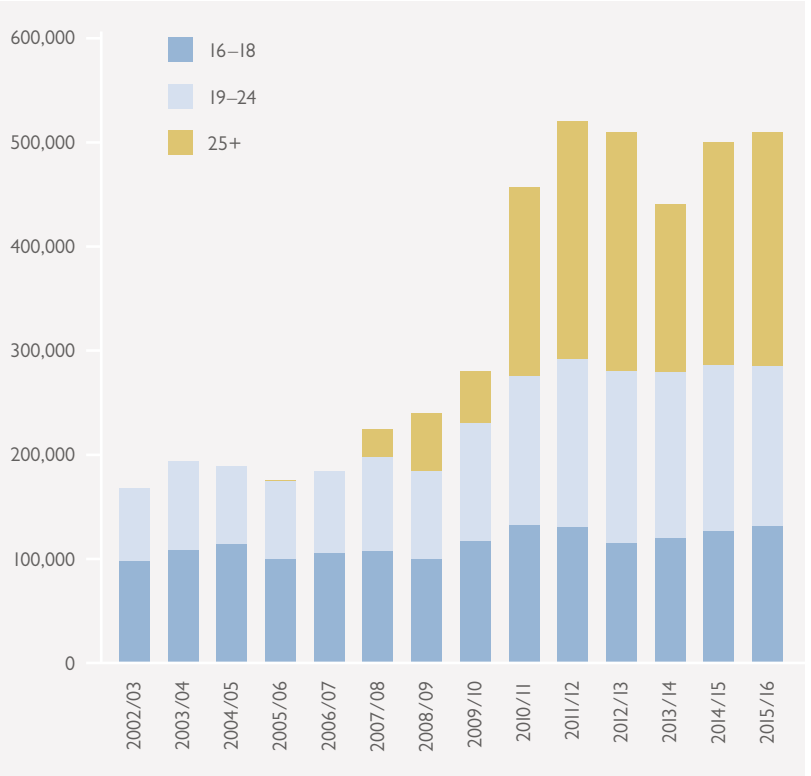

Chart 3: Apprenticeship starts in England by age over time. Source: DFE/ESFA FE data library

The inclusion of adults in the apprenticeship system did not significantly alter the proportion of apprenticeships at each level. In 2006/07 around 70% of apprentices were at Level 2, and in 2011/12, the peak year for starts, the proportion at Level 2 was 63%. In other words, most adult apprenticeships were at Level 2.

Table 4 shows the apprenticeship starts at each level for 2015/16. Level 2 apprenticeships are still in the majority, however there has been growth at the higher levels. There are some early indications that the introduction of the apprenticeship levy and degree apprenticeships may lead to a significant expansion at Level 6+.

	Percentage of apprenticeship starts
Level 2	57%
Level 3	37%
Level 4	2%
Level 5	3%
Level 6+	>1%

Table 4: Apprenticeship starts in England by level in 2015/16. Source: DFE/ESFA FE data library

As with vocational qualifications, apprenticeships are normally classified by Sector Subject Area (SSA). Chart 4 shows the starts by SSA from 2003 to 2016. Four SSAs stand out in terms of the numbers of apprenticeship starts: Business, Administration and Law; Health, Public Services and Care; Retail and Commercial Enterprise; Engineering and Manufacturing Technologies.

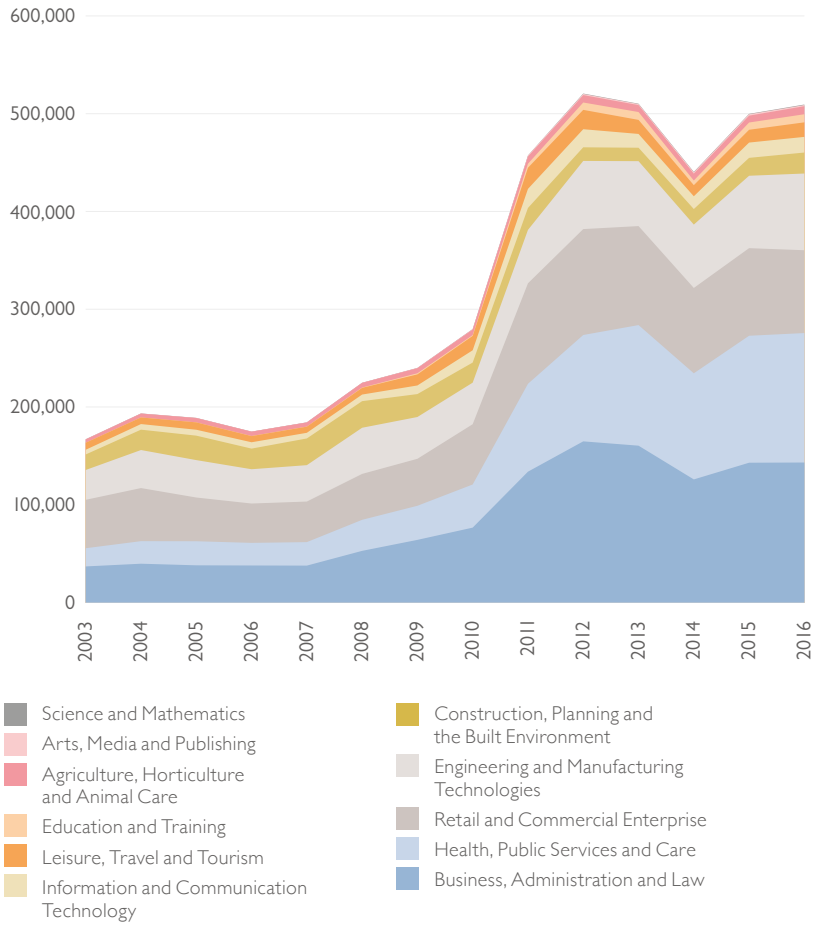

Chart 4: Apprenticeship starts in England by Sector Subject Area over time. Source: DFE/ESFA FE data library

UNDERGRADUATES

Table 6 shows the growth in full-time undergraduate student numbers since 2006/07. STEM subjects account for around 46% of undergraduate numbers and this proportion has remained reasonably steady for many years.

However, while overall undergraduate numbers in STEM subject areas have increased by 20% since 2006/07, this includes a significant growth in the number of non-UK students.

Table 5 shows the number of STEM undergraduates broken down by domicile. UK student numbers in STEM subjects grew 16% since 2006/07, while other EU and non-EU student numbers in STEM subjects grew by 52% and 63%, respectively. The effect on these numbers of the UK's decision to leave the European Union will become clearer in the next few years.

	Domicile	2006/07	2009/10	2012/13	2015/16	% change since 2006/07
STEM subjects	UK	497,290	528,735	548,270	576,110	15.8%
	Other EU	21,125	26,190	29,180	32,015	51.6%
	Non-EU	35,240	43,390	50,760	57,270	62.5%
All subjects	UK	1,071,550	1,160,855	1,180,880	1,212,055	13.1%
	Other EU	52,490	66,090	71,765	77,195	47.1%
	Non-EU	84,630	106,950	133,040	146,165	72.7%
Total	All	1,762,325	1,932,210	2,013,895	2,100,810	19.2%

Table 5: Full-time student enrolments on undergraduate courses (UK HEIs). Source: HESA

	2006/07	2009/10	2012/13	2015/16	% change since 2006/07
Medicine & Dentistry	42,950	45,455	46,230	45,075	4.9%
Subjects allied to Medicine	149,870	148,770	147,615	151,600	1.2%
Biological Sciences	108,830	122,370	139,130	154,760	42.2%
Veterinary Science	3,855	4,355	4,800	5,185	34.5%
Agriculture & related subjects	9,785	11,135	11,690	12,060	23.2%
Physical Sciences	50,765	57,190	63,940	68,550	35.0%
Mathematical Sciences	21,670	26,225	29,600	31,150	43.7%
Computer Science	59,090	58,680	59,600	66,340	12.3%
Engineering & Technology	77,120	89,480	96,360	103,825	34.6%
Architecture, Building & Planning	29,695	34,645	29,235	26,850	-9.6%
Subtotal: STEM subject areas	553,630	598,305	628,200	665,395	20.2%
Subtotal: Non-STEM subject areas	655,015	735,595	757,475	770,020	17.6%
Total: All subject areas	1,208,645	1,333,900	1,385,675	1,435,415	18.8%
STEM as a percentage of all subjects	45.8%	44.9%	45.3%	46.4%	

Table 6: Full-time student enrolments on undergraduate courses (UK HEIs). Source: HESA

TEACHER NUMBERS

A prerequisite for high-quality STEM education and strong progression rates post-16 is the ability of schools and colleges to attract and retain specialist teachers with in-depth knowledge of the subject(s) they are to teach. Table 7 shows the number of secondary school teachers in STEM disciplines recruited in recent years. 2013/14 saw a number of changes to teacher training, including the introduction of School Direct (a school-based teacher training programme), and these changes appear to have affected Physics recruitment in particular.

After many years of under-recruiting Physics specialists into teaching during the 1990s, numbers picked up significantly from 2008/09 to 2012/13, although the government target has never been reached and has fallen significantly short in recent years. The recruitment target continues to grow every year, partly due to school population growth and partly due to more teachers choosing to leave the profession. The Department for Education is attempting to address the shortage by increasing the training bursary available. In 2018/19, training bursaries and scholarships of up to £28,000 are available for Physics, Chemistry and Computing teaching, depending on degree classification and experience. For Biology it is up to £26,000 and for Maths it is up to £22,000 with two additional early career payments totalling £10,000.

Year	Physics	Chemistry	Biology	General Science	Maths	Computing	Design & Technology
2008/09	584	889	1,194	988	2,531		1,297
2009/10	571	963	1,241	924	2,897		1,437
2010/11	656	999	1,097	902	2,797		1,363
2011/12	864	1,305	696	375	2,687		976
2012/13	900	1,170	800	50	2,500		700
2013/14	700	1,080	700		2,230	350	380
2014/15	637	823	845		2,170	519	409
2015/16	740	985	1,058		2,453	504	513
2016/17	851	1,038	1,356		2,605	495	423
2017/18	720	875	1,025		2,450	475	305
Gov't estimate for no. required in 2017/18	1,055	1,053	1,188		3,102	723	917

Table 7: Secondary school teachers recruited in science, maths and technology subjects in England. Source: NCTL census (first published version each year)

Notes

The numbers of teachers recruited by Teach First are included from 2015/16. From 2013/14, general science recruits were included within Biology.

GENDER

At GCSE, STEM subjects are relatively well-balanced in terms of gender, with the exceptions of Computing (80% male) and Design and Technology (61% male). However, post-GCSE there are significant variations in uptake of subjects by gender. Girls account for 50% of the entries to Physics GCSE but only 22% of entries to Physics A level. The total cohort size for Physics A level has increased by almost 30% in the last decade; however, the proportion of girls has remained almost static. Computing continues to be an unpopular subject among girls at A level, where they make up only 10% of entries.

The figures for apprenticeships in Engineering, Information Technology and Construction are stark. In 2015/16 just 2% of Construction starts, 8% of Engineering starts and 16% of ICT starts were girls. Chart 5 shows the gender balance, or lack thereof, across STEM GCSEs, A levels and apprenticeships.

> THE FIGURES FOR APPRENTICESHIPS IN ENGINEERING, INFORMATION TECHNOLOGY AND CONSTRUCTION ARE STARK. IN 2015/16 JUST 2% OF CONSTRUCTION STARTS, 8% OF ENGINEERING STARTS AND 16% OF ICT STARTS WERE GIRLS

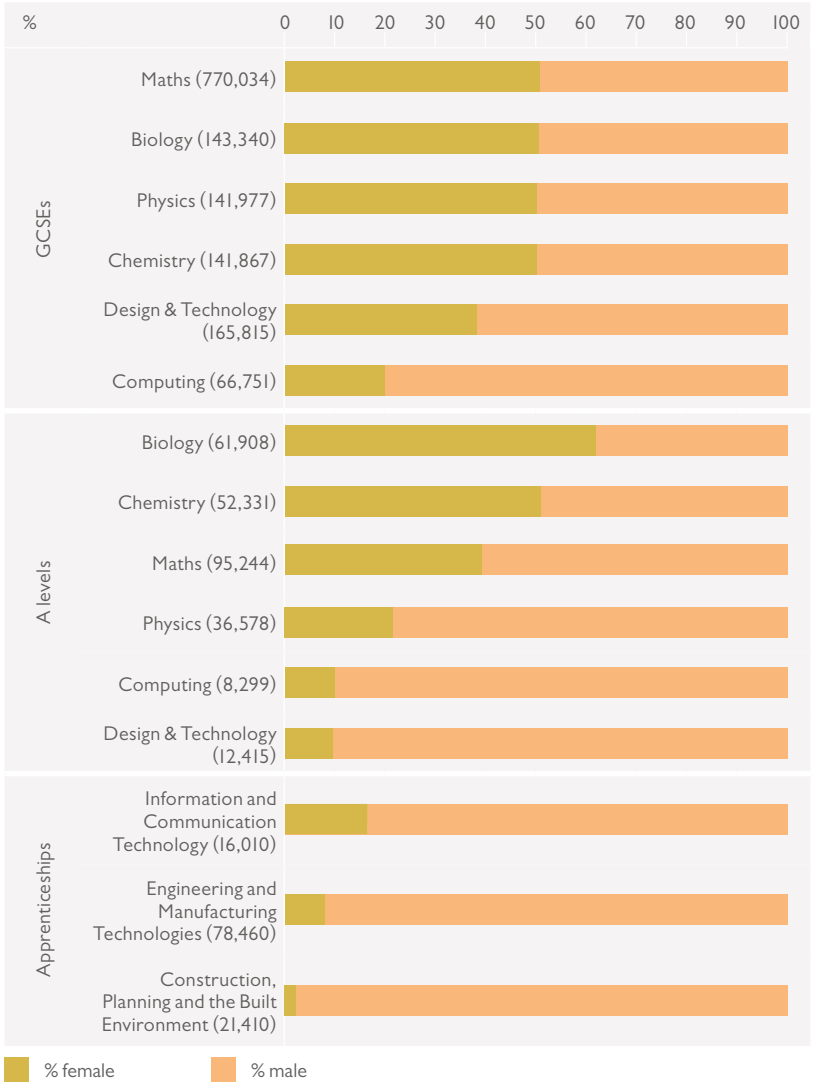

Chart 5: Gender balance across STEM GCSEs, A levels and apprenticeships.
Sources: JCQ and DFE/ESFA

Notes

All UK figures for GCSEs and A levels (2017).
England figures for apprenticeships (2015/16).
Number of entries/starts are given in brackets.

SEEDASH

Gatsby has worked with colleagues from the Institute of Physics and the Royal Academy of Engineering, to collaborate with SchoolDash to provide new insights and ways of visualising STEM education qualification data. The SEEdash website (www.seedash.org) is focussed predominantly on STEM data for schools in England, but also includes information on non-STEM subjects for comparison.

SEEdash uncovers correlations in data about STEM subject uptake, attainment and progression, allowing immediate comparison and overlay of data sets for different subjects and subject combinations, student characteristics, cohorts, geographical regions and school types between 2002 and 2016.

Chart 6 is taken from the SEEdash website and shows how average GCSE Maths attainment by school varies with the proportion of pupils who are eligible for free school meals. It shows a clear trend that the lower the proportion of students eligible for free school meals, the higher the average score in GCSE Maths. On the SEEdash website it is possible to explore whether this is true across the country. For example, schools in London do not seem to follow this trend.

> THERE IS A CLEAR TREND THAT THE LOWER THE PROPORTION OF STUDENTS ELIGIBLE FOR FREE SCHOOL MEALS, THE HIGHER THE AVERAGE SCORE IN GCSE MATHS

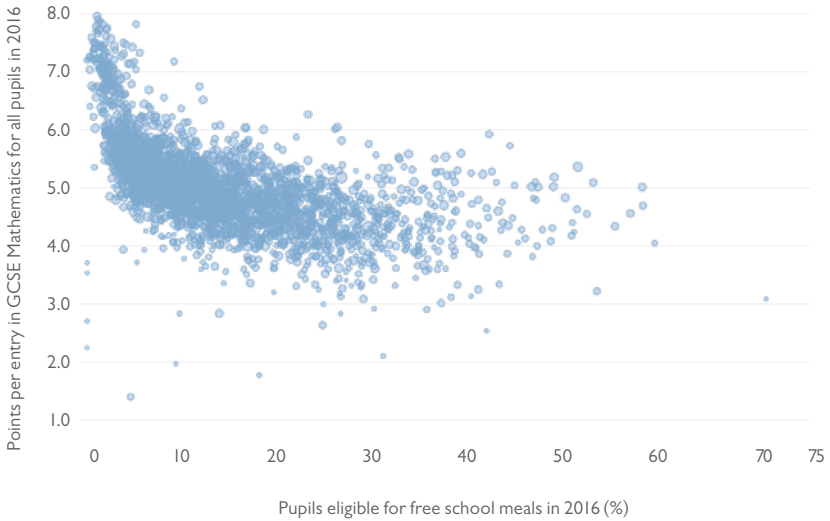

Chart 6: Relationship between GCSE Mathematics attainment and free school meals uptake in England. Source: DFE National Pupil Database

NOTES

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