TIMSS 2019

England

Dr. Tina Isaacs
Dr. Jennie Golding
Dr. Mary Richardson
Ms. Christina Swensson
UCL Institute of Education, London

Introduction

Overview of Education System

The school system in England is directed centrally by the Department for Education (DfE). In 2019, there were 8.82 million students in 24,323 schools and 257 further education colleges.[1,2] Full time education is compulsory from ages 5 to 16, after which young adults are required to continue in full time education, an apprenticeship or traineeship, or part time education or training alongside paid or volunteer work through age 18.[3]

Most students move from primary to secondary school at age 11. Many secondary schools offer education for students until age 18; however, students may choose to enter a Sixth Form or Further Education (FE) college, apprenticeship, or traineeship at age 16. State funded schools include Local Authority maintained schools, voluntary aided schools, academies, and free schools. All schools, state-funded or independent, are required to provide a broad and balanced curriculum, and there are statutory requirements for particular subjects.

Exhibit 1 details the structure of education in England.

Exhibit 1: Structure of School Education in England

Phase	Key Stage	Ages	School/College Structure	
Early Years	Early Years Foundation Stage	0–5	Nursery schools, nursery classes in primary schools, children's centers, and registered child minders	
Primary	Key Stage 1	5–7	Infant school	Commonly combined in a single primary school
	Key Stage 2	7–11	Junior school	
Secondary	Key Stage 3 (Lower secondary)	11–14	Secondary school (ages 11–18)	
	Key Stage 4 (Upper secondary)	14–16		
	Post-Sixteen	16–18	Sixth Form College (ages 16–18)	
			Further Education College (ages 16+, sometimes 14+)	

A new national curriculum, optional in academies, free, and independent schools was introduced between 2014 and 2016. Subjects are divided into programs of study for each key stage, which set out national performance expectations.

Use and Impact of TIMSS

England has taken part in all TIMSS cycles, and results demonstrate improvement in mathematics, improvement in Year 5 (international Grade 4) science, and consistency in Year 9 (international Grade 8) science. In 2015, the proportion of students reaching the low benchmark in mathematics in Years 5 and 9 increased significantly. Significant 2015 performance issues included students making relatively little progress in mathematics between Years 5 and 9; a far higher proportion achieving the Advanced and High TIMSS International Benchmarks in both subjects in the highest performing countries; and wider achievement gaps between more and less advantaged students than in most other high performing countries. Students value learning mathematics and science and feel confident in these subjects compared with other international peers, and schools score highly on their focus on academic performance. However, in areas such as teacher recruitment, teacher challenges, and job satisfaction, England compares less favorably.[4]

Sample schools participating in TIMSS receive confidential feedback to support school and professional development. They are invited to a TIMSS schools' conference to discuss the national results and share ideas for improvement. TIMSS findings (together with those from other international benchmark studies) have been used to identify priorities for improving policy and practice —for example, via the National Centre for Excellence in the Teaching of Mathematics (NCETM) and the National Science, Technology, Engineering, and Mathematics (STEM) Learning Centre, as described below.

The Mathematics Curriculum in Primary and Lower Secondary Grades

Most students who participated in the TIMSS mathematics assessments had been taught under the September 2014 National Curriculum, outlined below, since its inception; Year 9 students had previously been taught the predecessor curriculum.

The national curriculum for mathematics aims to ensure that all students become fluent in the fundamentals of mathematics, are able to reason mathematically, and can solve problems by applying their mathematics. In addition, they should be able to communicate mathematical thinking effectively, make connections within mathematics, and apply their mathematical knowledge to science and other areas.

The programs of study for mathematics are set out year by year for Key Stages 1 and 2. An indicative summary of the upper Key Stage 2 (Years 5 and 6) program follows. Full details can be found in the National Curriculum document.[5] Each successive year subsumes the intended curriculum for previous years.

The principal focus of mathematics teaching in upper Key Stage 2 is to ensure that students extend their understanding of the number system including place value. This objective supports students in developing connections across and between key operations with fractions, decimals, percentages, and ratios. By the end of Year 6, students should begin to extend their algebraic understanding of number to more formal algebra. Students develop their ability to solve a wider range of problems using increasingly complex properties of number and problems demanding efficient written and mental methods of calculation. Learning in geometry and measures consolidates and extends knowledge developed in number and ensures that students classify shapes with increasingly complex geometric properties. Students should also understand, read, spell, and pronounce mathematical vocabulary correctly.

Exhibit 2 lists the content areas and main curriculum elements for Grade 4 (Year 5).

Exhibit 2: Indicative Summary Content—Mathematics Curriculum for Grade 4 (Year 5)

Content Area	Focus	Objectives
Number	Number and place value	▪ Read, write, order, and compare numbers to at least 1 million and determine the value of each digit ▪ Count forward or backward in steps of powers of 10 for any given number up to 1 million ▪ Interpret negative numbers in context, count forward and backward with positive and negative whole numbers, including through 0 ▪ Read Roman numerals to 1,000 (M) and recognize years written in Roman numerals
	Addition and subtraction	▪ Add and subtract whole numbers with more than four digits, including using formal written methods (columnar addition and subtraction) ▪ Add and subtract numbers mentally with increasingly large numbers ▪ Use rounding to check answers to calculations and determine accuracy in the context of a problem ▪ Solve multistep addition and subtraction problems in contexts, deciding which operations and methods to use and why
	Multiplication and division	▪ Identify multiples and factors, including finding all factor pairs of a number and common factors of two numbers ▪ Solve problems involving multiplication and division, including using knowledge of factors and multiples, squares, and cubes ▪ Solve problems involving addition, subtraction, multiplication, division, and a combination of these operations, including understanding the equal sign ▪ Solve problems involving multiplication and division including scaling by simple fractions and problems involving simple rates
	Fractions (including decimals and percentages)	▪ Compare and order fractions whose denominators are all multiples of the same number ▪ Identify, name, and write equivalent fractions of a given fraction, represented visually, including tenths and hundredths ▪ Work with decimals to three places and begin to work with fraction, decimal, and percentage equivalences

Content Area	Focus	Objectives
Measurement		▪ Understand and use equivalences between metric and imperial units ▪ Measure and calculate the perimeter of composite rectilinear shapes; work with simple areas and volumes, including estimations ▪ Use all four operations to solve problems involving measure (for example, length, mass, volume, money)
Geometry	Properties of shapes	▪ Identify three-dimensional shapes from two-dimensional representations ▪ Know angles are measured in degrees; estimate and compare acute, obtuse, and reflex angles ▪ Draw given angles and measure them in degrees ▪ Begin to engage with two-dimensional geometrical reasoning around lengths and angles, and with two-dimensional reflections and translations
Statistics		▪ Solve comparison, sum, and difference problems using information presented in a line graph ▪ Complete, read, and interpret information in tables, including timetables

Grade 8 (Year 9) students taking TIMSS assessments will usually have met most of the Key Stage 3 mathematics program of study which aims to ensure that all students:

- Become fluent in the fundamentals of mathematics, through varied and frequent practice with increasingly complex problems over time, so that students develop conceptual understanding and the ability to recall and apply knowledge rapidly and accurately
- Reason mathematically by following a line of inquiry, conjecturing relationships and generalizations, and developing an argument, justification, or proof using mathematical language
- Can solve problems by applying their mathematics to a variety of routine and nonroutine problems with increasing sophistication, including breaking down problems into a series of simpler steps and persevering in seeking solutions

The curriculum is organized into distinct domains, and students build on learning achieved at Key Stage 2 and connections across mathematical ideas to develop fluency, mathematical reasoning, and competence in solving increasingly sophisticated problems with good written and mental arithmetic. The use of equipment such as calculators is recommended only as a supporting tool from near the end of Key Stage 2. Teachers and students use digital tools and materials for mathematics teaching and learning as teachers deem appropriate. Below, in Exhibit 3, we summarize the curriculum content for Grade 8 (Year 9). Full details can be found online.[5]

Exhibit 3: Indicative Summary—Mathematics Curriculum for Grade 8 (Year 9)

Content Area	Objectives
Number	▪ Understand and use place value for decimals, measures, and integers of any size ▪ Order positive and negative integers, decimals, and fractions; use the number line as a model for ordering the real numbers; use the symbols =, ≠, <, >, ≤, ≥ ▪ Use the four operations, including formal written methods, applied to positive and negative integers, decimals, proper and improper fractions, and mixed numbers ▪ Use integer powers and associated real roots (square, cube, and higher); recognize powers of 2, 3, 4, 5; and distinguish between exact representations of roots and their decimal approximations ▪ Interpret and compare numbers in standard form $A \times 10^n$ for $1 \leq A < 10$, where n is a positive or negative integer or 0 ▪ Work interchangeably with terminating decimals and their corresponding fractions (such as 3.5 and $\frac{7}{2}$ or 0.375 and $\frac{3}{8}$), with percentages, and with percentages and fractions as operators ▪ Estimate and approximate answers appropriately ▪ Appreciate the infinite nature of sets of integers, real numbers, and rational numbers
Algebra	▪ Use and interpret algebraic notation ▪ Substitute numerical values into formulas and expressions, including scientific formulas ▪ Understand, manipulate, and use the concepts and vocabulary of expressions, equations, inequalities, terms, and factors ▪ Reduce a given linear equation in two variables to the standard form $y = mx + c$; calculate and interpret gradients and intercepts of graphs of such linear equations numerically, graphically, and algebraically ▪ Find approximate solutions to contextual problems from given graphs of a variety of functions, including piecewise or simultaneous linear, quadratic, exponential, and reciprocal graphs ▪ Recognize arithmetic and geometric sequences and appreciate other sequences that arise
Ratio, proportion, and rates of change	▪ Change freely between related standard units (for example, time, length, area, volume/capacity, mass) ▪ Use scale factors, scale diagrams, and maps ▪ Express one quantity as a fraction of another, where the fraction is less than 1 or greater than 1 ▪ Solve ratio and percent change, and direct and inverse proportion problems, making links across arithmetic, algebraic, and graphical representations ▪ Use compound units such as speed, density, and unit pricing, to solve problems
Geometry and measures	▪ Derive and apply formulas to calculate and solve problems involving perimeter and area of triangles, parallelograms, trapezoids, and circles, and volume of cuboids and other prisms ▪ Work with standard geometric constructions and appropriate technologies to explore two-dimensional geometry ▪ Apply standard angle facts, including in polygons and related to parallel lines, triangle congruence, similarity and properties of quadrilaterals, to derive results about angles and sides, including the Pythagorean theorem, and use known results to obtain simple proofs ▪ Use the Pythagorean theorem and trigonometric ratios in similar triangles to solve problems involving right-angled triangles ▪ Use the properties of faces, surfaces, edges and vertices of cubes, cuboids, prisms, cylinders, pyramids, cones, and spheres to solve problems involving three-dimensional shapes ▪ Interpret mathematical relationships both algebraically and geometrically

Content Area	Objectives
Probability	▪ Record, describe, and analyze the frequency of outcomes of simple probability experiments involving randomness, fairness, and equally and unequally likely outcomes, using appropriate language and the 0−1 probability scale ▪ Understand that the sum of the probabilities of all possible outcomes equals 1 ▪ Generate theoretical sample spaces for single and combined events with equally likely, mutually exclusive outcomes, and use them to calculate theoretical probabilities ▪ Use and apply set notation and Venn diagrams
Statistics	▪ Describe, interpret, and compare observed distributions of a single variable through appropriate graphical representation involving discrete, continuous, and grouped data, and appropriate measures of central tendency (mean, mode, median) and spread (range, consideration of outliers) ▪ Construct and interpret appropriate tables, charts, and diagrams including frequency tables, bar charts, pie charts, and pictograms for categorical data, and vertical line (or bar) charts for ungrouped and grouped numerical data ▪ Describe simple mathematical relationships between two variables in observational and experimental contexts and illustrate using scatter graphs

The Science Curriculum in Primary and Lower Secondary Grades

In 2019, most students who participated in TIMSS science assessments had been taught under the September 2014 National Curriculum outlined below from its inception. Year 9 (Grade 8) students had previously been taught under the preceding curriculum.

The national curriculum for science aims to ensure that all students develop scientific knowledge and conceptual understanding of biology, chemistry, and physics along with a comprehension of the uses and implications of science.

The program of study for science are set out year by year for Key Stages 1 and 2 (Year 5 is the penultimate year of Key Stage 2.) The focus of the upper Key Stage 2 program of study is described here along with a summary of Year 5 curriculum content. Full details can be found online in the National Curriculum for England.[6]

At upper Key Stage 2, students explore a wide range of scientific ideas and more systematically analyze functions, relationships, and interactions. They deal with abstract ideas and work toward understanding and predicting how the world operates, recognizing that scientific ideas can change over time. They select appropriate responses to scientific questions using different types of scientific inquiry including observations, noticing patterns, grouping and classifying things, carrying out comparative and fair tests, and using a range of secondary sources. They draw conclusions based on data and observations, use evidence to justify ideas, and use scientific knowledge and understanding to explain findings. They also are expected to understand, read, spell, and pronounce an increasingly scientific vocabulary.

During Year 5, students expand their tools and approaches for working scientifically. They learn to use practical scientific methods, processes and skills, including planning scientific inquiries, taking measurements using a range of equipment, recording data and results, using results to make predictions, testing those predictions fairly, reporting and presenting findings, and identifying scientific evidence that has been used to support or refute ideas or arguments. Exhibit 4 lists content in Grade 4 (Year 5).

Exhibit 4: Indicative Summary Content—Science Curriculum for Grade 4 (Year 5)

Content Area	Objectives
Living things and their habitats	▪ Describe the differences in the life cycles of different animals ▪ Describe the life process of reproduction
Animals, including humans	▪ Describe the changes as humans develop to old age
Properties and changes of materials	▪ Compare and group everyday materials based on their properties ▪ Know that some materials dissolve in liquid to form a solution ▪ Use knowledge of solids, liquids, and gases to separate mixtures ▪ Demonstrate that dissolving, mixing, and changes of state are reversible ▪ Explain that some changes result in the formation of new materials and are not usually reversible
Earth and space	▪ Describe the movement of the Earth, the Moon, and other planets ▪ Describe the Sun, the Earth, and the Moon as approximately spherical bodies ▪ Use the idea of the Earth's rotation to explain day and night
Forces	▪ Identify effects of gravity, air/water resistance, and other friction ▪ Recognize that some mechanisms, including pulleys, levers, and gears, can increase the effect of a force

The science program of study for Key Stage 3 students (to Grade 8/Year 9) focuses on developing a deeper understanding of a range of scientific ideas. Students learn about the "big ideas" underpinning scientific knowledge and understanding. They relate scientific explanations to phenomena in the world around them and use modeling and abstract ideas to develop and evaluate explanations.

Students refine their tools for and approaches to working scientifically. They learn that science includes working objectively, modifying explanations to account for new evidence and ideas, subjecting results to peer review, selecting appropriate types of scientific inquiry, and developing a deeper understanding of important factors in collecting, recording, and processing data. They evaluate their results and identify further questions arising from them. Students refine and use scientific nomenclature, vocabulary and units, and mathematical representations.

Working across biology, chemistry, and physics, students develop skills in the following areas:

- Scientific attitudes
- Experimentation and investigation
- Analysis and evaluation
- Measurement

We outline a sample of the curriculum content in Exhibit 5. Further details can be found in the National Curriculum for England.[6]

Exhibit 5: Indicative Summary Content—Science Curriculum for Grade 8 (Year 9)

Content Area	Focus	Elements
Biology	Cells and organization	▪ Plant and animal cells, including functions of cellular structures ▪ Diffusion in and across cells ▪ Structural adaptations of some unicellular organisms ▪ Hierarchical organization of multicellular organisms
	The skeletal and muscular systems	▪ Structure and function of the human skeleton ▪ Biomechanics
	Nutrition and digestion	▪ Requirements in a healthy daily diet ▪ Consequences of diet imbalances ▪ Human digestive system ▪ How plants gain nutrients
	Gas exchange systems	▪ Structure and functions of the gas exchange system in humans ▪ Mechanism of breathing ▪ Impact of exercise, asthma, and smoking on the human gas exchange system ▪ Role of leaf stomata in gas exchange in plants
	Reproduction	▪ Reproduction in humans and plants
	Health	▪ Effects of recreational drugs on behavior, health, and life processes
	Photosynthesis	▪ Reactants in, and products of, photosynthesis ▪ The dependence of almost all life on Earth on photosynthesis ▪ Adaptations of leaves for photosynthesis
	Cellular respiration	▪ Aerobic and anaerobic respiration in living organisms ▪ Process of anaerobic respiration in humans and micro-organisms
	Relationships in an ecosystem	▪ Interdependence of organisms in an ecosystem ▪ Importance of plant reproduction in human food security ▪ How organisms affect, and are affected by, their environment
	Inheritance, chromosomes, DNA and genes	
	Heredity	▪ A simple model of chromosomes, genes, and DNA ▪ Differences between species ▪ Natural selection ▪ The importance of biodiversity
Chemistry	Particulate nature of matter	▪ Properties of the states of matter ▪ Changes of state in terms of the particle model
	Atoms, elements, and compounds	▪ A simple (Dalton) atomic model ▪ Differences between atoms, elements, and compounds ▪ Chemical symbols and formulas ▪ Conservation of mass, changes of state, and chemical reactions
	Pure and impure substances	▪ Pure substances and mixtures, including dissolving ▪ Diffusion in terms of the particle model ▪ Simple techniques for separating mixtures

Content Area	Focus	Elements
	Chemical reactions	▪ Chemical reactions as rearrangement of atoms ▪ Representing chemical reactions using formulas and equations ▪ Combustion, thermal decomposition, oxidation, and displacement reactions ▪ Acids and alkalis ▪ The pH scale ▪ Reactions of acids with metals and alkalis ▪ Catalysts
	Energetics	▪ Energy changes on changes of state ▪ Exothermic and endothermic chemical reactions
	The periodic table	▪ Physical and chemical properties of different elements, including metals and nonmetals ▪ Principles of the periodic table ▪ How patterns in reactions can be predicted with reference to the periodic table ▪ Chemical properties of metal and nonmetal oxides
	Materials	▪ Order of metals and carbon in the reactivity series ▪ Use of carbon in obtaining metals from metal oxides ▪ Properties of ceramics, polymers, and composites
	Earth and atmosphere	▪ Composition and structure of the Earth ▪ Rock cycle and the formation of rocks ▪ Earth as a source of limited resources ▪ Composition of the atmosphere ▪ Production of carbon dioxide by human activity and impact on climate
Physics	**Energy**	
	Calculation of fuel uses and costs in the domestic context	▪ Comparing energy values of different foods ▪ Comparing power ratings of appliances ▪ Domestic fuel use and costs ▪ Fuels and energy resources
	Energy changes and transfers	▪ Simple machines ▪ Heating and thermal equilibrium ▪ Other processes involving energy transfer
	Changes in systems	▪ Energy as a quantity that can be measured and calculated ▪ Increases and decreases in energy associated with changes in systems
	Motion and forces	
	Describing motion	▪ Relationship between speed, distance, and time ▪ Relative motion

Content Area	Focus	Elements
	Forces	
	Forces arising from the interaction between two objects	▪ Using force arrows in diagrams ▪ Turning effect of a force ▪ Forces associated with deforming objects, springs, friction, pushing, resistance to motion of air and water ▪ Measurements of force ▪ Force-extension linear relation; Hooke's Law ▪ Work done and energy changes on deformation ▪ Noncontact forces including gravity, magnets, and static electricity
	Pressure in fluids	
	Atmospheric pressure	▪ Pressure in liquids ▪ Pressure measured by ratio of force over area
	Balanced forces	▪ Opposing forces and equilibrium
	Forces and motion	▪ Forces needed to stop or start objects moving, or change speed or direction ▪ Change depending on direction of force and its size
	Waves	
	Observed waves	▪ Waves on water as undulations that travel with transverse motion
	Sound waves	▪ Frequency, echoes, reflection, and absorption of sound ▪ Speed of sound through different mediums ▪ Sound production by vibration ▪ Auditory range of humans and animals
	Energy and waves	▪ Pressure waves transferring energy
	Light waves	▪ Speed of light ▪ Transmission of light through materials ▪ Ray model of light ▪ Light transferring energy ▪ Color and light frequencies
	Electricity and electromagnetism	
	Current electricity	▪ Electric current ▪ Potential difference ▪ Differences in resistance between conducting and insulating components
	Static electricity	▪ Separation of positive or negative charges when objects are rubbed together ▪ Electric fields
	Magnetism	▪ Magnetic poles and fields, attraction and repulsion ▪ Earth's magnetism, compass, and navigation ▪ Magnetic effect of a current, electromagnets, DC motors
	Matter	
	Physical changes	▪ Conservation of material and mass, and reversibility, in changes of state and dissolving ▪ Similarities and differences between solids, liquids, and gases ▪ Brownian motion in gases ▪ Diffusion in liquids and gases

Content Area	Focus	Elements
	Difference between chemical and physical changes—particle model	▪ The differences in arrangements of particles explaining changes of state, shape, and density ▪ Atoms and molecules as particles
	Energy in matter	▪ Changes with temperature in motion and spacing of particles ▪ Internal energy
	Space physics	▪ Gravity force, weight on Earth and other planets, gravity forces between Earth, the Sun, and the Moon ▪ The Sun as a star, other stars and galaxies ▪ Seasons, day length ▪ Light years

Professional Development Requirements and Programs

In November 2018, there were 453,400 full time equivalent teachers in state funded schools in England.[7] Ninety-five percent of teachers have Qualified Teacher Status, and 98.7 percent hold qualifications at degree level or higher. Following formal training, teachers start their careers as Newly Qualified Teachers with Qualified Teacher Status. They are supported by in-school mentors, and development is assessed against a set of national standards during a statutory two-year induction during which they enjoy reduced teaching commitments. There is no statutory requirement for annual continuous professional development (PD) or entitlement to subject-specific PD. However, the 2016 Standard for Professional Development provides nonstatutory guidance on effective PD.[8] Most primary teachers teach across the curriculum. Specialist teaching is increasingly common as students progress through secondary school, although mathematics and physics, especially at Key Stage 3 (to Grade 8/Year 9), is sometimes taught by nonspecialists, underlining the importance of subject-specific teacher PD. Recent reports confirm the importance of such PD in mathematics, science, and computing going forward.[9]

Within mathematics and science, the DfE provides funding to NCETM and the National STEM Learning Centre (more detail is given in the section "Special Initiatives in Mathematics and Science Education.") These organizations offer a range of subject-specific PD courses and support local teacher professional collaborative projects or inquiry focused on nationally or locally identified mathematics or science priorities.

Centrally funded PD is complemented by a range of opportunities available from professional associations such as the Association for Science Education; learned societies, such as the Institute of Physics; local authorities; and independent education consultants. Universities also offer subject-specific short courses and accredited programs with or without a subject-specific focus (for example, for a master's degree or doctorate in education). However, funding for such provision and any related release from teaching is at the employing school's discretion and competes with other budgetary priorities.

Monitoring Student Progress in Mathematics and Science

Statutory national assessments take place at Key Stages 1 and 2. Key Stage 1 includes a phonics screening (Year 1) and teacher assessments in English reading, writing, mathematics, and science (Year 2). Results from Year 2 are published at the national and local authority levels only and inform the primary progress measure.

Grade 5 (Year 6) includes externally set and marked tests in English reading, grammar, punctuation and spelling, and mathematics. Teachers assess writing in English. Results are published at the school level and determine national attainment measures for primary schools. There is also a biennial national science sampling exercise.

From 2019–2020, Year 4 students will participate in an online assessment on multiplication tables. From autumn 2020, schools will administer new reception (age 5) baseline assessments. Key Stage 1 assessments will become nonstatutory in 2023. Students in Key Stage 3 are internally assessed only.

Most students age 16 take General Certification of Secondary Education (GCSE) examinations. Examinations are written externally, administered under controlled conditions, and graded by examination boards. Internal assessment is typically limited to practical subjects. GCSEs in mathematics and science are 100 percent externally assessed through timed written papers. Science students complete mandatory practical examinations that do not contribute to their grade, though examinations include related questions.

GCSEs are graded on a scale of 9 to 1, where "Grade 5" is considered a "strong pass" and "Grade 4" is a "standard pass." On average, students take nine GCSEs.[10] The English Baccalaureate recognizes achievement of "good passes" ("Grade 4+") in English, mathematics, sciences, languages, and humanities. A school accountability measure ("Progress 8") shows students' progress from Year 6 across English, mathematics, three other English Baccalaureate subjects, and three further subjects. There is no national curriculum for students over 16, but those who have not attained a "Grade 4+" in English or mathematics must continue to engage with that subject.

Special Initiatives in Mathematics and Science Education

The DfE offers increased payments to some specialist mathematics/science trainee teachers—at secondary level up to £28,000 of additional funding in physics, chemistry, and computing, and up to £26,000 in biology. Trainee mathematics teachers receive up to £22,000 during training followed by two early-career payments totalling £10,000 in years three and five of teaching. There is also bursary funding for some specialist primary mathematics trainees.

As mentioned above, the DfE also funds NCETM, the National STEM Learning Centre, and other high quality continuing professional development and leadership education for mathematics and science teachers. Of particular note is the large-scale mathematics Teaching for Mastery program, which focuses on pedagogic approaches employed in some high performing East Asian jurisdictions and builds on a teacher exchange program between England and Shanghai that began in 2014.[11] This approach features detailed lesson planning by specially trained teachers and whole class learning, supported by high quality resources. Coordinated by NCETM, the approach has been funded to reach 8,000 primary schools between 2016 and 2020.

Support for mathematics and science teachers in delivering the revised National Curriculum is primarily provided by DfE-funded programs including NCETM, the National STEM Learning Centre, and locally led science PD courses. The former operates a network of school-based "Maths Hubs" and forums to offer a targeted range of mathematics-specific, funded development opportunities and materials across early years/primary/secondary/post-compulsory education. These opportunities are often carried out through professional work groups and focus on nationally and locally identified priorities and especially developing practices aligned approaches used in high performing jurisdictions. The National STEM Learning Centre also operates an online bank of resources for science and technology teaching and learning for ages 3 to 18 and runs well-funded[12] one-day and longer courses.

These, and other smaller-scale initiatives, target improved quality in teaching and student attainment and enhanced participation in science and mathematics qualifications and pathways at all levels. There is particular emphasis on participation by girls where gender imbalance is an issue and by students in historically disadvantaged schools or areas.

Suggested Readings

Department for Education. (2019). *Attitudes to STEM subjects by gender at key stage 4*. Retrieved from https://www.gov.uk/government/publications/attitudes-to-stem-subjects-by-gender-at-key-stage-4

House of Commons. (2018). *Delivering STEM skills for the economy*. London: The Stationery Office. Retrieved from https://publications.parliament.uk/pa/cm201719/cmselect/cmpubacc/691/691.pdf

National Audit Office (NAO). (2018). *Delivering STEM (science, technology, engineering and mathematics) skills for the economy*. Retrieved from https://www.nao.org.uk/wp-content/uploads/2018/01/Delivering-STEM-Science-technology-engineering-and-mathematics-skills-for-the-economy.pdf

References

1 Department for Education. (2019). *Schools, pupils and their characteristics: January 2019*. Retrieved from https://www.gov.uk/government/statistics/schools-pupils-and-their-characteristics-january-2019

2 Association of Colleges. (2019). *College key facts 2018/19*. Retrieved from https://www.aoc.co.uk/about-colleges/research-and-stats/key-further-education-statistics

3 Department for Education. (2015). *Raising the participation age (RPA)*. Retrieved from https://www.gov.uk/know- when-you-can-leave-school

4 Greany, T., Barnes, I., Mostafa, T., Pensiero, N., & Swensson, C. (2016). *Trends in Mathematics and Science Study (TIMSS): National Report for England*. Retrieved from https://www.gov.uk/government/publications/timss-2015-national-report-for-england

5 Department for Education. (2014). *The national curriculum in England: Mathematics programmes of study*. Retrieved from https://www.gov.uk/government/publications/national-curriculum-in-england-mathematics-programmes-of-study

[6] Department for Education. (2014). *The national curriculum in England: Science programmes of study*. Retrieved from https://www.gov.uk/government/publications/national-curriculum-in-england-science-programmes-of-study

[7] Department for Education. (2019). *School workforce in England: November 2018*. Retrieved from https://www.gov.uk/government/collections/statistics-school-wkforce

[8] Department for Education. (2016). *Standard for teachers' professional development implementation guidance for school leaders, teachers, and organisations that offer professional development for teachers.* Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/537031/160712_-_PD_Expert_Group_Guidance.pdf

[9] Royal Society (2017). Retrieved from https://royalsociety.org/topics-policy/projects/vision/teaching-profession/

[10] Carroll, M., & Gill, T. (2018). *Uptake of GCSE subjects 2017. Statistics report series no. 120.* Cambridge, UK: Cambridge Assessment. Retrieved from https://www.cambridgeassessment.org.uk/Images/518813-uptake-of-gcse-subjects-2017.pdf

[11] Department for Education. (2016). *South Asian method of teaching maths to be rolled out in schools.* Press release. Retrieved from https://www.gov.uk/government/news/south-asian-method-of-teaching-maths-to-be-rolled-out-in-schools

[12] National STEM Learning Centre. (2019). Retrieved from https://www.stem.org.uk/