Towards universal participation in post-16 mathematics: lessons from high-performing countries

Country profile: England

Population (Mid-Year 2010):		52,234,000[1]
Population aged 5-19:		9,150,400[1]
Population aged 16-18 (2011):		1,910,000[2]
Registered state school students (5-15, 2011):		6,964,000[3]
Number of schools:[4]	Nursery and Primary	17, 242
	Secondary	3, 268
	Special and PRU (Pupil Referral Unit)	1, 442
	Independent	2, 420 (approx. 7% of student population)
	Total	24, 372[5]

Education is currently compulsory in England between the ages of 5 and 16. The leaving age for compulsory education has recently been raised by the Education and Skills Act 2008. Education will be compulsory until the age of 17 from 2013, and 18 from 2015.

[1] http://www.ons.gov.uk/ons/rel/pop-estimate/population-estimates-for-uk--england-and-wales--scotland-and-northern-ireland/mid-2010-population-estimates/index.html

[2] Extracted from data tables produced by the Department for Education (DfE), available at: http://www.education.gov.uk/rsgateway/DB/SFR/s001055/index.shtml which give figures for each year group for 2011 as: 620,100 (16 year-olds), 637,700 (17 year-olds), 652,200 (18 year-olds). Note that the DfE figures differ slightly from the ONS figures as the ONS use mid-year figures and the DfE use end-year figures. DfE figures are reported here as they are used in subsequent analysis in this profile.

[3] http://www.education.gov.uk/rsgateway/DB/STR/d001051/index.shtml

[4] http://www.education.gov.uk/rsgateway/DB/SFR/s001071/index.shtml

[5] Note that data do not include sixth form colleges (SFCs) or general further education colleges (GFEs), though a high proportion of A levels are taught in SFCs and some A levels, as well as nearly all vocational programmes, are taught in GFEs.

The education system is divided into four phases:

Phase	Age	School Year	Key Stage	Education Providers
Nursery	3	Nursery	Foundation	Nursery / Infant School / Primary School
Primary	4-11	Reception		
		1	Key Stage 1	
		2		
		3	Key Stage 2	Junior School / Primary School
		4		
		5		
		6		
Secondary	11-18	7	Key Stage 3	Secondary School
		8		
		9		
		10	Key Stage 4 / GCSE	
		11		
		12	Sixth-Form / A levels / Further Education	College / university etc.
		13		
Tertiary	18+			

1. What is the national policy for, and structure of, mathematics education provision for 16-18/19 year-old (pre-university level) learners?

→ Is upper secondary education compulsory or optional?
→ What is the structure of upper secondary programmes?
→ Is any mathematics compulsory in the upper secondary age group?
→ What, if any, are the mathematics options in upper secondary education?

Upper secondary education (post-16 – a term we will use in this profile as it reflects the age range and common terminology of the system in England) is currently optional in England. There are a vast number of course and qualification options available to post-16 learners. Upper secondary education (ages 16-19) predominantly covers Entry Level – Level 3 of the National Qualifications Framework (NQF) and Qualifications and Credit Framework (QCF): [6]

Level	Examples of NQF qualifications	Examples of QCF qualifications
Entry	- Entry level certificates - English for Speakers of Other Languages (ESOL) - Skills for Life - Functional Skills at entry level (English, mathematics and ICT)	- Awards, Certificates, and Diplomas at entry level - Foundation Learning at entry level - Functional Skills at entry level

[6] http://www.ofqual.gov.uk/qualifications-and-assessments/qualification-frameworks/ These frameworks articulate with the overarching European Qualifications Framework, which provides a translation device for qualification levels: http://www2.ofqual.gov.uk/qualifications-assessments

Level	Examples of NQF qualifications	Examples of QCF qualifications
1	- GCSEs grades D-G - BTEC Introductory Diplomas and Certificates - OCR Nationals - Key Skills at level 1 - Skills for Life - Functional Skills at level 1	- BTEC Awards, Certificates, and Diplomas at level 1 - Functional Skills at level 1 - Foundation Learning Tier pathways - NVQs at level 1
2	- GCSEs grades A*-C - Key Skills level 2 - Skills for Life - Functional Skills at level 2	- BTEC Awards, Certificates, and Diplomas at level 2 - Functional Skills at level 2 - OCR Nationals - NVQs at level 2
3	- A levels (AS and A2) - GCE in applied subjects - International Baccalaureate (IB) - Key Skills level 3	- BTEC Awards, Certificates, and Diplomas at level 3 - BTEC Nationals - OCR Nationals - NVQs at level 3
4	- Certificates of Higher Education	- BTEC Professional Diplomas Certificates and Awards - HNCs - NVQs at level 4
5	- HNCs and HNDs - Other higher diplomas	- HNDs - BTEC Professional Diplomas, Certificates and Awards
6	- National Diploma in Professional Production Skills - BTEC Advanced Professional Diplomas, Certificates and Awards	- BTEC Advanced Professional Diplomas, Certificates and Awards
7	- Diploma in Translation - BTEC Advanced Professional Diplomas, Certificates and Awards	- BTEC Advanced Professional Diplomas, Certificates and Awards - NVQs at level 5 (in the QCF framework)
8	- Specialist awards	- Award, Certificate and Diploma in strategic direction

There are currently various routes through 14-19 education and training in England which broadly fall into two pathways:

- GCSEs[7] and A levels - 'The Traditional Route'
- Vocational routes, i.e. NVQs / BTEC

Two other programmes which do not clearly fit these pathways are:

- The Diploma[8] - an attempt to bridge academic and vocational pathways

[7] The General Certificate of Secondary Education usually taken at the end of lower secondary education.
[8] Note that the Diploma has never been a significant route in 14-19 education and will not be offered from 2013, see: http://www2.ofqual.gov.uk/qualifications-assessments/89-articles/16-diploma?dm_i=BTP,SAYU,290C9M,2AVUZ,1

- Apprenticeships - these are not qualifications in themselves but a training pathway that may include qualifications from other pathways

GCSEs and A levels - 'The Traditional Route'

- A levels and GCSEs are taken by more than one million young people each year.
- GCSE Mathematics at Grade C is a requirement for many career pathways including teaching and some nursing routes.
- They are currently undergoing various reviews and revisions and it is likely that the information contained in this document will be subject to substantial change.
- GCSEs graded D-G are at level 1 on the NQF, GCSEs graded A*-C are at level 2
- Each subject at A level is made up of two parts, each designed to be studied over one year: AS and A2. At the end of the first (AS) year, students can choose to be awarded an AS level as a stand-alone qualification in a subject or continue their study to achieve a full A level.
- Typically students undertake AS levels in 4 subjects and continue at A2 in only 3 of these, but some students take more and some less than this.
- A levels are an ISCED[9] Level 3 qualification and the most widely recognised for university admission.

Vocational Routes and Apprenticeships

- NVQs[10] (National Vocational Qualifications) are competency-based practical qualifications concerned with developing specific work-related skills, available in six major areas:
  - business and administration
  - sales, marketing and distribution
  - health and social care
  - food, catering and leisure services
  - construction and property
  - manufacturing, production and engineering
- NVQs are assessed through practical assignments and portfolios and are available at Levels 1 – 5 of the QCF. Level 3 can lead into Higher Education or other qualifications such as the HNC or HND.
- HNC (Higher National Certificate) and HND[11] (Higher National Diploma) are work-related Higher Education qualifications based on the application of skills in specific areas.
- On the QCF, HNCs are awarded at Level 4 and HNDs are awarded at Level 5.
- HNCs and HNDs are provided by higher education (HE) and further education (FE) institutions, and are available in the following areas:
  - agriculture
  - computing and IT
  - construction and civil engineering
  - engineering
  - health and social care
  - business and management
  - sport and exercise sciences
  - performing arts
  - retail and distribution
  - hospitality management

[9] International Standard Classification of Education (ISCED)
[10] http://www2.ofqual.gov.uk/qualifications-assessments/89-articles/18-nvqs
[11] http://www2.ofqual.gov.uk/qualifications-assessments/89-articles/250-explaining-the-national-qualifications-framework

- BTEC qualifications have been awarded for over 25 years; they are work-related qualifications that are available from Entry Level to Level 7.
- BTEC qualification provide a vocational path through education and training that allows entry to, or transfer to, university.
- BTEC qualifications are available in the following subject areas:
  - Applied Science
  - Art and Design
  - Business and Services
  - Children and Young People
  - Construction and the Built Environment
  - Engineering
  - Hair and Beauty
  - Health and Social Care
  - Hospitality, Travel and Tourism
  - IT
  - Land-based and Environment
  - Media
  - Performing Arts and Music
  - Public Services and Uniformed Services
  - Sport

- Apprenticeships are a form of vocational training that enables learners to gain skills necessary to succeed in their chosen career and earn money at the same time, involving a combination of on- and off-the-job training.
- Apprentices work alongside experienced staff to gain job-specific skills and receive training.
- An Apprenticeship is not a qualification in itself, but a framework that contains separately certified elements, including:
  a. A work-based qualification such as an NVQ at either level 2 or level 3
  b. Functional skills in Communication and Application of Number or GCSE English Language and Mathematics[12]
  c. A relevant knowledge-based qualification such as BTEC

The Diploma[13]

Note: The Diploma will not be offered from 2013.

- The Diploma is designed for 14-19-year-olds, although very few students have taken take this route and it is rapidly becoming an obsolete route with low take-up and completion rates.
- The Diploma combines academic and vocational/applied learning and prepares young people for progression to further/ higher education and employment.
- All diplomas must include:
  a. Principal learning (50%): sector-related learning developed by employers and universities
  b. Project or extended project: a single piece of work of a student's choosing, related to the Diploma subject or sector
  c. Functional Skills: available in English, mathematics and ICT

[12] Functional Skills replace the similar Key Skills as a mandatory component of Apprenticeships from October 2012: http://www.apprenticeships.org.uk/partners/keyskillsextension.aspx and http://archive.excellencegateway.org.uk/pdf/fsfa.s2.m2.handout3.final.pdf

[13] http://www.education.gov.uk/childrenandyoungpeople/youngpeople/qandlearning/diploma/a0064416/what-is-the-diploma, http://www.education.gov.uk/schools/teachingandlearning/qualifications/diploma/a0064416/what-is-the-diploma and DCSF. (2009). Delivering the 2013 Diploma Entitlement: guidance to local authorities and providers. London: Department for Children, Schools and Families.

d. Work experience
e. Personal, learning and thinking skills (PLTS)
f. Additional/specialist learning: either an 'additional' qualification to add breadth or a 'specialist' qualification to add depth to principal learning

- All Diplomas are available at Foundation (level 1), Higher (level 2) and Advanced (level 3) levels.
- Fourteen Diplomas are available:
  - Engineering
  - IT
  - Creative and media
  - Construction and the built environment
  - Society, health and development
  - Hair and beauty studies
  - Environment and land-based studies
  - Hospitality
  - Business, administration and finance
  - Manufacturing and product design
  - Travel and tourism
  - Public services
  - Retail business
  - Sport and active leisure

As education is not yet compulsory post-16[14], mathematics learning is not compulsory for this age group (although it is included in many courses where students lack a GCSE A*-C qualification or where it is essential to support the course). Current recommendations are for mathematics to be made compulsory for all students up to age 19 who do not have the equivalent of GCSE A*-C[15] and a recent House of Lords Select Committee on Science and Technology report recommends making mathematics compulsory for all school students staying on after the age of 16.[16]

Upper secondary students who choose to study mathematics have a number of options within the above general 14-19 education and training options.

Qualification	Details
A level (Including AS / A2 Level)	• Mathematics • Further Mathematics • Statistics

[14] The leaving age for compulsory education was raised to 18 in 2008, although the change does not take effect until 2013 for 16-year-olds and 2015 for 17-year-olds.
[15] Wolf , A. (2011). Review of Vocational Education – The Wolf Report. London: Department for Education and Advisory Committee on Mathematics Education. (2010). Post-16 in 2016 Proposals for 16-19 Mathematics in anticipation of the review of qualifications scheduled for 2013 with resulting changes to be implemented from 2016. London: Advisory Committee on Mathematics Education, The Royal Society.
[16] House of Lords Select Committee on Science and Technology. (2012). Higher Education in Science, Technology, Engineering and Mathematics (STEM) subjects: Report. London: The Stationery Office.

AS Use of Mathematics (UoM)	Use of Mathematics – typically taken by students with Grades B/C at GCSE and has an emphasis on modelling and mathematical application. It is more often taken in colleges than in schools. The programme consists of three level 3 FSMQs: - Working with Graphical and Algebraic Techniques (compulsory) - 1 module from: Using and Applying Statistics OR Modelling with Calculus OR Using and Applying Decision Mathematics[17] - Applying Mathematics (compulsory) The programme is designed to widen participation to include those who may need to use mathematics in the future generally, but is not generally intended for those who intend to study 'traditional' numerate and mathematical courses at HE.[18]
Free Standing Mathematics Qualification (FSMQ)	FSMQs are available at Levels 1 – 3 in the NQF. Level 2 and 3 may provide a bridge between GCSE and A level – may be taken by students who have taken GCSE early. FSMQ Advanced Level units are equivalent to AS modules. FSMQs may be taken alongside any other qualifications.
Diploma	*N.B. The Diploma is being phased out, but is included here to represent the complexity of the English system* Only a few of the Diploma options (e.g. Engineering) have a specified mathematics component. However all students need to pass the three Functional Skills assessments in English, mathematics and ICT at level 2 (functional Mathematics is not available at level 3). Few students take the Diploma.

Alternative qualifications are available. They include academic qualifications with entries mainly from the independent sector, such as the Cambridge Pre-U (similar to A levels but without a modular structure) and the International Baccalaureate (IB) (where mathematics is a compulsory component but is available at 3 levels) although small numbers take these. There are also a number of qualifications more narrowly focused than the Diplomas, such as the National Vocational Qualifications (split into five levels, with the third level comparable to A levels) or the BTEC Diploma (equivalent to three A levels). These do not include stand-alone mathematics qualifications at this level, but like Diplomas may feature elements of mathematics depending on the chosen course.[19]

Some students in post-compulsory education are taking independent one-year mathematics courses at level 2 or below if they have not already achieved this; most of these are repeating GCSE mathematics courses but some are studying for FSMQs at Level 1 and 2 or Functional Skills or Adult Numeracy Qualifications.[20]

[17] For choice in the unit, see: http://www.aqa.org.uk/qualifications/a-level/maths/use-of-mathematics/use-of-mathematics-overview

[18] Hutcheson, G. D., Pampaka, M., & Williams, J. (2011). Enrolment, achievement and retention on 'traditional'and 'Use of Mathematics' pre-university courses. Research in Mathematics Education, 13(2), 147-168.

[19] The International Baccalaureate (IB) is also available and has a compulsory mathematics element but is taken by less than one per cent of students.

[20] Functional Skills and Adult Numeracy Qualifications will become the same thing from 2013

2. What are the overall participation rates in mathematics study for 16-18-year-olds both as proportions of students and proportions of the age cohort?

→ What are current levels of participation in mathematics overall among the upper secondary cohort and age group?
→ What are the current levels by gender?
→ How have these participation rates changed over time?

Percentage of 2008/09 KS4 cohort going to, or remaining in, an education destination in 2009/10 Year:[21]

	Number of Students	569,115
% Going to a Sustained Education Destination	Any Educational Destination	85
	Further Educational College	33
	Other Further Education Provider	4
	School Sixth Form	36
	Sixth Form College	12
	Apprenticeships	4
	Work Based Learning	0
	Higher Education Institution	0
	School/College Combination	0
% Not Recorded in the Measure	Education Destination not Sustained	9
	Not Captured in Data	6

Participation of 16-18-year-olds in England in all education and training by gender and total numbers, 2009 – 2011[22]

		Males			Females			All		
		end 2009	end 2010	end 2011 prov	end 2009	end 2010	end 2011 prov	end 2009	end 2010	end 2011 prov
Aged 16	Full-time education	83.4%	85.9%	83.7%	88.2%	90.2%	88.8%	85.8%	88.0%	86.2%
	Work Based Learning	5.7%	4.4%	4.6%	4.0%	2.9%	2.9%	4.9%	3.7%	3.8%
	Employer Funded Training	1.4%	1.1%	1.3%	1.2%	0.9%	0.9%	1.3%	1.0%	1.1%
	Other Education and Training	3.5%	4.5%	6.2%	2.9%	3.7%	5.1%	3.2%	4.1%	5.6%
	Total Education and training	**93.7%**	**95.6%**	**95.8%**	**96.2%**	**97.5%**	**97.6%**	**94.9%**	**96.5%**	**96.7%**
	Not in any education or training - in employment	1.3%	1.0%	0.8%	0.8%	0.6%	0.2%	1.0%	0.8%	0.5%

[21] http://www.education.gov.uk/researchandstatistics/statistics/recentreleases/a00210491/destinations-ks-4-5-pupils
[22] Extracted from data available at: http://www.education.gov.uk/rsgateway/DB/SFR/s001072/index.shtml

		Males			Females			All		
		end 2009	end 2010	end 2011 prov	end 2009	end 2010	end 2011 prov	end 2009	end 2010	end 2011 prov
	Not in any education, employment or training	5.1%	3.4%	3.4%	2.9%	1.9%	2.2%	4.0%	2.7%	2.8%
	Total Not in any Education or Training	**6.3%**	**4.4%**	**4.2%**	**3.8%**	**2.5%**	**2.4%**	**5.1%**	**3.5%**	**3.3%**
Aged 17	Full-time education	70.8%	73.0%	72.4%	77.1%	79.0%	79.1%	73.9%	75.9%	75.6%
	Work Based Learning	8.1%	7.0%	7.4%	5.9%	5.4%	5.2%	7.1%	6.2%	6.3%
	Employer Funded Training	3.1%	2.7%	2.6%	2.2%	2.4%	2.2%	2.6%	2.5%	2.4%
	Other Education and Training	4.7%	5.0%	6.9%	4.1%	4.6%	5.8%	4.4%	4.8%	6.4%
	Total Education and training	**86.5%**	**87.5%**	**89.2%**	**89.3%**	**91.3%**	**92.3%**	**87.8%**	**89.4%**	**90.7%**
	Not in any education or training - in employment	5.3%	4.2%	2.8%	4.4%	2.8%	2.5%	4.9%	3.5%	2.6%
	Not in any education, employment or training	8.2%	8.3%	8.0%	6.4%	5.9%	5.3%	7.3%	7.2%	6.7%
	Total Not in any Education or Training	**13.5%**	**12.5%**	**10.8%**	**10.7%**	**8.7%**	**7.7%**	**12.2%**	**10.6%**	**9.3%**
Aged 18	Full-time education	44.2%	46.9%	47.3%	50.2%	52.1%	53.7%	47.1%	49.4%	50.4%
	Work Based Learning	8.2%	8.4%	8.4%	5.4%	5.8%	6.1%	6.8%	7.1%	7.3%
	Employer Funded Training	6.3%	6.5%	5.7%	4.2%	4.3%	4.7%	5.3%	5.4%	5.2%
	Other Education and Training	6.0%	6.1%	7.0%	5.5%	5.3%	6.4%	5.7%	5.7%	6.7%
	Total Education and training	**64.4%**	**67.5%**	**68.4%**	**65.2%**	**67.4%**	**70.9%**	**64.8%**	**67.5%**	**69.6%**
	Not in any education or training - in employment	17.1%	20.1%	16.0%	19.5%	20.1%	15.7%	18.3%	20.1%	15.8%
	Not in any education, employment or training	18.4%	12.4%	15.5%	15.3%	12.5%	13.5%	16.9%	12.5%	14.5%
	Total Not in any Education or Training	**35.6%**	**32.5%**	**31.6%**	**34.8%**	**32.6%**	**29.1%**	**35.2%**	**32.5%**	**30.4%**

		Males			Females			All		
		end 2009	end 2010	end 2011 prov	end 2009	end 2010	end 2011 prov	end 2009	end 2010	end 2011 prov
Aged 16-18	Full-time education	65.7%	68.1%	67.5%	71.4%	73.3%	73.6%	68.4%	70.6%	70.5%
	Work Based Learning	7.4%	6.6%	6.8%	5.1%	4.7%	4.7%	6.3%	5.7%	5.8%
	Employer Funded Training	3.7%	3.5%	3.2%	2.6%	2.5%	2.6%	3.1%	3.0%	2.9%
	Other Education and Training	4.8%	5.2%	6.7%	4.2%	4.6%	5.8%	4.5%	4.9%	6.3%
	Total Education and training	**81.2%**	**83.2%**	**84.2%**	**83.2%**	**85.0%**	**86.7%**	**82.2%**	**84.1%**	**85.4%**
	Not in any education or training - in employment	8.1%	8.7%	6.7%	8.4%	8.1%	6.2%	8.3%	8.4%	6.5%
	Not in any education, employment or training	10.7%	8.1%	9.1%	8.4%	6.9%	7.1%	9.6%	7.5%	8.1%
	Total Not in any Education or Training	**18.8%**	**16.8%**	**15.8%**	**16.8%**	**15.0%**	**13.3%**	**17.8%**	**15.9%**	**14.6%**

Participation of 16-18-year-olds in England in full-time education by highest qualification aim and work based learning, by gender and total numbers, 2009 – 2011[23]

		Males			Females			All		
		end 2009	end 2010	end 2011 prov	end 2009	end 2010	end 2011 prov	end 2009	end 2010	end 2011 prov
Aged 16	Full-time education	83.4%	85.9%	83.7%	88.2%	90.2%	88.8%	85.8%	88.0%	86.2%
	Higher Education (Level 4 and above)	0.0%	0.1%	0.0%	0.1%	0.1%	0.1%	0.0%	0.1%	0.0%
	Further Education	83.4%	85.8%	83.7%	88.2%	90.1%	88.8%	85.7%	87.9%	86.1%
	Level 3	56.9%	59.1%	58.6%	67.7%	69.7%	69.7%	62.2%	64.2%	64.0%
	GCE/VCE A/AS levels	45.1%	46.3%	45.6%	54.3%	55.7%	56.0%	49.6%	50.9%	50.7%
	NVQ 3 and equivalents	11.8%	12.8%	13.0%	13.4%	13.9%	13.7%	12.6%	13.4%	13.3%
	Level 2	14.1%	12.5%	12.2%	13.5%	12.8%	12.4%	13.8%	12.7%	12.3%
	GCSE/Inter-mediate GNVQ	3.6%	3.5%	3.8%	3.2%	3.3%	3.4%	3.4%	3.4%	3.6%
	NVQ 2 and equivalents	10.6%	9.0%	8.4%	10.3%	9.6%	9.0%	10.4%	9.3%	8.7%

[23] Extracted from data tables at: http://www.education.gov.uk/rsgateway/DB/SFR/s001072/sfr12-2012.xls

		Males			Females			All		
		end 2009	end 2010	end 2011 prov	end 2009	end 2010	end 2011 prov	end 2009	end 2010	end 2011 prov
	Level 1	9.1%	10.3%	9.2%	5.1%	5.4%	4.6%	7.1%	7.9%	7.0%
	Foundation GNVQ	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	NVQ 1 and equivalents	9.1%	10.3%	9.2%	5.1%	5.4%	4.6%	7.1%	7.9%	7.0%
	Other courses[24]	3.3%	3.9%	3.7%	1.9%	2.2%	2.1%	2.6%	3.1%	2.9%
	Work Based Learning (WBL)	5.7%	4.4%	4.6%	4.0%	2.9%	2.9%	4.9%	3.7%	3.8%
	Apprenticeships Total	3.7%	4.1%	4.6%	2.7%	2.7%	2.9%	3.2%	3.4%	3.8%
	Advanced Apprenticeships (AAs)	*1.0%*	*1.1%*	*1.2%*	*0.1%*	*0.2%*	*0.2%*	*0.6%*	*0.7%*	*0.7%*
	Apprenticeships (As)	*2.7%*	*3.0%*	*3.4%*	*2.6%*	*2.6%*	*2.7%*	*2.6%*	*2.8%*	*3.0%*
	Entry to Employment (E2E)	2.0%	0.3%	0.0%	1.3%	0.2%	0.0%	1.7%	0.2%	0.0%
	Other[25]	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Population aged 16	328,200	325,100	318,700	309,800	307,000	301,400	638,000	632,100	620,100
Aged 17	Full-time education	70.8%	73.0%	72.4%	77.1%	79.0%	79.1%	73.9%	75.9%	75.6%
	Higher Education (Level 4 and above)	0.5%	0.5%	0.5%	0.7%	0.7%	0.7%	0.6%	0.6%	0.6%
	Further Education	70.3%	72.5%	71.9%	76.4%	78.3%	78.3%	73.3%	75.3%	75.0%
	Level 3	54.0%	55.8%	56.6%	65.4%	67.0%	68.1%	59.5%	61.2%	62.2%
	GCE/VCE A/AS levels	38.2%	38.5%	39.1%	46.8%	47.5%	48.4%	42.3%	42.9%	43.6%
	NVQ 3 and equivalents	15.8%	17.3%	17.4%	18.6%	19.4%	19.7%	17.2%	18.4%	18.5%
	Level 2	10.1%	9.4%	8.8%	7.6%	7.2%	6.6%	8.9%	8.3%	7.8%
	GCSE/Inter-mediate GNVQ	0.8%	0.8%	0.8%	0.7%	0.7%	0.7%	0.8%	0.8%	0.8%
	NVQ 2 and equivalents	9.3%	8.6%	8.0%	6.8%	6.5%	5.9%	8.1%	7.6%	7.0%
	Level 1	3.8%	4.6%	3.9%	2.0%	2.4%	2.1%	2.9%	3.6%	3.0%
	Foundation GNVQ	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	NVQ 1 and equivalents	3.7%	4.6%	3.9%	2.0%	2.4%	2.1%	2.9%	3.6%	3.0%
	Other courses[26]	2.4%	2.7%	2.6%	1.4%	1.7%	1.6%	2.0%	2.2%	2.1%

[24] Includes all courses below level 1 and those of unknown or unspecified level (also includes PRUs; and special schools, for which no qualification breakdown is available)
[25] Various work-related provision including basic skills, individually tailored provision and learning as part of Train to Gain
[26] Includes all courses below level 1 and those of unknown or unspecified level (also includes PRUs; and special schools, for which no qualification breakdown is available)

		Males			Females			All		
		end 2009	end 2010	end 2011 prov	end 2009	end 2010	end 2011 prov	end 2009	end 2010	end 2011 prov
	Work Based Learning (WBL)	8.1%	7.0%	7.4%	5.9%	5.4%	5.2%	7.1%	6.2%	6.3%
	Apprenticeships Total	6.7%	6.7%	7.4%	4.9%	5.1%	5.2%	5.8%	5.9%	6.3%
	Advanced Apprenticeships (AAs)	*1.9%*	*2.0%*	*2.3%*	*0.7%*	*0.8%*	*1.0%*	*1.3%*	*1.4%*	*1.7%*
	Apprenticeships (As)	*4.8%*	*4.6%*	*5.1%*	*4.2%*	*4.3%*	*4.2%*	*4.5%*	*4.5%*	*4.6%*
	Entry to Employment (E2E)	1.4%	0.4%	0.0%	1.0%	0.2%	0.0%	1.2%	0.3%	0.0%
	Other[27]	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Population aged 17	343,900	331,400	327,900	324,300	312,300	309,800	668,100	643,700	637,700
Aged 18	Full-time education	44.2%	46.9%	47.3%	50.2%	52.1%	53.7%	47.1%	49.4%	50.4%
	Higher Education (Level 4 and above)	20.8%	21.7%	23.3%	27.4%	27.9%	29.9%	24.0%	24.7%	26.5%
	Further Education	23.4%	25.2%	24.0%	22.7%	24.2%	23.8%	23.1%	24.7%	23.9%
	Level 3	15.6%	17.0%	16.5%	17.3%	18.5%	18.4%	16.4%	17.7%	17.4%
	GCE/VCE A/AS levels	5.1%	5.8%	5.5%	5.2%	5.8%	5.6%	5.1%	5.8%	5.5%
	NVQ 3 and equivalents	10.5%	11.2%	11.0%	12.1%	12.7%	12.8%	11.2%	11.9%	11.9%
	Level 2	4.3%	4.3%	3.9%	3.4%	3.3%	3.1%	3.9%	3.8%	3.5%
	GCSE/Inter-mediate GNVQ	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
	NVQ 2 and equivalents	4.0%	4.0%	3.6%	3.2%	3.1%	2.8%	3.6%	3.5%	3.2%
	Level 1	1.8%	2.1%	1.8%	1.0%	1.2%	1.1%	1.4%	1.6%	1.5%
	Foundation GNVQ	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	NVQ 1 and equivalents	1.8%	2.1%	1.8%	1.0%	1.1%	1.1%	1.4%	1.6%	1.5%
	Other courses[28]	1.7%	1.8%	1.8%	1.1%	1.2%	1.2%	1.4%	1.5%	1.5%
	Work Based Learning (WBL)	8.2%	8.4%	8.4%	5.4%	5.8%	6.1%	6.8%	7.1%	7.3%
	Apprenticeships Total	7.6%	8.0%	8.4%	4.9%	5.5%	6.0%	6.3%	6.8%	7.2%
	Advanced Apprenticeships (AAs)	*3.5%*	*3.6%*	*3.6%*	*1.6%*	*1.9%*	*2.1%*	*2.6%*	*2.8%*	*2.9%*
	Apprenticeships (As)	*4.0%*	*4.3%*	*4.7%*	*3.3%*	*3.6%*	*3.9%*	*3.7%*	*4.0%*	*4.3%*

[27] Various work-related provision including basic skills, individually tailored provision and learning as part of Train to Gain

[28] Includes all courses below level 1 and those of unknown or unspecified level (also includes PRUs; and special schools, for which no qualification breakdown is available)

		Males			Females			All		
		end 2009	end 2010	end 2011 prov	end 2009	end 2010	end 2011 prov	end 2009	end 2010	end 2011 prov
	Entry to Employment (E2E)	0.5%	0.2%	0.0%	0.4%	0.1%	0.0%	0.4%	0.1%	0.0%
	Other[29]	0.1%	0.2%	0.0%	0.1%	0.2%	0.0%	0.1%	0.2%	0.0%
	Population aged 18	354,400	348,300	335,500	333,400	328,300	316,700	687,800	676,600	652,200
Aged 16-18	Full-time education	65.7%	68.1%	67.5%	71.4%	73.3%	73.6%	68.4%	70.6%	70.5%
	Higher Education (Level 4 and above)	7.4%	7.7%	8.2%	9.7%	9.9%	10.5%	8.5%	8.8%	9.3%
	Further Education	58.3%	60.4%	59.4%	61.7%	63.4%	63.1%	59.9%	61.8%	61.2%
	Level 3	41.7%	43.4%	43.5%	49.5%	51.1%	51.6%	45.5%	47.1%	47.5%
	GCE/VCE A/AS levels	29.0%	29.7%	29.8%	34.8%	35.7%	36.3%	31.8%	32.6%	32.9%
	NVQ 3 and equivalents	12.7%	13.7%	13.8%	14.7%	15.3%	15.4%	13.7%	14.5%	14.6%
	Level 2	9.4%	8.6%	8.3%	8.0%	7.7%	7.3%	8.7%	8.2%	7.8%
	GCSE/Inter-mediate GNVQ	1.5%	1.5%	1.6%	1.4%	1.4%	1.4%	1.4%	1.4%	1.5%
	NVQ 2 and equivalents	7.9%	7.2%	6.6%	6.7%	6.3%	5.9%	7.3%	6.7%	6.3%
	Level 1	4.8%	5.6%	4.9%	2.6%	2.9%	2.6%	3.7%	4.3%	3.8%
	Foundation GNVQ	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	NVQ 1 and equivalents	4.8%	5.6%	4.9%	2.6%	2.9%	2.6%	3.7%	4.3%	3.8%
	Other courses[30]	2.5%	2.8%	2.7%	1.5%	1.7%	1.6%	2.0%	2.2%	2.1%
	Work Based Learning (WBL)	7.4%	6.6%	6.8%	5.1%	4.7%	4.7%	6.3%	5.7%	5.8%
	Apprenticeships Total	6.0%	6.3%	6.8%	4.2%	4.5%	4.7%	5.1%	5.4%	5.8%
	Advanced Apprenticeships (AAs)	*2.2%*	*2.3%*	*2.4%*	*0.8%*	*1.0%*	*1.1%*	*1.5%*	*1.7%*	*1.8%*
	Apprenticeships (As)	*3.8%*	*4.0%*	*4.4%*	*3.4%*	*3.5%*	*3.6%*	*3.6%*	*3.8%*	*4.0%*
	Entry to Employment (E2E)	1.3%	0.3%	0.0%	0.9%	0.2%	0.0%	1.1%	0.2%	0.0%
	Other[31]	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%
	Population aged 16-18	1,026,500	1,004,800	982,100	967,400	947,500	927,900	1,993,900	1,952,400	1,910,000

[29] Various work-related provision including basic skills, individually tailored provision and learning as part of Train to Gain

[30] Includes all courses below level 1 and those of unknown or unspecified level (also includes PRUs; and special schools, for which no qualification breakdown is available)

[31] Various work-related provision including basic skills, individually tailored provision and learning as part of Train to Gain

16-18-year-old students in England in 2010-2011 entered for level 3 qualifications at least equivalent in size to one GCE/Applied GCE A level[32]

	Male	Female	Total
Comprehensive Schools	63,611	72,272	135,883
Selective Schools	10,548	11,642	22,190
Modern Schools	2,482	2,772	5,254
All Maintained Schools	77,238	87,430	164,668
Independent Schools	18,092	17,581	35,673
All Schools	95,330	105,011	200,341
Sixth Form Colleges	26,642	32,927	59,569
Other FE Sector Colleges	52,924	59,135	112,059
All FE Sector Colleges	79,566	92,062	171,628
All Schools and FE Sector Colleges	**174,896**	**197,073**	**371,969**

Participation in Level 3 qualification routes amongst 16-18-year-olds in England, 2010-2011[33]

Qualification Route	Male		Female		Total	
	Number	%	Number	%	Number	%
GCE A level	110,884	63.4	130,462	66.2	241,408	64.9
Applied A level	4,372	2.5	6,898	3.5	11,531	3.1
International Baccalaureate	1,749	1.0	2,168	1.1	4,092	1.1
BTEC/OCR	47,222	27.0	43,159	21.9	90,388	24.3
NVQ/VRQ	10,319	5.9	14,189	7.2	24,550	6.6
All qualification routes	**174,896**	**99.8**	**197,073**	**99.9**	**371,969**	**100**

[32] Extracted from table at: http://www.education.gov.uk/rsgateway/DB/SFR/s001055/sfr01-2012t1t9.xls
[33] Extracted and calculated from data available at: http://www.education.gov.uk/rsgateway/DB/SFR/s001055/sfr01-2012t1t9.xls

Participation (number of entries and percentages of total AS and A level exam entries) of 16-18-year-olds in traditional mathematics options by gender: GCE AS and A level Examination Entries 2010-2011[34]

	AS level Examination Entries						A level Examination Entries					
	Male		Female		Total		Male		Female		Total	
Mathematics	61,147	11%	43,439	6.9%	104,586	8.9%	45,322	12.5%	30,225	7.2%	75,547	9.7%
Further Mathematics	8,199	1.5%	4,228	0.7%	12,427	1.1%	7,819	2.2%	3,589	0.9%	11,408	1.5%
All Subjects	**548,339**		**633,160**		**1,181,499**		**362,062**		**420,717**		**782,779**	

For the 2010-2011 academic year 85.4% of the 16-18 population of 1,910,000 were in education and training, with 70.5% in full-time education. This equates to 1,631,140 students in education and training, of whom 1,346,550 (82.6% of those in education and training) were in full-time education. 47.5% of 16-18-year-olds in 2011 (907,250 students) were working at or towards Level 3 qualifications. Of these students, 371,969 (41%) were entered for Level 3 qualifications.

At Level 3, or advanced mathematics in upper secondary, qualifications are dominated by AS- and A2-level qualifications, although there are small numbers of alternative qualifications, such as IB or Cambridge Pre-U.[35] Additionally, some advanced mathematics is embedded within vocational courses, particularly engineering, although our interpretation of the FE STEM (Science, Technology, Engineering and Mathematics) data project suggests that these account for a very small number of students.[36] Hence, in calculating these estimates, we focus on AS and A2 qualifications.[37]

For the 2010-2011 academic year 9.7% of A level exams sat were in Mathematics and 1.5% were in Further Mathematics. The best measure uses data that match candidates to examination subjects. An analysis of matched candidate data for A level participation in mathematics compared to other subjects was only available for 2007 and not compared to overall participation in education and training.[38]

The following figures for England are therefore approximate but based on matched candidate data. In our previous report, we calculated advanced participation rate using 2009 data as follows:

> 43% of the age cohort took A levels. 25% of those taking A level took mathematics (AS or A2). Thus approximately 11% of the age cohort took advanced mathematics.

[34] Extracted from data available at: http://www.education.gov.uk/rsgateway/DB/SFR/s001055/index.shtml
[35] The IB accounts for approximately 1% of Level 3 qualifications. Assuming that, as with A level, approximately 25% of these students take the advanced mathematics options, perhaps 0.25% of the cohort would have taken advanced mathematics within this route, although all will have done some mathematics.
[36] Royal Academy of Engineering. (2011). *FE STEM Data Project: July 2011 report*. London: Royal Academy of Engineering.
[37] The AS and A2 figures include entries from older students outside upper secondary and are likely to be a slight overestimate of participation at A level. Hence, we have not adjusted these estimates to account for the small numbers in alternative qualifications.
[38] This calculation is based on JCQ data in Matthews, A., & Pepper, D. (2007). *Evaluation of participation in GCE mathematics: Final report. QCA/07/3388*. London: Qualifications and Curriculum Authority.

Since approximately 80% of the age cohort are in education and training, about 13% of the education and training cohort took mathematics at A level.

Mathematics AS and A2 entries have risen since 2009. In 2011, there were 104,586, which is approximately 13% of an estimated Education, Employment and Training cohort of 800,000. Hence, our participation estimate for participation in advanced mathematics is unchanged from our previous report.[39]

The number of entries for A level Mathematics has fluctuated over the last 16 years. The absolute number of entries dramatically fell in 2002 after a syllabus change, but numbers have increased steadily since then, as shown in the table below. There are currently concerns that proposed reforms to the A level system may again lead to a decline in entries.[40]

Change in A level entries in Mathematics, Further Mathematics and all subjects from 1995/96 to 2010/11[41]

Academic year ending	Total A level entries				
	Mathematics		Further Mathematics		All subjects
	Number	% of all entries	Number	% of all entries	Number
2011	75,547	9.7	11,408	1.5	782,779
2010	69,803	8.9	10,813	1.4	783,347
2009	64,519	8.5	9,443	1.2	757,697
2008	57,618	7.8	8,447	1.1	741,356
2007	53,331	7.4	7,241	1.0	718,756
2006	49,805	7.0	6,516	0.9	715,203
2005	46,034	6.7	5,192	0.8	691,371
2004	46,017	6.8	5,111	0.8	675,924
2003	44,453	6.7	4,730	0.7	662,670
2002	44,156	6.8	4,498	0.7	645,033
2001	54,157	7.9	5,063	0.7	681,553
2000	53,674	8.0	5,015	0.7	672,362
1999	56,100	8.2	5,145	0.8	680,048
1998	56,589	8.3	5,211	0.8	681,082
1997	56,050	8.5	4,999	0.8	662,163
1996	54,125	8.7	4,913	0.8	620,164

Note, however, that, while there has been an increase in the number of A level entries in mathematics, the size of the A level cohort has also increased. The proportion of mathematics entries compared to total entries in 2011 is very similar to historic levels as represented by 1996. The proportion of entries in Further Mathematics is small, although this data suggest a recent increase, following an initiative aimed at increasing participation.

[39] It is possible that this may be a slight under-estimate, although we note that the calculations in our previous report suggest a confidence interval of around 1% on this.
[40] Mansell, W. (2010). A-level reforms could trigger 'collapse' in maths take-up, Times Educational Supplement, 30th July 2010.
[41] Includes ungraded, no award (absent/declined) and pending; http://www.education.gov.uk/rsgateway/DB/SFR/s001055/sfr01-2012t13t14.xls Note: DCSF data differs slightly from JCQ data

3. What are the patterns of participation in terms of following different routes involving mathematics?

→ What are current levels of participation in different mathematics options among the upper secondary cohort and age group?

It should be acknowledged that: 'It is extremely difficult to produce or reproduce reliable statistics on STEM subjects in FE and beyond due to the diversity of courses.'[42] This complexity and diversity is clear from the Level 3 qualifications (2010-2011) table in section 2. Note that this information from the Department for Education (DfE) does not include participation levels for Key Skills at Level 3. These participation figures are known to be very small. The vast majority of Level 3 mathematics qualifications achieved in the FE and Skills sector are A/AS levels followed by FSMQs and Key Skills, with <1% taking an alternative Level 3 qualification.[43]

AQA entry figures for 2010 show how many students took alternative ISCED Level 3 qualifications: [44]

Level 3 Qualification / Examination		AQA entries
AS level Use of Mathematics		991
AS level Use of Mathematics (Pilot)		1,448
Free Standing Mathematics Qualifications – Advanced Level (ISCED Level 3)	Calculus	418
	Data Analysis	1,429
	Decision Mathematics	1,101
	Dynamics	162
	Hypothesis Testing	84
	Mathematical Principles for Personal Finance	302

[42] Roper, T. (2008). Review for the LSIS STEM Programme. *Unpublished report commissioned by the National Centre for Excellence in Teaching Mathematics (NCETM).* Information supplied by country expert.
[43] Royal Academy of Engineering. (2011). FE STEM Data Project: July 2011 report. London: Royal Academy of Engineering.
[44] Extracted from data available from: http://web.aqa.org.uk/over/stat_pdf/AQA-AS-STATS-JUNE10.PDF and http://web.aqa.org.uk/over/stat_pdf/AQA-FSMQ-FND-INT-STATS-JUNE10.PDF and http://web.aqa.org.uk/over/stat_pdf/AQA-FSMQ-ADV-PILOT-STATS-JUNE10.PDF

Entries at Level 1 and Level 2 covering mathematics are relatively low, as shown in the following table of AQA entries in 2010:[45]

Level 1 and Level 2 Qualification / Examination		AQA entries
Free Standing Mathematics Qualifications – Foundation Level (ISCED Level 1)	Money Management	454
	Spatial Techniques	107
	Using Data	39
Free Standing Mathematics Qualifications – Intermediate Level (ISCED Level 2)	Data Handling	379
	Financial Calculations	255
Free Standing Mathematics Qualifications – Advanced Level	Calculus	418
	Data Analysis	1,429
	Decision Mathematics	1,101
	Dynamics	162
	Hypothesis Testing	84
	Mathematical Principles for Personal Finance	302

In practice, the majority of those studying mathematics either take an academic specialist route or take what is effectively "remedial" mathematics focused on GCSE retakes. In recent years the number of 16-19-year-olds re-sitting and achieving GCSE post-16 has reduced.[46] However, there has been an increase in GCSE pass rates at 16, thereby reducing the number of students taking re-sits. Anecdotal evidence suggests that since schools are focused on gaining Cs at GCSE, many of the students who might have got D in the past are being supported to get C the first time round, which again reduces the population of re-takes. Nevertheless, a significant proportion of the population, around 42% in 2012, do not achieve a C in GCSE Mathematics at age 16. Anecdotally, this group may be facing some further disadvantage, as some colleges appear to be imposing an entry requirement of D at 16.[47]

Some students retake GCSE in upper secondary education. In 2009, 8% of those entered for GCSE mathematics were aged 17, 18 or 19: 35,777 aged 17 (5.2%), 13,042 aged 18 (1.9%) and 5,488 aged 19 (0.8%)[48]. Assuming that those entered at age 18 and 19 have already retaken GCSE at age 17, GCSE re-sits constitutes approximately 6% of the Education, Employment and Training cohort and 5% of the age cohort. In fact, only an additional 3% of the age cohort have gained a GCSE grade C or equivalent by age 19 (Wolf, 2011).[49] We have not included these students in the participation estimates for reasons of comparability. This is because many other systems require such students to repeat a grade ('grade retention'), meaning that unlike England (and Scotland), not all students aged 16 or over are in upper secondary education. In addition, many of these students may receive very little teaching beyond immediate pre-examination revision or remedial teaching.

The Royal Academy of Engineering's (2011) analysis of FE and Skill sector STEM data suggests that there a relatively large number of qualifications with mathematics,

[45] Extracted from data available from: http://web.aqa.org.uk/over/stat_pdf/AQA-AS-STATS-JUNE10.PDF and http://web.aqa.org.uk/over/stat_pdf/AQA-FSMQ-FND-INT-STATS-JUNE10.PDF and http://web.aqa.org.uk/over/stat_pdf/AQA-FSMQ-ADV-PILOT-STATS-JUNE10.PDF
[46] Wolf , A. (2011). Review of Vocational Education – The Wolf Report. London: Department for Education.
[47] Information from country expert
[48] Gill, T. (2010). How old are GCSE candidates? Statistics Report Series No. 20. Cambridge: Research Division Statistics Group Assessment Research and Development, Cambridge Assessment.
[49] Wolf , A. (2011). Review of Vocational Education – The Wolf Report. London: Department for Education.

mathematics-related or numeracy components taken by students aged 16-19.[50] However, the data available are not of a high quality. The data records all enrolments, completions and achievements, but does not distinguish multiple achievements by individual students (and there is likely to be a considerable amount of double-counting).[51] Aside from stand-alone courses such as Functional Skills, Key Skills, GCSE or A level, many of these courses are available as embedded modules within larger vocational courses and it is not clear whether the mathematics, mathematics-related or numeracy module is actually taken[52]. Our judgement of the data suggests that many apparently mathematics-related modules may actually involve very little mathematical content. Moreover, some students who have already achieved a GCSE C grade or equivalent may be exempted from the mathematics component. Indeed, more than half of these qualifications are at Level 1 or below and the FE STEM data report concludes that the evidence suggests that "some learners may be taking qualifications below the level they have already achieved whilst others are taking no mathematics or numeracy beyond 16" (p.37). A further issue is that the number of qualifications fluctuates very significantly from year to year and the FE STEM data project concludes that this provision is particularly responsive to institutional factors other than student demand or need (e.g., funding, targets or league tables). Such variation increases the likelihood of students taking inappropriate qualifications.

As a result, it is difficult to calculate a valid and reliable estimate of participation rates in at least some mathematics. In our judgement, and in order to provide a valid estimate that is valid for our purpose of comparing participation between systems, the best solution is to follow the same procedure as in our previous report in which we estimated participation in basic mathematics on the basis of FSMQs, Functional Skills and Key Skills as slightly under 7%. Hence, adding this to the proportion studying advanced mathematics, the total participation in at least basic mathematics is slightly under 20%.

4. What is the content and level of the different kinds of provision?

→ What is the structure and content of the mathematics options?
→ How is teacher education organised in order to offer the mathematics options?

Advanced Subsidiary (AS) and Advanced Level (A level) Mathematics and Further Mathematics

All assessment units are weighted at 16.7% for A level (6 units) and 33.3% for AS level (3 units).

AS and A level students may take options in:

- Pure Core Mathematics
- Statistics
- Mechanics

[50] Royal Academy of Engineering. (2011). FE STEM Data Project: July 2011 report. London: Royal Academy of Engineering.
[51] Even allowing for the double counting, the RAEng data suggest that there is a considerable drop out for Key Skills qualifications – information from country expert
[52] The mathematics, mathematics-related or numeracy module may be optional and students may be exempted because they are studying for Key Skills or have a GCSE C grade.

- Decision Mathematics

There are multiple units within each option, and many combinations of AS and A2 optional applied units are permitted for A level Mathematics. The table below details the mathematical subject content of each unit:[53]

Unit	Content	Unit	Content
AS Pure Core 1	• Algebra • Coordinate Geometry • Differentiation • Integration	AS Statistics 1	• Numerical Measures • Probability • Binomial Distribution • Normal Distribution • Estimation • Correlation and Regression
AS Pure Core 2	• Algebra and Functions • Sequences and Series • Trigonometry • Exponentials and logarithms • Differentiation • Integration	A2 Statistics 2	• Discrete Random Variables • Poisson Distribution • Continuous Random Variables • Estimation • Hypothesis Testing • Chi-Square ($\chi 2$) Contingency Table Tests
A2 Pure Core 3	• Algebra and Functions • Trigonometry • Exponentials and Logarithms • Differentiation • Integration • Numerical Methods	A2 Statistics 3	• Further Probability • Linear Combinations of Random Variables • Distributional Approximations • Estimation • Hypothesis Testing
A2 Pure Core 4	• Algebra and Functions • Coordinate Geometry in the (x, y) plane • Sequences and Series • Trigonometry • Exponentials and Logarithms • Differentiation and Integration • Vectors	A2 Statistics 4	• Geometric and Exponential Distributions • Estimators • Estimation • Hypothesis Testing • Chi-Squared ($\chi 2$) Goodness of Fit Tests

[53] http://store.aqa.org.uk/qual/pdf/AQA-6360-W-SP-12.PDF

Unit	Content	Unit	Content
AS Further Pure 1	• Algebra and Graphs • Complex Numbers • Roots and Coefficients of a quadratic equation • Series • Calculus • Numerical Methods • Trigonometry • Matrices and Transformations	AS Mechanics 1	• Mathematical Modelling • Kinematics in One and Two Dimensions • Statics and Forces • Momentum • Newton's Laws of Motion • Connected Particles • Projectiles
A2 Further Pure 2	• Roots of Polynomials • Complex Numbers • De Moivre's Theorem • Proof by Induction • Finite Series • The Calculus of Inverse Trigonometrical Functions • Hyperbolic Functions • Arc Length and Area of surface of revolution about the x-axis	A2 Mechanics 2	• Mathematical Modelling • Moments and Centres of Mass • Kinematics • Newton's Laws of Motion • Application of Differential Equations • Uniform Circular Motion • Work and Energy • Vertical Circular Motion
A2 Further Pure 3	• Series and Limits • Polar Coordinates • Differential Equations • Differential Equations – First Order • Differential Equations – Second Order	A2 Mechanics 3	• Relative Motion • Dimensional Analysis • Collisions in one dimension • Collisions in two dimensions • Further Projectiles • Projectiles on Inclined Planes
A2 Further Pure 4	• Vectors and Three-Dimensional Coordinate Geometry • Matrix Algebra • Solution of Linear Equations • Determinants • Linear Independence	A2 Mechanics 4	• Moments • Frameworks • Vector Product and Moments • Centres of mass by Integration for Uniform Bodies • Moments of Inertia • Motion of a Rigid Body about a Fixed Axis

Unit	Content	Unit	Content
AS Decision 1	• Simple Ideas of Algorithms • Graphs and Networks • Spanning Tree Problems • Matchings • Shortest Paths in Networks • Route Inspection Problem • Travelling Salesperson Problem • Linear Programming • Mathematical Modelling	A2 Mechanics 5	• Simple Harmonic Motion • Forced and Damped Harmonic Motion • Stability • Variable Mass Problems • Motion in a Plane using Polar Coordinates
A2 Decision 2	• Critical Path Analysis • Allocation • Dynamic Programming • Network Flows • Linear Programming • Game Theory for Zero Sum Games • Mathematical Modelling		

These options are at an advanced level and geared towards complex technical use of mathematics in a traditional approach to STEM subjects in higher education, although they are taken by many students who will not study these subjects.

For Further Mathematics, four Further Pure units are available (pure Core Units cannot be used towards AS/A level Further Mathematics). Some units which are allowed to count towards AS/A level Further Mathematics are common with those for AS/A level Mathematics and AS/A level Pure Mathematics. Therefore there are restrictions on combinations of subject awards that candidates are allowed to enter.[54]

AS Use of Mathematics consists of three units:[55]

1. *FSMQ Working with Graphical and Algebraic Techniques (Compulsory)*

This unit aims to be useful for students who need to use algebra, functions and graphs in their other studies (for example in Technology, Science, Economics or Business Studies). Students use graphic calculators and graph plotting software.

2. *Applying Mathematics (Compulsory)*

This unit aims to extend the use of mathematics in the areas of algebra, functions and graphs. It aims to allow students to learn how to develop mathematical models, think critically about how mathematics is used, and develop their powers of mathematical comprehension, explanation, reasoning and communication.

[54] http://store.aqa.org.uk/qual/pdf/AQA-6360-W-SP-12.PDF
[55] Provided by the country expert on the basis of examination board specifications

3. *One choice of module from:*

- Using and Applying Statistics
- Modelling with Calculus
- Using and Applying Decision Mathematics

Free Standing Mathematics Qualifications

FSMQ units are designed to allow students to develop real-world mathematical understanding and are designed to support other courses. Options differ by NQF Level:

Level 1: Money Management, Spatial Techniques, Using Data

Level 2: Data Handling, Financial Calculations

Level 3: Calculus, Data Analysis, Decision Mathematics, Dynamics, Hypothesis Testing, Mathematical Principles for Personal Finance[56]

Functional Skills Qualifications

The Functional Skills qualifications (taken either on their own or as part of a diploma) are intended to cater to uses of mathematics either in some vocational area or in everyday life.

The qualifications at each level cover:[57]

Functional Skills Level 1	• Representing using mathematics • Analysing situations mathematically • Interpreting solutions to problems using mathematics • Coverage of mathematical content in number, geometry and statistics
Functional Skills Level 2	• Representing using mathematics • Analysing situations mathematically • Interpreting solutions to problems using mathematics • Coverage of mathematical content in number, algebra, geometry and statistics

Teacher Education

There are multiple routes into secondary mathematics teaching in England. Students on post-graduate Initial Teacher Training (ITT) courses are required to pay tuition fees, but training bursaries are available for candidates with good degrees in shortage subjects such as mathematics at levels as indicated in the following table:[58]

[56] Examples of the type of activities covered are available at: http://www.nuffieldfoundation.org/fsmqs/level-3-calculus

[57] These examples / qualifications coverage are taken from Edexcel as an example. Other awarding bodies may provide different content. http://www.edexcel.com/migrationdocuments/Functional%20skills1/FC023242-Functional-Skills-Mathematics-Lev-1-and-2-issue-2-1810101.pdf

[58] http://www.education.gov.uk/get-into-teaching/funding/training-in-england/postgraduate-funding.aspx

		ITT Specialism		
		Physics, mathematics, chemistry, modern languages	**Other priority secondary specialisms and primary**	**General science and non-priority secondary specialisms**
Training Bursary 2012/2013	Trainee with first	£20,000	£9,000	£0
	Trainee with 2:1	£15,000	£5,000	
	Trainee with 2:2	£12,000	£0	

The two main routes into school teaching are university-based training or school-based training. University-based training includes the Postgraduate Certificate in Education (PGCE) for those with a subject degree, and undergraduate Initial Teacher Training courses. School-based training involves options including the Graduate Teacher Programme, School-Centred Initial Teacher Training, School Direct and Teach First. The current Government has expressed concern about Initial Teacher Training and recently launched a consultation into this.[59]

Routes into teaching in Further Education are more complex and the requirements for FE ITT are currently being reviewed.[60] The required teaching qualification is the Diploma in Teaching in the Lifelong Learning Sector (DTLLS). This is a one-year qualification usually offered by university teacher training departments. It is also possible to take the Certificate in Teaching in Lifelong Learning Sector (CTLLS) to work as an associate teacher (not suitable for numeracy and other skills for life teachers).

Skills for Life teachers in Further Education – which includes numeracy – must have a subject specialist qualification in addition to the DTLLS.[61] Bursaries towards training costs are available in some subject areas.[62] Teachers qualified in FE can teach in schools.[63]

The former Training and Development Agency set out professional standards for teachers in schools which have recently been revised and will be replaced from 1 September 2012 by new teachers' standards.[64] The teachers' standards will be used to assess all trainees working towards Qualified Teacher Status (QTS), and all those completing their statutory induction period. They will also be used to assess the performance of all teachers subject to the Education (School Teachers' Appraisal) (England) Regulations 2012.skills.[65] Following the white paper in 2010, Continuing Professional Development (CPD) became the responsibility of teaching schools. However, there is still a wide range of provision of CPD including higher education institutions, local authorities, subject associations and

[59] See for example: Department for Education. (2011). Training our next generation of outstanding teachers: Consultation report. London: Department for Education and Teaching Agency. (2012). Consultation on the review of the Secretary of State's accreditation criteria and requirements for initial teacher training: Analysis of responses to the consultation document. London: Department for Education.
[60] http://www.bis.gov.uk/assets/biscore/further-education-skills/docs/p/12-670-professionalism-in-further-education-interim.pdf
[61] http://repository.excellencegateway.org.uk/fedora/objects/eg:1639/datastreams/DOC/content
[62] http://www.parliament.uk/documents/commons-vote-office/March_2012/27-03-12/2.BIS-Further-Education-Bursaries.pdf
[63] http://www.education.gov.uk/schools/careers/traininganddevelopment/qts/a00205922/qlts-guidance
[64] Mathematics exemplification of these standards is available at: https://www.ncetm.org.uk/resources/37789
[65] http://www.education.gov.uk/schools/leadership/deployingstaff/a00205581/teachers-standards1-sep-2012-

independent providers.[66] Increasingly schools are offering CPD 'in-house' and developing more bespoke approaches. Evidence (mostly anecdotal, though collected by talking to a range of providers and head teachers) suggests that the one area where schools feel they need external support is mathematics[67]. The DfE continues to fund the National Centre for Excellence in the Teaching of Mathematics (NCETM) and Further Mathematics Support Programme (FMSP) as part of their commitment to supporting subject-specific CPD for mathematics.[68]

5. How are the different mathematics options assessed?

→ How and when are students assessed for summative purposes?
→ Are any alternative assessment pathways available?

Advanced Subsidiary (AS) and Advanced Level (A level) Mathematics and Further Mathematics

All Pure Core, Further Pure and Decision Mathematics units are assessed through written examinations (modular). Each paper is 1 hour 30 minutes in length and calculators are not allowed to be used in Pure Core 1. Graphics calculators may be used for other papers.

Dependent on the examination board, some units have coursework options, combining this with a shorter written paper. There is a choice of taking this option (combining coursework and a shorter written paper) or being fully assessed through a longer written paper. All other papers are assessed through longer written papers.

Students may take units in any order, although some require prerequisite knowledge from other units for completion.

AS Use of Mathematics

FSMQ *Working with Graphical and Algebraic Techniques* and FSMQ *Using and Applying Statistics* are each assessed by a coursework portfolio (worth 50% of the unit) and a written (one and a half hour) exam (also worth 50%) where the questions are based on a pre-released Data Sheet. *Applying Mathematics* is assessed by two written papers: a one-hour mathematical comprehension with questions based on pre-release material and a one and a half hour paper which assesses your ability to apply mathematical techniques.

Free Standing Mathematics Qualifications

Foundation, Higher and Advanced (pilot) level FSMQs are assessed by one 100% examination. Current Advanced FSMQs are assessed by 50% portfolio and 50%

[66] See for instance the CPD provided by Mathematics in Education and Industry: http://www.mei.org.uk/index.php?page=alevel&section=cpd&PHPSESSID=b3b2b45861fa334983fbded04973cf38
[67] Information provided by country expert
[68] Information provided by country expert

examination. Foundation and Advanced FSMQs are graded A–E. Higher FSMQs are graded A*–D.[69]

Functional Skills Qualifications

Functional Skills Qualifications are assessed through paper-based and on-screen assessments. Each consists of one paper and lasts for one and a half hours.

Alternative Assessment Pathways

Reasonable adjustments may be made for students with Special Educational Needs and Disabilities (SEND).[70]

6. What information is available on students' learning outcomes in secondary education?

→ What research or policy evidence is available on students' expectations, attitudes and attainment in relation to mathematics in lower and upper secondary education?

In PISA 2009, England achieved a mean score of 493 for mathematics, which was not statistically different from the OECD average of 496.[71] Although England's mathematics PISA score has fallen since 2000, analysis of the sampling bias suggests that the PISA national average for England has actually not fallen but has been consistently at the OECD average.[72]

In TIMSS 2007, 8th Grade equivalent age students in England produced an average scale score of 513.[73]

Cumulative percentages for GCSE Mathematics awarded by gender, 2011[74]

Level	Subject	Gender	Number sat	% of number sat	Grade Awarded								
					A*	A	B	C	D	E	F	G	U
GCSE	Mathe-matics	Male	384,258	15.2	5.3	16.6	32.2	58.9	75.7	86.5	94.3	98.4	100.0
		Female	388,686	14.8	5.2	16.5	31.9	58.6	76.5	87.4	94.6	98.4	100.0
		All	772,944	15.0	5.2	16.5	32.0	58.8	76.1	87.0	94.5	98.4	100.0

[69] http://web.aqa.org.uk/qual/fsmq/what.php
[70] http://comment.ofqual.gov.uk/section96/part-1/section-96-duty-to-make-reasonable-adjustments-to-general-qualifications-and-a-new-power-for-the-appropriate-regulator/
[71] Bradshaw, J., Ager, R., Burge, B., & Wheater, R. (2010). PISA 2009: Achievement of 15-year-olds in England. Slough: NFER.
[72] Jerrim, J. (2011). England's "plummeting" PISA test scores between 2000 and 2009: Is the performance of our secondary school pupils really in relative decline? London: Institute of Education, Department of Quantitative Social Science.
[73] Mullis, I. V. S., Martin, M. O., Foy, P., Olson, J. F., Preuschoff, C., Erberber, E., Arora, A., Galia, J. (2008). TIMSS 2007 International Mathematics Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.
[74] http://www.jcq.org.uk

Grades awarded in AS and A level Mathematics examinations by gender, 2010-2011[75]

Level	Subject	Gender	% Awarded Grade						
			A*	A	B	C	D	E	Other
AS level	Mathematics	Male	N/A	23.9	14.9	14.6	13.8	12.4	20.6
		Female		25.0	17.2	15.8	14.2	11.7	16.1
		All		24.4	15.8	15.1	13.9	12.1	18.7
	Further Mathematics	Male		39.9	17.5	13.8	10.4	7.5	11.0
		Female		42.2	18.5	14.0	9.6	7.5	8.3
		All		40.7	17.8	13.9	10.1	7.5	10.1
A level	Mathematics	Male	18.7	26.3	21.2	15.5	10.6	6.0	1.6
		Female	17.2	27.8	22.9	15.8	9.9	5.0	1.3
		All	18.1	26.9	21.9	15.6	10.4	5.6	1.5
	Further Mathematics	Male	27.8	31.1	20.7	10.3	5.8	2.9	1.3
		Female	26.6	31.4	21.8	10.2	5.4	3.1	1.3
		All	27.4	31.2	21.1	10.3	5.7	3.0	1.3

Cumulative grades awarded in AS and A level mathematics examinations by gender, 2010-2011[76]

Level	Subject	Gender	Cumulative % Awarded Grade						
			A*	A	B	C	D	E	Other
AS level	Mathematics	Male	N/A	23.9	38.8	53.4	67.2	79.6	100.2
		Female		25.0	42.2	58.0	72.2	83.9	100.0
		All		24.4	40.2	55.3	69.2	81.3	100.0
	Further Mathematics	Male		39.9	57.4	71.2	81.6	89.1	100.1
		Female		42.2	60.7	74.7	84.3	91.8	100.1
		All		40.7	58.5	72.4	82.5	90.0	100.1
A level	Mathematics	Male	18.7	45.0	66.2	81.7	92.3	98.3	99.9
		Female	17.2	45.0	67.9	83.7	93.6	98.6	99.9
		All	18.1	45.0	66.9	82.5	92.9	98.5	100.0
	Further Mathematics	Male	27.8	58.9	79.6	89.9	95.7	98.6	99.9
		Female	26.6	58.0	79.8	90.0	95.4	98.5	99.8
		All	27.4	58.6	79.7	90.0	95.7	98.7	100.0

7. What vocational education options are available at upper secondary level?

- → What is the structure and content of the vocational courses available?
- → What status do vocational courses have in comparison to other options?
- → What are the participation levels in these courses?
- → How much mathematics is included in vocational education courses and at what levels?

The Royal Academy of Engineering STEM data report points to a wide range of vocational qualifications. See sections above for participation levels. Vocational qualifications fit within

[75] Data extracted from tables available at: http://media.education.gov.uk/assets/files/xls/s/main%20tables%20sfr272011.xls

[76] Calculated from data extracted from tables available at (due to rounding errors these do not always sum to 100%): http://media.education.gov.uk/assets/files/xls/s/main%20tables%20sfr272011.xls

the nine NQF/QCF Levels outlined in the table in section 1. Each vocational qualification indicates its level, size and subject. Size refers to whether the qualification is an Award (1 to 12 credits or 10 and 120 hours' learning), Certificate (13 to 36 credits or 130 to 360 hours' learning) or Diploma (37 credits or 370 or more hours' learning).

The structure and content of vocational courses varies considerably both in what they cover and in the mathematics included. As an example, students taking the BTEC Level 2 (certificate or diploma) in engineering[77] take mandatory units (the number based on the length of the course) and select from a wide range of optional units. These optional units may include mathematical components; for instance units are available in:

- Interpreting and Using Engineering Information
- Mathematics for Engineering Technicians (2 units, one being mandatory for Diplomas)

The table below outlines the assessment outcomes and course content of the Mathematics for Engineering Technicians unit:

To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 use arithmetic methods to evaluate two engineering problems ensuring answers are reasonable	M1 transpose and evaluate complex formulae	D1 transpose and evaluate combined formulae
P2 use algebraic methods to transpose and evaluate simple formulae	M2 identify the data required and determine the area of two compound shapes	D2 carry out chained calculations using an electronic calculator
P3 plot a graph for linear and non-linear relationships from given data	M3 identify the data required and determine the volume of two compound solid bodies	
P4 determine the area of two regular shapes from given data	M4 use trigonometry to solve complex shapes	
P5 determine the volume of two regular solid bodies from given data		
P6 solve right-angled triangles for angles and lengths of sides using basic Pythagoras' theorem, sine, cosine and tangent functions		

[77] See information at: http://www.edexcel.com/quals/firsts10/eng/Pages/default.aspx and qualification specification available from: http://www.edexcel.com/migrationdocuments/BTEC%20Firsts%20from%202010/BTEC_Firsts_Engineering_spec.pdf

BTEC students also have the opportunity to take stand-alone Functional Skills qualifications at Level 2. When taken alongside the BTEC Level 2 engineering, Functional Skills in Mathematics would include:

Skill:	When Learners Are:
Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations	solving routine electrical and mechanical problems set within engineering contexts and situations
Identify the situation or problem and the mathematical methods needed to tackle it	recognising the relevant parameters and formulae to be applied to given electrical and mechanical situations
Select and apply a range of skills to find solutions	selecting and applying formulae to solve electrical mechanical problems in engineering
Use appropriate checking procedures and evaluate their effectiveness at each stage	checking the results of solutions to electrical and mechanical problems to evaluate their effectiveness and reality at each stage of the calculation

A recent study suggests that students undertaking vocational education view it as important but that they believe that vocational education occupies a low status within society in England and the education system.[78]

Vocational education is currently under review in England and a number of policy and consultation documents have been produced to this effect.[79] In particular, the Wolf Report has highlighted the complexity of provision and that low attainers are often diverted onto courses that are not recognised for further progression either in employment or in education. Wolf recommended that low attainers should "concentrate on the core academic skills of English and Maths, and on work experience" (p.14). Wolf's recommendation that all students, who have not secured a C grade in GCSE Mathematics, should continue to study mathematics post-16 has been accepted by government, although this policy has yet to be implemented.[80] The recent Funding Formula Review recognises the importance of students who have not achieved an A*-C GCSE in mathematics and/or English by the age of 16

[78] Atkins, L., Flint, K., & Oldfield, B. (2011). Practical matters: what young people think about vocational education in England. Nottingham: City & Guilds Centre for Skills Development, Nottingham Trent University.

[79] See for example:

Advisory Committee on Mathematics Education. (2011). Mathematical Needs: Mathematics in the workplace and in Higher Education London: Advisory Committee on Mathematics Education: The Royal Society.

Department for Education. (2011c). Review of the National Curriculum in England: Report on subject breadth in international jurisdictions. London: Department for Education.

Department for Education. (2011e). Study Programmes for 16- to 19-year-olds. London: Department for Education.

Greenwood, C., Harrison, M., & Vignoles, A. (2011). The labour market value of STEM qualifications and occupations: An analysis for the Royal Academy of Engineering. London: Department of Quantitative Social Science, Institute of Education.

Oates, T. (2010). *Parity of esteem between academic and vocational qualifications: time to abandon a misguided notion*. Paper presented at the Edge/Gatsby conference on Technical Education for the 21st Century, London, Tuesday 14th December 2010.

Wolf , A. (2011). Review of Vocational Education – The Wolf Report. London: Department for Education.

[80] Wolf Review of Vocational Education: Government Response, available at: http://media.education.gov.uk/assets/files/pdf/w/wolf%20review%20of%20vocational%20education%20%20%20government%20response.pdf

continuing to study these subjects and intends to introduce this as a condition of funding in the near future.[81]

Research suggests that where mathematics (and literacy and language) are embedded into the vocational course (with teams of teachers working together rather than the vocational skills teacher teaching numeracy), success and retention rates are higher. A 20% difference in obtaining a numeracy qualification has been found between those students taking embedded courses and those whose numeracy provision consists of a separate course, suggesting greater levels of engagement where numeracy is embedded into vocational study.[82]

8. What drives the pattern of take-up? How is it linked to the needs of HE, employers and national policy objectives?

- → What are the official criteria, if any, for acceptance to the mathematics options?
- → Are there any unofficial / local criteria for acceptance to the mathematics options?
- → What information, advice or guidance is there about the mathematics options?
- → Are any mathematics recruitment policies targeted to specific groups or types of students?
- → Which subjects and options are students expected or required students to take?
- → Please note the views of, for example, further/higher education institutions, employers, parents or the public more generally
- → Are there 'unofficial' expectations to have particular mathematics qualifications for entry to particular HE courses?

Access to upper secondary mathematics courses

Schools and colleges set their own admissions criteria, but commonly ask for a minimum of five GCSE passes at grades A*, A, B or C for admission to A level courses.[83] For mathematics, these include the achievement of GCSE passes at specified grades in mathematics, in some cases asking for a Grade A, although schools exert individual flexibility in deciding on entry requirements.[84] Although not constructed as lower than traditional A level Mathematics, AS Use of Mathematics is often available to those students who studied GCSE Mathematics at foundation level as well as to students with GCSE A*-C.

Mathematics requirements for access to Higher Education

Students wanting to study mathematics at university, particularly at the more competitive institutions, usually require an A* grade in A level Mathematics.[85] Many universities will also require A level Further Mathematics and STEP papers. STEP papers are the Sixth Term

[81] https://www.education.gov.uk/publications/eOrderingDownload/16-19%20funding%20policy%20document%20-%202012.pdf
[82] Casey, H., Cara, O., Eldred, J., Grief, S., Hodge, R., Ivanič, R., Jupp T., Lopez, D., & McNeil, B. (2006). "You wouldn't expect a maths teacher to teach plastering..." Embedding literacy, language and numeracy in post-16 vocational programmes - the impact on learning and achievement. London: National Research and Development Centre for Adult Literacy and Numeracy, Institute of Education.
[83] There are likely to be differences between the entry requirements in different types of organisation.
[84] NCETM. (2008). Factors Influencing Progression to A Level Mathematics: Report of a Study by the National Centre for Excellence in the Teaching of Mathematics (NCETM). London: National Centre for Excellence in the Teaching of Mathematics (NCETM).
[85] http://www.furthermaths.org.uk/universities.php

Examination Papers. These are mathematics university admission tests initially developed by OCR (Oxford, Cambridge and RSA Examinations) for the highest attaining students. Some universities will also set their own entrance examinations. Most universities require high grades – often AAA – across the A level options taken.

A number of non-mathematics courses (often those which are quantitatively based such as Business Management, Computer Science, Economics, Engineering and Physical Sciences) do not have specific requirements for students to have followed particular A level routes – including mathematics – but there is concern about the mathematical skills of these students[86] and in competitive institutions students may benefit from having studied A level mathematics.

Course selection and information, advice and guidance (IAG)

Although students will usually need to satisfy the entry requirements of the school or college, student take-up of post-16 mathematics is largely self-selecting. Schools and colleges will provide various degrees of information, advice and guidance to students of 14-19 options and course selections. There are also a number of publications available to students, parents and teachers in helping them navigate the various education and training pathways.[87] However, schools and colleges may act strategically when admitting students to mathematics courses, particularly A level mathematics, in order to bolster their performance in league tables.[88] It is not clear whether students are informed of the personal benefits of a mathematics qualification, such as:

- An A level qualification in mathematics has been found by one study to increase earnings by 7-10% of lifetime earnings[89],
- A GCSE "C"/ Level 2 qualification has been found to reduce the likelihood of unemployment by 7 percentage points and increase earnings by roughly 18% (and the effect of numeracy is greater than the effect for literacy).[90]

Mathematics recruitment policies

There are currently initiatives to explore ways of increasing uptake of student numbers in STEM subjects, both at upper secondary level and in Higher Education.[91] There are also ongoing concerns about the gender balance in some A level options and career/training choices, and advice is given to schools to address this in their careers education.[92]

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[86] Osmon, P. (2009). A-level mathematics: a qualification for entry to quantitative university courses. Paper presented at the British Society for Research into Learning Mathematics.
[87] See for example: Department for Education. (2011). Which way now? How to choose your key stage 4 options. London: Department for Education and Russell Group. (2011). Informed Choices: A Russell Group guide to making decisions about post-16 education. London: The Russell Group and http://www.mathscareers.org.uk/
[88] Matthews, A., & Pepper, D. (2007). Evaluation of participation in A level mathematics: Final report. London: Qualifications and Curriculum Authority.
[89] Dolton, P. J., & Vignoles, A. (2002). The Return on Post–Compulsory School Mathematics Study. *Economica, 69*(273), 113-142.
[90] Layard, R., McIntosh, S., & Vignoles, A. (2002). *Britain's record on skills. CEEDP, 23*. London: Centre for the Economics of Education, London School of Economics and Political Science.
[91] See for instance the TISME Research Programme: http://tisme-scienceandmaths.org/the-tisme-research-projects/
[92] Ofsted. (2011). Girls' career aspirations. Manchester: The Office for Standards in Education.

Support is available to students and teachers in deciding on mathematics options, particularly whether to follow Further Mathematics, through the Further Mathematics Support website.[93] They list five benefits to studying Further Mathematics which include access to prestigious universities:

- Students taking Further Mathematics overwhelmingly find it to be an enjoyable, rewarding, stimulating and empowering experience.
- For someone who enjoys mathematics, it provides a challenge and a chance to explore new and/or more sophisticated mathematical concepts.
- It enables students to distinguish themselves as able mathematicians in the university and employment market.
- It makes the transition to a mathematics-rich university course easier.
- Some prestigious university courses will only accept students with Further Mathematics qualifications.

9. What policies and practices are there for transition and retention?

→ What policies or practices are there to support students' transition from lower secondary to upper secondary mathematics options?
→ More generally, what policies or practices are directed at students struggling with upper secondary mathematics?

We have found, as reported by others, little evidence directly addressing the issues of 'enrolment, retention and progression in STEM subjects in FE'.[94]

Lack of provision / appropriate pathways

There are very limited pathways available for students who have a Grade C at GCSE but do not want or are unable to study AS or A level mathematics. It should be noted that most schools discourage those students who have not achieved at least a Grade A at GCSE (or in some cases a Grade B), from studying AS / A level. There are clear reasons for this policy. The success rate at A level of students with a Grade B or a Grade C at GCSE is considerably lower than that of those achieving A or A* Grade.[95] Moreover, many students do not want or need to study a 'traditional' mathematics with calculus pathway. An option of replacing calculus with a course focused on statistics and increasing fluency in 'basic' mathematics might be appropriate for further study in the social sciences, the biological sciences, for some vocationally-focused engineering and for business studies. In addition, there is evidence that the related AS Use of Mathematics is more effective than traditional AS Mathematics in retaining relatively lower attaining students (those with a Grade B at

[93] http://www.furthermaths.org.uk/index.php
[94] Roper, T. (2008). Review for the LSIS STEM Programme. *Unpublished report commissioned by the National Centre for Excellence in Teaching Mathematics (NCETM).* Information supplied by country expert.
[95] Bell, J. F., & Emery, J. L. (2007). *The relationship between A-level grade and GCSE grade by subject. Statistics Report Series No. 7*. Cambridge: Cambridge Assessment.

GCSE) possibly because it can make mathematics more meaningful to students than A level mathematics.[96]

In those parts of the system where alternative pathways are potentially available, the system tends to respond better to factors other than student demand or need. The Royal Academy of Engineering's (2011) analysis of FE and Skill sector STEM indicates considerable variation in patterns of participation over a relatively short period of time (2007-2010). They argue that this suggests that, at least in the FE and skills sector, provision in mathematics and numeracy is particularly influenced by non-demand incentives such as funding, targets and league tables and, as a result, constraints are placed on the extent to which the system responds to learner demand.[97] Similarly, in the school sector, one option for (relatively) lower attaining students might be to offer a two-year AS course. However, funding is tied to examination pass rates and, as a result, schools offering this would receive proportionately less funding in relation to the teaching required.

Increased early entry to GCSE Mathematics

Over the period 2000-2009, early entry to GCSE increased from 2% to 8% of all entries.[98] As a consequence, some students may complete their formal study of mathematics early (at 15 rather than 16) or begin AS mathematics early, potentially without sufficient foundation. The DfE has asked Ofsted to discourage this.[99]

Retention and Support

A small scale study by the NCETM found that in schools with high levels of progression into and participation in A level Mathematics, levels of individual academic support for upper secondary mathematics students was high and teachers responded 'positively and generously to their A level pupils' requests for support. This is usually informal one-to-one or two-to-one support on occasions in the day when pupils and teachers are both available. In schools with larger A level Mathematics cohorts more formal "clinics" and "drop-in workshops" are organised.'[100]

Private Tutoring

In England, 27% of students have received tutoring at some point during their school career, with most having tutoring in mathematics (17% of Year 6, 18% Year 11 and 19% Year 13).

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[96] Hutcheson, G. D., Pampaka, M., & Williams, J. (2011). Enrolment, achievement and retention on 'traditional' and 'Use of Mathematics' pre-university courses. *Research in Mathematics Education, 13*(2), 147-168. See also: http://www.tlrp.org/proj/wphe/wp_williams.html and http://www.acme-uk.org/media/9786/acme_post16discussionpaperjul2012.pdf

[97] See also the ACME paper on this: http://tlp.excellencegateway.org.uk/tlp/stem/images/stories/docs/LSIS_STEM_Progression_through_STEM_FINAL_Oct_09.pdf

[98] See: Gill, T. (2010). *How old are GCSE candidates? Statistics Report Series No. 20.* Cambridge: Cambridge Assessment. We have calculated these figures by comparing the proportion of entries of students aged 15 or less with those aged 16: 2% and 86% in 2000, and 8% and 82% in 2009. This is likely to be an underestimate as some students will be entered repeatedly.

[99] http://www.education.gov.uk/inthenews/inthenews/a00204891/ofsted-asked-to-discourage-gcse-early-entry-a-damaging-trend-harming-interests-of-many-pupils

[100] NCETM. (2008). Factors Influencing Progression to A Level Mathematics: Report of a Study by the National Centre for Excellence in the Teaching of Mathematics (NCETM). London: National Centre for Excellence in the Teaching of Mathematics (NCETM).

Tutoring is more prevalent among students of higher socio-economic status. Tutoring is usually short-term (the majority being for only a term) and focussed on transition points. 71% of tutors were employed to help students do well in examinations.[101]

10. What information is available on (other) factors affecting recruitment and retention?

→ What factors would you attribute to the upper secondary mathematics recruitment levels in England?
→ Please give details of any supporting information or sources

Lack of incentives to choose advanced mathematics at upper secondary

England is a 'free-choice' system. There are limited incentives for students to choose advanced mathematics in upper secondary. Although there was some evidence of a softening of students' perceptions after changes to the content of A level mathematics in 2004, students still often perceive mathematics as a relatively 'difficult' subject and, hence, choose other subjects at A level.[102] See Section 8 on course selection and advice, information and guidance.

Lack of incentives to choose basic, or Level 2, mathematics at upper secondary

There are also limited incentives for students to choose basic, or Level 2, mathematics, although this may be less of the case with key/functional skills being mandatory within vocational programmes. Students often perceive mathematics as a relatively 'difficult' subject and, hence, choose other subjects. Students perceive themselves as having failed and so it is understandable that they see mathematics as difficult. So the main incentives need to be very directly linked to their perceived needs and goals.[103]

Student attitude and engagement

Low participation in mathematics is often blamed on students' attitudes to mathematics. Indeed, there is a great deal of evidence that even high attaining students perceive mathematics to be irrelevant and boring.[104] Hence, students are likely to choose subjects that they perceive to be more relevant to what they hope to do in the future. In a 'free choice' system, it is important to demonstrate the value, relevance and interest of mathematics to students. However, better information, advice and guidance on the personal benefits of a mathematics qualification are unlikely to be sufficient and more attention needs to be focused on engaging students. Indeed, it is unlikely that simply telling students about the importance of mathematics is sufficient. Students need to be convinced not only about the

[101] Ireson, J., & Rushforth, K. (2011). Private tutoring at transition points in the English education system: its nature, extent and purpose. Research Papers in Education, 26(1), 1-19.
[102] Matthews, A., & Pepper, D. (2007). Evaluation of participation in A level mathematics: Final report. London: Qualifications and Curriculum Authority.
[103] Information provided by country expert
[104] See, for example:
Brown, M., Brown, P., & Bibby, T. (2008). "I would rather die": Attitudes of 16 year-olds towards their future participation in mathematics. *Research in Mathematics Education, 10*(1), 3-18.
Osborne, J., Black, P., Boaler, J., Brown, M., Driver, R., & Murray, R. (1997). *Attitudes to Science, Mathematics and Technology: A review of research*. London:: King's College, University of London.

value of mathematics but also that it is accessible to themselves.[105] However, if gains in participation are to be accompanied by gains in attainment, students' confidence in their preparedness for specific mathematics courses should be realistic.[106] More generally, attitudes and engagement are unlikely to improve without associated improvements to attainment.

Student attainment and understanding

Despite considerable increases in examination performance, the ICCAMS 30-year comparison indicates that in England, aside from some aspects of decimal number, students' understanding of the key topics of proportional reasoning and algebra have not increased and in most cases fallen since the 1970s.[107]

Prior Attainment (GCSE)[108]

- Those with lower GCSE grades are more likely to enrol onto Use of Mathematics (UoM) courses
- The percentage of students who enrol onto traditional courses steadily increases with GCSE grade

There are "very different patterns of enrolment for the traditional and UoM courses. Enrolment onto the traditional courses is biased towards those students with higher GCSE-grades and those who intend to follow mathematically demanding courses in HE, particularly STEM courses. This group contains relatively high numbers of Asian students and those from low-participation neighbourhoods. Enrolment onto the UoM courses, on the other hand, is biased towards those from other ethnicities who tend to have lower GCSE-grades and do not plan to follow the more traditional mathematically-demanding subjects at university." (p.163)

UPMAP Project[109]

The UPMAP (Understanding Participation rates in post-16 Mathematics And Physics) project is investigating the factors that contribute towards participation rates in post-16 mathematics and physics. They explore factors under the categories of:

- Individual
- School
- Out-of-school

[105] Matthews, A., & Pepper, D. (2007). Evaluation of participation in A level mathematics: Final report. London: Qualifications and Curriculum Authority.
[106] For a discussion of specific issues here, see Pajares, F., & Kranzler, J. (1995). Self-Efficacy Beliefs and General Mental Ability in Mathematical Problem-Solving. Contemporary Educational Psychology, 20(4), 426-443.
[107] Hodgen, J., Brown, M., Küchemann, D., & Coe, R. (2011). *Why have educational standards changed so little over time: The case of school mathematics in England.* Paper presented at the British Educational Research Association (BERA) Annual Conference, Institute of Education, University of London.
[108] Hutcheson, G. D., Pampaka, M., & Williams, J. (2011). Enrolment, achievement and retention on 'traditional'and 'Use of Mathematics' pre-university courses. Research in Mathematics Education, 13(2), 147-168.
[109] Reiss, M., Hoyles, C., Mujtaba, T., Riazi-Farzad, B., Rodd, M., Simon, S., & Stylianidou, F. (2011). Understanding Participation rates in post-16 Mathematics and Physics: Conceptualising and operationalising the UPMAP Project. International Journal of Science and Mathematics Education, 9(2), 273-302.

Data is being analysed in three strands:

- Mapping trajectories of engagement and disengagement
- Investigating subjectivities and school culture
- Documenting the reasons for HE choice

Early reported findings on the factors impacting on students choosing to take mathematics post-16 include:[110]

- Students expressed the desire to choose mathematics and/or physics because of the probable external rewards (entrance into Higher Education or careers)
- Subject choice is derived from a sense of personal empowerment and/or pleasure in being able to do mathematics and/or physics, an empowerment coming from within the individual
- Young people are more likely to continue with mathematics and/or physics after the age of 16:
    - If they have been encouraged to do so by a key adult (usually in their family or at their school)
    - If they believe that they will gain from studying the subject in terms of job satisfaction and/or material rewards
    - If they can manifest conceptual understanding in the subject(s)
    - If they have been well taught.

[110] Simon, S., Hoyles, C., Mujtaba, T., Riazi-Farzad, B., Reiss, M., Rodd, M., & Stylianidou, F. (2012). Understanding Participation in Mathematics and Physics (UPMAP). Paper presented at the American Educational Research Association Annual Meeting, Vancouver, British Columbia, Canada, April 13th - 17th.