Improving school governance

Questions for Governors: A framework to facilitate discussions between governors and school leaders

Focus: science and maths in English secondary schools.

wellcome trust

Questions for governors

A framework to facilitate discussions between governors and school leaders

Focus: science and maths in English secondary schools

The framework can be adapted to other curriculum areas or other types of school or college

Questions for governors to ask about science and maths in English secondary schools

Schools have the opportunity – and a responsibility – to engage their students through inspiring science and maths teaching. Teaching should enable students to achieve their best in these high-stakes core subjects and open up future learning and employment opportunities. Schools should also sustain their students' curiosity, allowing them to enjoy the cultural pleasures of our scientific heritage and keep apace with new developments, including those highly relevant to their own lives. Consideration of how schools perform in science and maths should extend beyond simple exam results.

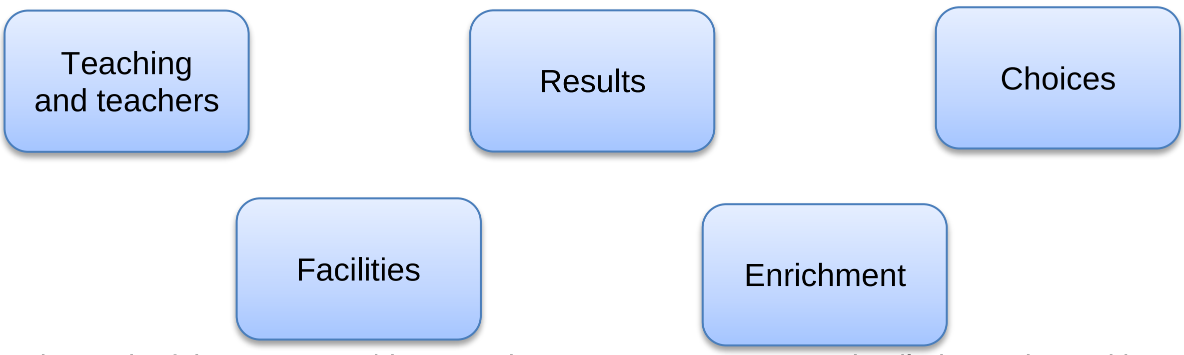
> "Very few [schools] measured their [science] departments' performance against the lofty goal of 'maintaining curiosity'", *Ofsted 2013.*

The questions in this framework can help governing bodies identify areas to celebrate or challenge in science and maths, enabling them to work with their senior leaders to drive improvement. Governing bodies are increasingly assessed on how well they carry out their roles and responsibilities – unless a governing body is deemed outstanding by Ofsted, a school cannot be judged outstanding. We hope that this framework will enable governors to perform at their best, exemplifying an approach which could also benefit other curriculum areas.

Why do governors need to think about science and maths?

- First and foremost, science and maths are core subjects that are compulsory for students in England until the age of 16.
- Continuing to study science and maths post-16 opens doors for students to job opportunities and further and higher education, and not just in specific science and maths sectors. Skills gained through science and maths are applicable, and often critical, to many other areas of learning and employment.
- A good understanding of science and maths can improve learning across many areas of the curriculum through improved understanding of the world around us, application of concepts and development of basic investigative skills.
- It is essential that everyone has an understanding of science and maths to be able to make informed decisions on a range of personal issues, from health care to personal finance, to appreciate our scientific culture and heritage and to engage with advances in technology.

What are the questions?
We have identified five over-arching question areas that will help governors build up a rich picture of science and maths in their school.



Under each of these over-arching question areas are some more detailed questions with benchmarks to help senior leaders and governors see how their school compares nationally for different aspects of science and maths education. Questions are cross-referenced and you can dip into them in any order. It may be useful to look at one area at a time, depending on the priorities of your school.

The webpages at www.questionsforgovernors.co.uk take these questions further, by showing:

- why each question is important
- how you can measure your school against national benchmarks (it is important to note that these benchmarks show national averages, not necessarily ideal performance)
- ideas for what a school might do to improve its performance – these include ideas for actions governors could take, and those for senior or subject leaders.

How to use these questions

These questions have been developed to facilitate conversations between school governors, headteachers and teachers about science and maths education. The questions could be used as a basis for an annual report, or to identify a focus area. This particular version is aimed at secondary schools in England, but much of it will also be useful for sixth form colleges.

Senior leaders could use the questions to monitor school performance and identify opportunities for improvement, and then governors could interpret the results and apply them to a future strategy for science or maths in their school. We have indicated which areas for improvement concern the strategic oversight of the schools and may be taken forward by governors, and which are more operational matters, of great use to senior or subject leaders. It’s important to make sure that both governors and teachers are clear about what the questions are being used for and their role in using them.

One way you might like to use this framework is:

1. decide as a governing body to look at the questions – you may choose to focus on particular areas, or look at them as a whole
2. identify a governor who will ask the questions, for example, the science or maths link governor
3. share the questions with the headteacher or head of science or maths and talk to them about what you both want to get out of using the questions
4. have a discussion between the governors and head of science, or leader responsible for science, using all the data provided in the questions, as well as the ideas for improvement – governors might also gather their own information from student surveys or learning walks (where governors visit a number of classrooms for a short time to see a range of lessons)
5. report back to the governing body on key findings and identify next steps.

Background

These questions have been produced by the Wellcome Trust in consultation with experts from scientific, mathematics and education communities, including the Advisory Committee on Mathematics Education, Campaign for Science and Engineering, Education Endowment Foundation, Gatsby Charitable Foundation, Institute of Physics, the National Governors’ Association, National Science Learning Centre, Royal Society of Chemistry and many other organisations. We aim for them to be updated as the school environment changes, and new opportunities for improvement arise.

We will be researching how these questions are used in a number of schools and identifying areas for improvement. We also plan to tailor different versions for Northern Ireland, Scotland and Wales and produce a version for primary schools.

This work builds upon the Recommended Code of Governance published by the Wellcome Trust in 2011, which is now being piloted in 20 schools. The Code uses a series of questions for governors to think about their role, and encourages them to use data and a range of focus areas to understand the performance of their school effectively. The Code helps governing bodies to improve how they work and fulfil their responsibilities, and these questions move on to how governors and school leaders can improve particular areas of their school. Element C of the Code also suggests performance indicators that schools can use, outside of traditional results – linking into the data covered in these questions.

As you will know, there are many documents available to help governors monitor progress and set strategic direction for their school. We hope this document can complement those broad guides by focusing on a subject area.

The questions

Teaching: What is the quality of science and maths teaching in your school?
T1. How many science and maths teachers have qualifications relevant to the subjects they teach?
T2. What opportunities are there for teachers and technicians to develop professionally and how are they encouraged to pursue them?
T3. How do teachers inspire and engage their students?
T4. How many science lessons include practical work?

Results: How do your school's students perform in science?
R1. How do results in the sciences at GCSE and A level (if appropriate) measure up (a) against other subjects in the school, especially maths and English, and (b) nationally?
R2. What is the trend over time for results?

Choices: What options do students have for studying science, maths and related subjects, and what do they choose?
C1. Are triple science GCSEs (i.e. separate physics, chemistry and biology GCSEs) available for all students? What proportion of students take them?
C2. (For schools with post-16 provision) Are all three major sciences available for study at A and AS level? Is further maths available at AS and A level as well as maths?
C3. What proportion of students choose to continue each of the sciences (physics, chemistry and biology) and maths at A level?
C4. What proportion of students choosing each of physics, chemistry, biology and maths are female?
C5. What proportion of students choosing A level science and maths qualify for the pupil premium? How does this compare with all pupils?
C6. (For schools with post-16 provision) What proportion of A level students choose to study STEM (science, technology, engineering and maths) subjects at university?
C7. Are students able to easily access post-16 vocational courses in the local area for science, engineering and technology? What proportion of students choose to go on to vocational study or an apprenticeship in a scientific or technical field?
C8. What opportunities do students have to find out about further and higher education (A levels and university courses) or careers that they could follow in STEM?

Facilities: What science facilities are available to your students?
F1. Is a reasonable amount of the school budget spent on science and maths equipment and facilities?
F2. Does your school have enough specialist science laboratories so that every timetabled science lesson can take place in one?
F3. Does your school employ an adequate number of full time equivalent laboratory technicians?

Enrichment: What science and maths related extra-curricular or enrichment activities are available for students, and how are they encouraged to participate?
E1. What science and maths extra-curricular opportunities are there for students to engage with in and out of school?

List of tables

List of charts

Teaching: What is the quality of science and maths teaching in your school?

High quality teaching can have a hugely beneficial impact on students' enjoyment and attainment in all subjects, including science and maths. In the 2012 Wellcome Trust Monitor survey[1] 14-to-19-year-olds were asked to state what encouraged or discouraged them to learn science; 58% said having a good teacher encouraged them, and 43% said having a bad teacher discouraged them.

In order to achieve high quality teaching, teachers must have the appropriate understanding of their subject and related pedagogical skills (T1), kept up-to-date and developed through a range of professional development opportunities (T2), and they should teach in an inspiring and engaging manner (T3), providing many practical activities for the students (T4).

T1. How many science and maths teachers have qualifications relevant to the subjects they teach?

Why this is important
The question of whether better subject qualifications lead to better teaching skills can be contentious – certainly every school leader can tell you about superbly qualified staff that are poor teachers, and vice versa. But there is general agreement that, other things being equal, better subject qualifications lead to better teaching.

- Teachers who are knowledgeable and passionate about their subject are better able[2] to inspire students to achieve the best results possible and continue with further education.
- There are reports[3] and studies that suggest having a science specialist teacher is one factor that contributes to better participation and achievement in that subject. An Ofsted report from December 2013, 'Maintaining Curiosity'[4], highlighted the importance of specialist science teachers and that recruitment of permanent science specialist teachers was a factor in schools in which science achievement had improved.
- It is important to note that 11-16 schools may have different needs from 11-19 schools offering science and maths A levels; likewise, there may be different demands across Key Stages 2 and 3. Schools should look at how their science specialist teachers are deployed throughout the school.

Benchmarks
A specialist teacher is described by SCORE (Science Community Representing Education)[2] as a teacher who has a relevant degree in the subject they teach, or an equivalent qualification, or has had sufficient experience in the subject through their career, and then gone on to complete a teaching qualification in the specialist subject.

In 2004, the government set the following targets[5] for the proportions of **specialist science teachers in secondary schools for 2014**:

- **25% of science teachers to be physics specialists**
- **31% of science teachers to be chemistry specialists**
- **95% of maths lessons to be delivered by maths specialists.**

[1] 'The Wellcome Trust Monitor Wave 2', *Wellcome Trust,* 2012.
[2] 'Subject specialist teaching in the sciences: definitions, targets and data', *SCORE,* 2011.
[3] 'State of the nation report: Science and mathematics education, 14-19', *Royal Society,* 2008.
[4] 'Maintaining Curiosity', *Ofsted,* 2013.
[5] 'Educating the next generation of scientists', *National Audit Office DfE,* 2010.

Currently, national benchmarks do not reach these targets. Only 18% of science teachers have a degree relevant to physics and 21% have a degree relevant to chemistry (and 27% have a degree relevant to biology).

Table 1: Proportion of teachers with relevant degree or higher qualification in science and maths (for England, 2012)

Subject	No. teachers	Proportion with relevant degree or higher qualification	Proportion without a relevant post A level qualification
Maths	33,000	45%	23%
Biology	9,000	79%	12%
Chemistry	7,000	66%	24%
Physics	6,000	55%	34%
General Science	33,000	77%	8%
English (for comparison)	37,000	65%	20%

Note: Teachers qualified in biology, chemistry or physics are taken to teach general science also, so someone with a physics degree is double counted as a physics teachers and general science teacher. These figures include Key Stages 3 and 4, and post-16; it is likely that more teachers are specialist in their subject further up the schools. The 'subject mapping tables' on the School Workforce in England data webpage[5] lists the relevant degrees.

- There are many **more biology specialist teachers than physics and chemistry specialists.**
    - In 2010, the Institute of Physics stated that there was **an average of 1.6 physics specialists per school** and that there are **500 state schools with no specialist physics teachers** at all.
- A high number of teachers teaching science have no science specialism at all.
- It is important to note that these figures include Key Stages 3 and 4, and post-16, and it is likely that a much higher percentage of science post-16 teachers are specialist in their subject.

Teaching quality

- Most schools assess their teachers throughout the year, to check the quality of teaching in their school. Many schools make these assessments against Ofsted criteria. In the Ofsted report, 'Maintaining Curiosity', 68% of Key Stage 4 science lessons and 59% of Key Stage 3 science lessons were deemed good or outstanding. In the Ofsted report, 'Made to Measure'[6], 48% of maths teachers surveyed were deemed good or outstanding, with a lower number of good or outstanding teachers in Key Stage 3.

Ideas for improvement

- A school may find it easier to attract and retain specialists if it clearly prioritises science and is able to offer a reasonable proportion of specialist teaching on the timetable, as well as attractive facilities and professional development opportunities.
- If it doesn't already, your school may want to set up a way of assessing teaching quality internally. This is something that can be worked out between a governor and senior leaders. It will then show you whether your teaching quality differs across Key Stages or different ability groups.

[6] 'Made to Measure', *Ofsted*, 2012.

- Part of a governing body's responsibility is to decide on the total budget allocated to staff salaries. It is important for governors to understand how and why the chosen figure is used.
- As school leaders know only too well, there is no quick answer to finding enough good subject specialist teachers. One approach is to train your own, using the School Direct school-based training route, or upskill your teachers through intensive professional development courses (see T3).
- One course available is a subject knowledge enhancement (SKE) programme, available for maths, physics and chemistry as well as other subjects.
- Teach First, a charity attempting to address educational disadvantage, trains a high proportion of science and maths graduates to become new teachers.

Back to question list

T2. What opportunities are there for teachers and technicians to develop professionally and how are they encouraged to pursue them? These could include:

- **subject specific professional development courses**
- **engagement with subject associations**
- **keeping up to date with science through reading and networking**
- **sharing ideas with colleagues, for example peer-to-peer observation.**

Why this is important

- Science develops rapidly, and teachers need to develop and update their subject knowledge to maintain their teaching quality.
- It is important for teachers to keep their teaching techniques fresh – new ideas are coming along all the time, for example in practical work and the use of ICT in teaching.
- Teachers with in-depth subject knowledge and exciting teaching styles are more likely to inspire students to achieve their best and continue with science.
- In an Ofsted report from December 2013, 'Maintaining Curiosity', about science education, subject-specific continuing professional development was listed as a factor associated with outstanding science teaching. "Of the 64 schools where teachers had access to science-specific training, 17 schools were outstanding. This contrasts with the 25 schools where no recent science training had taken place; only one of these was outstanding."
- In another Ofsted report from 2012, 'Made to Measure'[7], schools are encouraged to develop the expertise of staff by ensuring policies are backed up by professional development.
- The impact reports[8] of the National Science Learning Centre show that after a continuing professional development course at the Centre, 99% of participants reported impact, including impact on subject knowledge, motivation and confidence, teaching skills and leadership and management; 76% reported impact directly on students.
- Research shows[9] that one of the most effective ways for teachers to learn about how to improve their teaching is through sharing ideas with colleagues. A Wellcome Trust study[10] has also shown the benefits of providing an environment where collaboration can thrive within schools – particularly across teaching science, technology and maths.

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7 'Made to Measure', *Ofsted*, 2012.
8 'Impact on participants', *Science Learning Centres*, 2012-13.
9 'Student achievement through staff development', *Joyce and Showers*, 2003.
10 'Working together: making STEM happen in secondary schools', *Wellcome Trust*, 2011.

Benchmarks
The largest source of high quality CPD (continuing professional development) courses for science education in the UK are through regional Science Learning Centre Consortia and the National Science Learning Centre in York (NSLC).

In 2012/13:

- **14,218 teachers and technicians and 5,213 schools used SLC courses for CPD.**
- **2,913 teachers used the NSLC (over 70% of secondary schools have used it since it opened).**
- **99% of participants in SLC courses – including teachers, teaching assistants and technicians – reported impact, with 76% of these reporting impacts directly on students.**

Ideas for improvement

- Governors should ensure that continuing professional development, including all of the elements mentioned above, is built into the schools' strategic plan.
- Governing bodies can also build useful partnerships with other schools, and learn from their expertise to improve both the governing body and other aspects of the school.
- Most schools will have policies and practices to encourage teachers of all subjects to share ideas and learn from each other. It can be useful for departments to compare notes on how they do this.
- The Teacher Development Trust has produced a CPD quality framework[11] (Appendix) – a detailed structure to rate the quality of CPD across several areas.

School or subject leaders may find it helpful to know about the following.

- Science Learning Centres offer up to date CPD courses across the country. Visit their website to find out more.
- There are **generous bursary schemes** which enable teachers and technicians to access the SLC courses at low or no cost and often include contributions to cover travel and other expenses. Project ENTHUSE helps fund participation at the NSLC and Impact Awards support other SLC courses.
- The Stimulating Physics Network support physics teachers by providing subject-based CPD, particularly for teachers without a specialist background in physics, as well as offering teaching and learning coaches, and have seen positive results for uptake to A level and GCSE Triple Science.
- The Further Maths Support Programme offer a range of support for CPD in maths.
- The National Centre for Excellence in the Teaching of Mathematics offers CPD courses for maths teachers.
- Subject associations can offer resources and support for teachers, including the Association for Science Education, Royal Society of Chemistry, Society of Biology and Institute of Physics.
- There are many schemes that recognise excellent teaching and contribute towards development, for example becoming a Registered Science Technician or a Chartered Science Teacher, and the Teacher Recognition Scheme.
- There are several science education themed conferences that take place in the UK every year. The Association for Science Education host an annual conference, usually in January. Other conferences include those from the Institute of Physics, the Big Biology Give Away and many more.

Back to question list

[11] 'National Teacher Enquiry Network', *Teacher Development Trust,* 2014.

T3. How do teachers inspire and engage their students?

Why this is important
It is important that teachers inspire and engage their students because:

- school lessons should be enjoyable and interesting to students and capture their imaginations; teachers play a huge role in inspiring students
- students who enjoy a subject are likely to try to achieve the best results possible, and continue with that subject through education and into employment.

Benchmarks
In the 2012 Wellcome Trust Monitor survey[12], a sample of 14-to-19-year-olds representative of the UK population were questioned on their attitudes to science at school.

- **82%** said school science lessons were very or fairly **interesting.**
- **58%** found science lessons **more interesting than maths**, and **58%** found them **more interesting than English.**
- Female students were more likely to find English more interesting than science compared with male students (32% versus 18%). Still, 51% of female students said they found science more interesting than English.

These results[13] show that, in general, young people enjoy science.

In a 2011 TIMSS report[14] of year 5 and year 9 pupils in England, **81% of year 5 students said they liked or somewhat liked learning mathematics and 58% of year 9 students said they liked or somewhat liked learning mathematics.**

You may wish to find out what your students think about science and maths by asking them the questions young people were asked for the Monitor survey.

- Overall, how interesting do you find science lessons at school?
- In general, how interesting do you find studying science compared with studying maths/English?
- Did you become more or less interested in learning science at secondary school compared with primary school?

In the same Monitor survey, young people were asked what encourages or discourages them to learn science. We found that the **most important factor was their teacher**.

The top answers for what encouraged them were:

- **Having a good teacher (58%)**
- Being interested in the subject (44%)
- The chance to learn about things relevant to real life (40%)
- The chance to carry out experiments (37%)

Some of the top answers for what discouraged them were:

- **Having a bad teacher (43%)**
- Finding the subject too difficult (31%)
- Finding the subject boring (24%)

For a full list of questions and results, see the Wellcome Trust Monitor Survey.

[12] 'The Wellcome Trust Monitor Wave 2', *Wellcome Trust*, 2012.
[13] 'The Wellcome Trust Monitor Wave 2: Science education data', *Wellcome Trust*, 2012.
[14] TIMSS 2011: mathematics and science achievement in England, *TIMSS and NFER*, 2011.

A report[15] by the National Foundation for Educational Research in 2013 also provides information on year 5 and year 9 students' interest in science in English schools.

- 85% of students agreed they learn interesting things in science.
- 74% of students thought there were interesting things to do in science lessons.
- 76% of students were interested in what their teacher was saying.
- 28% of students wished they didn't have to study science.

Ideas for improvement

- It's important for governors to get an understanding of the learning environment in their school. Learning walks, where governors visit a number of classrooms for a short time to see a range of lessons, and student questionnaires can be good ways to do this, which can then be fed back to the governing body and senior leadership team.
- If students are not enjoying science very much, increasing the amount or quality of their practical work might help (see question T5 and Facilities). Ensuring that science is seen as relevant by contextualising it, for example, with contemporary or workplace examples, may also help (see question C7). Students may also enjoy science and maths more if they engage with them informally, outside of science lessons, for example in extracurricular trips or other enrichment activities.
- A 2013 report from NFER[16] listed some ways to try to improve students' engagement in STEM (science, technology, engineering and maths) subjects, including:
    - Make links with real-life and cutting edge technology.
    - Use practical contexts for teaching and open-ended activities to foster creativity (see T4).
    - Offer clubs, STEM days and enrichment activities (see E1).
    - Embed links between STEM subjects in the curriculum.
    - Provide consistent, high-quality professional development for teachers (see T2).
    - Demonstrate the full range of STEM careers (see C8).
    - Find role models who challenge stereotypes.

Back to question list

T4. How many science lessons include practical work?

Why this is important

- Practical work in science increases[9] engagement and interest of students, and can help to motivate them to achieve their best. An Ofsted report from December 2013, 'Maintaining Curiosity', listed practical science as one of the most effective approaches to stimulate interest in science, and in turn raise achievement.
- It helps students develop a range of practical skills, science knowledge and understanding.
- It is important to prepare students for the practical component of science-related subjects at university, and science-related employment. Universities[17] and employers[18] increasingly complain about the poor practical skills of their new entrants.

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[15] 'Science education – have we overlooked what we are good at?', *NFER*, 2013.
[16] 'Improving young people's engagement with science, technology, engineering and mathematics', *NFER*, 2013.
[17] 'University teachers' views on the practical skills of science undergraduates', *Gatsby Foundation*, 2011.
[18] 'STEM employers' views on science skills of school leavers', *Gatsby Foundation*, 2011.

Benchmarks
Benchmarks have been provided from PISA, the Programme for International Student Assessment, which compares educational standards in different countries.

Table 2 shows activity levels reported in a PISA questionnaire[19] – unfortunately these data are from 2006 and do not necessarily show ideal levels of practical work. In 2006, the UK compared well with other countries, with more lessons on average spent doing some practical work than (for example) Finland, New Zealand and Japan.

Table 2: Frequency of students carrying out practical work in lessons

	Proportion of lessons that include practical work		
	England	Wales	Northern Ireland
In all lessons	-	3%	2%
In most lessons	24%	17%	16%
In some lessons	62%	67%	66%
Never or hardly ever	11%	13%	16%

Ideas for improvement
If you think your school is not doing enough practical science, governors may like to ask the following questions of the senior leadership team:

- Are teachers well supported by laboratory technicians and equipment? If not, how can these be built into future budgets and strategic plans?
- Are teachers able to access enough professional development to improve their practical skills?

School leaders may also like to consider the following questions:

- Is science taught in properly equipped classrooms for most of the time?
- Are teachers well supported by laboratory technicians? (See question F3.)
- Are teachers confident about doing experiments? Sometimes, if teachers are teaching outside their subject specialism, they may be reluctant to try experiments that are unfamiliar to them. Professional development may help here. (See questions T1 and T2.)
- Are teachers spending so much of their time preparing for exams that they do not have time for practical work?

School leaders are responsible for deciding which exam boards they use. Governors should have an awareness of which exam boards are chosen when thinking about the curriculum as a whole. It is important to think about the reasons behind choosing a particular exam board and the boards vary in the way they approach practical work (bearing in mind that the exam regulator Ofqual has a responsibility to ensure that exam boards are setting equally difficult exams in a given subject).

Subject leaders may find the following information useful.

- CLEAPSS is a membership organisation which offers support for practical science and technology, with helpful guidelines and resources. Most schools are members of CLEAPSS, but it is worth checking if yours is.
- The Institute of Physics, Society of Biology and Royal Society of Chemistry have created a series of websites where you can find free ideas and resources. www.practicalphysics.org, www.practicalchemistry.org, and www.practicalbiology.org.

[19] 'Practical experiments in school science lessons', *DfE*, 2011.

- The Association for Science Education provides a wide range of resources through its open access website, www.schoolscience.co.uk, as well as links to other partner organisations through the ASE website.
- The National STEM Centre eLibrary includes over 7,000 teaching resources, and has grouped those that relate to practical work together based on curriculum focused topics for each of the separate sciences. www.nationalstemcentre.org.uk/sciencepractical.

Back to question list

Results: How do your school's students perform in science and maths?

Results are not the only way to measure the quality of science and maths teaching, but they do enable students to progress into further and higher education and can show the relative quality of teaching and learning when compared across subjects (R1) and enable monitoring over time (R2). It is important to review results in the light of student choice and uptake in different subjects (see Choice section, in which we also look at different groups of students).

R1. How do results in the core sciences at GCSE and A level (if appropriate) measure up (a) against other subjects in the school, especially maths and English, and (b) nationally?

Why this is important

- Qualifications at GCSE and A level enable students to progress to further and higher education, and some areas of employment.
- Comparisons against other subjects can show the relative quality of teaching and learning across different subjects.
- Exam results are used to hold the school to account through league tables and Ofsted ratings. It is also important to understand whether any demographic factors affect student performance – these issues are considered in more detail in the section on student choice.

Benchmarks

Your school will have abundant data from RAISE Online and the Fischer Family Trust to enable it to benchmark and monitor results. However, the following information may be useful.

The percentages of different grades achieved at GCSE[20] (JCQ data) level in 2013 in England for science and maths, with English included for comparison, are shown in Table 3.

- In England, it is compulsory for students to study science and maths at Key Stage 4, which for the majority of students is through GCSEs. The most common GCSE options for science are: science and additional science GCSEs, which are a combination of biology, chemistry and physics; and triple science, which is three separate GCSEs in biology, chemistry and physics.

The percentage of different grades achieved at A level[21] in 2013 in England for science and maths, with English included for comparison, is shown in Table 4. It is essential that your school's data are interpreted in conjunction with the number of entrants in the examinations for which there is choice – that is, it is reasonable to compare your students' performance in GCSE maths with a national level, but your students' performance in physics, say, may be higher than the national average if only a small proportion of students choose this subject.

[20] GCSE Examination results, *JCQ*.
[21] A level Examination results, *JCQ*.

Table 3: 2013 GCSE results

Subject	Percentages of each grade achieved at GCSE in each subject: A*-A	A*-C
Science	8.2	53.0
Additional science	11.6	63.9
Biology	40.5	89.8
Chemistry	42.0	89.9
Physics	41.3	90.8
Maths	14.2	57.7
English	14.2	63.7

Table 4: 2013 A level results

Subject	Percentages of each grade achieved at A level in each subject: A*-A	A*-C
Biology	28.2	73.5
Chemistry	33.4	79.3
Physics	31.3	73.8
Maths	42.9	80.9
Further maths	56.3	89.9
English	20.6	79.5

Ideas for improvement

- School leaders will have whole-school improvement strategies designed to maximise exam performance across all subjects, and subject leaders will have their own strategies in place. We hope that these questions for governors can act as a basis for a school self-assessment and help school leaders focus on areas of and strategies for improvement.
- You may wish to consider whether your school has the right balance between teaching students the subjects which are most valuable to them and those in which they can achieve the highest grades. Some students may not choose to study science or maths if they feel they cannot achieve the highest grades. In fact, Tables 4 and 5 show that students who choose to take single science GCSEs and science and maths A levels generally get relatively high grades. But more students may benefit from taking science and maths and getting lower grades than they might have achieved in some other subjects, or from raising very low grades or fails in science and maths to modest passes at the expense of higher performance in some other subjects. This is because many universities consider science and maths as 'facilitating[22]' subjects and place a high value on them.

Back to question list

R2. What is the trend over time for results?

Why this is important

- The trend in results indicates how changes in the school environment and student intake might affect students' attainment.

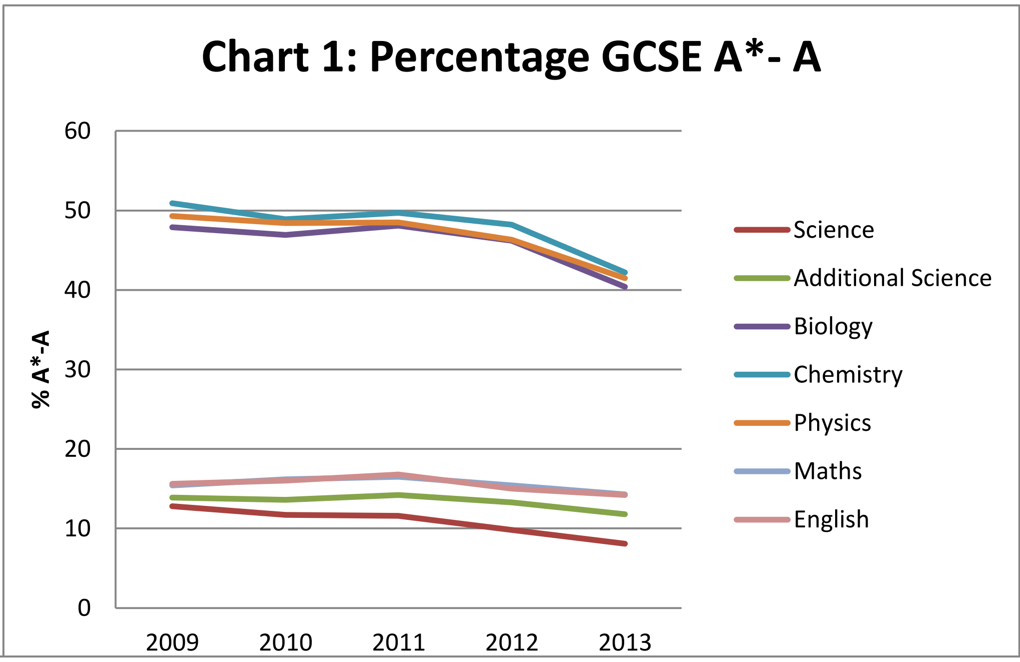
[22] 'Facilitating' subjects are subjects that the Russell Group universities have identified as opening doors to the widest range of degree subjects. See Russell Group publication 'Informed Choices'.

- There has been much turbulence around exam standards in recent years, as the Department for Education and Ofqual seek to put an end to grade inflation by 'toughening up' examinations. This makes it hard to tell whether changes in your own school's results are due to changes in the school's own situation, without referring to changes over time at the national level.

Benchmarks
Your school will have abundant data from RAISE Online and the Fischer Family Trust to enable it to benchmark and monitor results. However, the following information may be useful.

<u>GCSE</u>
Charts 1 and 2 illustrate the grade breakdown at GCSE for science, maths and English in England and how this has changed over the past five years, with the data in Table 5.

- There has been a **slight decrease in the numbers of students achieving grades A*-A** in the past two years, particularly for biology, physics and chemistry GCSE.
- The results for A*-C have been more steady, although there was a decrease in the number achieving a grade C last year.
- Results achieved for biology, chemistry and physics are generally much better than maths, English and general science GCSEs; however, fewer candidates are entered for triple science.



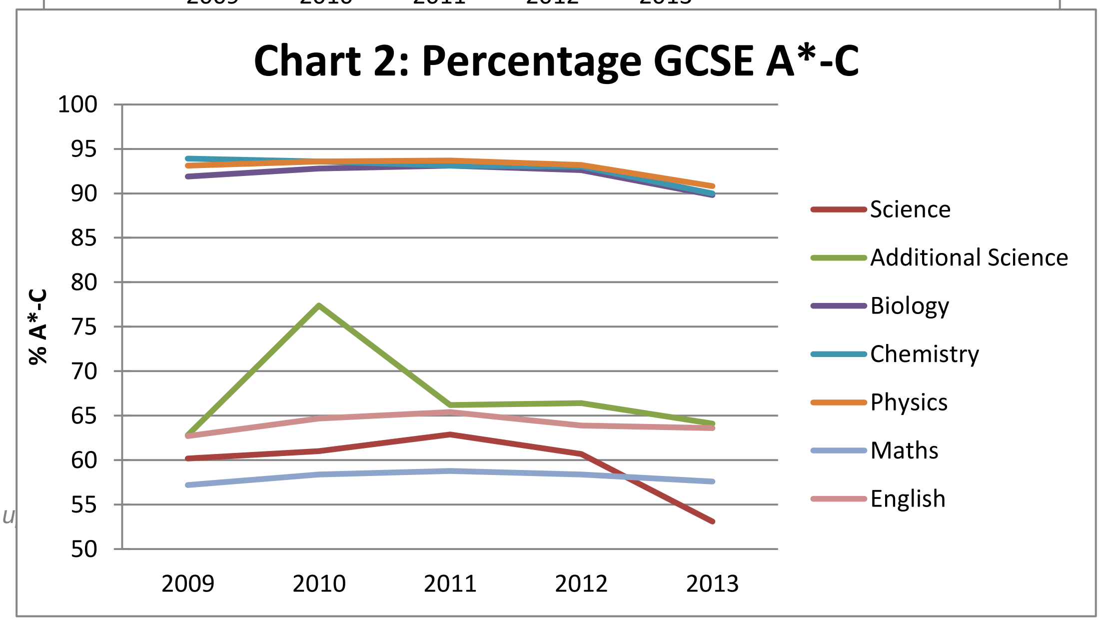


Table 5: GCSE results in science and maths 2009–2013

	Percentages of grades at GCSE across five years									
	2013		**2012**		**2011**		**2010**		**2009**	
Subject	A*-A	A*-C	A*-A	A*-C	A*-A	A*-C	A*-A	A*-C	A*-A	A*-C
Science	8.2	53.0	9.5	56.0	11.8	63.1	11.9	61.0	13.0	60.3
Additional Science	11.6	63.9	13.3	66.5	14.2	66.3	13.6	64.7	14.0	62.8
Biology	40.5	89.8	46.4	92.6	48.5	93.2	47.2	92.9	48.5	91.9
Chemistry	42.0	89.9	48.2	93.0	49.9	93.1	49.0	93.6	51.4	94.0
Physics	41.3	90.8	46.4	93.2	48.6	93.7	48.7	93.7	49.9	93.2
Maths	14.2	57.7	15.3	58.3	16.5	58.8	16.2	58.5	15.3	57.3
English	14.2	63.7	15.0	64.2	17.0	65.5	16.1	64.8	15.7	62.6

A level

Chart 3 and Table 6 show the grade breakdown at A level for science, maths and English in England, and how this has changed over the past five years.

- The number of students getting **A*-A has been consistent** for the past 5 years. Further maths has a very high percentage of A*-A (57-59%), maths is also high (43-45%) and the three sciences are lower, but still relatively high (28-35%).
- This may be because more able students are entered into science and maths A levels – your school's data should be interpreted in the light of what proportion of students are entered into the different exams.
- It is beneficial for students to take maths and further maths A levels, even if they are not likely to achieve the highest grades. Maths A level opens doors for many employment opportunities and on average gives school leavers an increased salary[23].
- The numbers of students getting A*-C and A*-E **is increasing**, particularly for the three sciences.

[23] 'The labour market value of STEM qualifications and occupations', *Royal Academy of Engineering,* 2011.

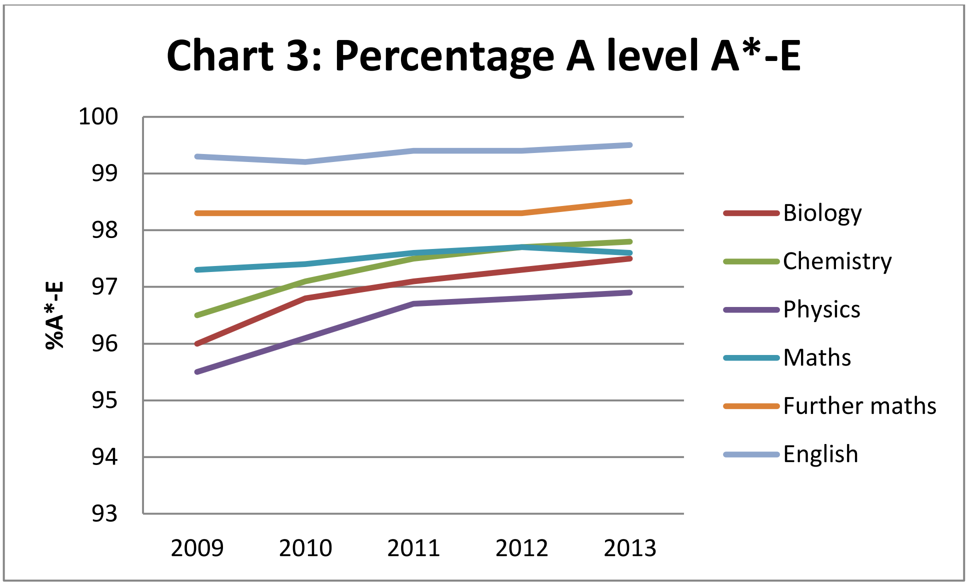


Table 6: A level results in science and maths 2009–2013

	Percentage of grades at A level across five years									
	2013		2012		2011		2010		2009	
Subject	A*-A	A*-C	A*-A	A*-C	A*-A	A*-C	A*-A	A*-C	A	A-C
Biology	28.2	73.5	28.3	73.4	27.8	72.8	27.8	71.9	27.3	69.6
Chemistry	33.4	79.3	34.2	78.9	34.0	78.0	34.1	76.9	34.0	75.8
Physics	31.3	73.8	32.1	73.9	33.2	73.4	33.0	72.6	32.2	70.5
Maths	42.9	80.9	43.7	81.3	44.4	81.5	44.5	81.4	44.8	81.4
Further maths	56.3	89.9	57.1	89.3	57.5	89.4	58.6	89.8	58.1	89.4
English	20.6	79.5	21.1	78.0	22.1	78.7	23.0	77.5	22.8	78.1

Ideas for improvement

- School leaders will have whole-school improvement strategies designed to maximise exam performance across all subjects, and subject leaders will have their own strategies in place. These questions can act as a basis for a school self-assessment, and to help school leaders focus on areas of improvement.
- As noted in the comments to R1, you may wish to consider whether your school has the right balance between teaching students the subjects which are most valuable to them and those in which they can achieve the highest grades.

Back to question list

Choices: What options do students have for studying science, maths and related subjects, and what do they choose?

Uptake of a subject at GCSE and A level gives a good indication of the quality of teaching of that subject. If students are taught well and engaged in lower years, they are more likely to choose to continue with science and maths at A level. The same is true for university options, employment and vocational routes after school.

In order to give students the greatest opportunities for employment and further education, they need to be able to make the best-informed decisions as early as possible. This covers GCSE choice (C1), A level options (C2 and C3) and ensuring they are equipped with knowledge of further education (C4) and careers (C7). It's also crucial to provide equal opportunities for all students (C6).

C1.
Are triple science GCSEs (i.e. separate physics, chemistry and biology) available for all students? What proportion of students take them?

Why this is important

- Allowing students the option to study each science subject separately gives them the opportunity to study the subjects in greater depth than with single or double combined science.
- There is a strong correlation between taking triple science at GCSE and studying science at A level. Triple science takes students further and deeper than double award combined science, though it is important to recognise that double award can be an appropriate preparation for A level.
- Having specialist triple science teaching available at GCSE can be a way of attracting specialist science teachers to apply for jobs at your school, and of retaining them. Physics specialists, for example (who are hard to come by), generally like the opportunity to teach their specialist subject at least some of the time.
- As taking triple science gives students the greatest opportunities for continuing with STEM (science, technology, engineering and maths) subjects, it can be beneficial to offer triple science to weaker students, even if they won't achieve the highest grades.
- Learning physics, chemistry and biology as separate subjects makes clear the separate identity of each – important when students come to make A level choices.

Benchmarks

In 2012, DfE data indicated that **84% of schools offered triple science** GCSE, and around **23% of students took triple science** exams.

Students at state schools must study all of biology, physics and chemistry up until the end of Key Stage 4, although they can be combined as in Additional Science.

Ideas for improvement

- School leaders will undoubtedly have considered the advantages and disadvantages of offering triple science, but for more advice, the DfE-funded Triple Science Support Programme aims to provide information and support for schools developing and delivering triple science.
- It is important to recognise that triple science has more content than double award combined science, and therefore needs more time to teach. It can be counterproductive to try to squeeze triple science into the same amount of time as double award. The Ofsted report from December 2013, 'Maintaining Curiosity', stated

that one way to improve achievement in science is to allow more time for triple science, for example, by starting it in year nine.

Back to question list

C2. (For schools with post-16 provision) Are all three major sciences available for study at AS and A level? Is further maths available at AS and A level as well as maths?

Why this is important

- Students should have the greatest opportunities to study STEM (science, technology, engineering and maths) subjects in higher and further education, or to enter into STEM apprenticeships and careers.
- Universities often require specific A level subjects for entry – for example, maths is required for entry to study physics – and many leading universities require further maths A level from applicants to study engineering.

Benchmarks

Table 7 shows the number of schools with sixth forms that enter students into each of the sciences at A level in England[24].

- **Each of the core science A levels is offered by over 90% of schools with sixth forms.**
- **98%** of schools have students taking **at least one core science A level.**

Table 7: Numbers of schools with students taking STEM subjects

Subject	Total number of schools with students progressing to each A level	% of total number schools teaching A levels
Physics	2,465	92
Chemistry	2,527	95
Biology	2,581	97
No science	57	2

- Across the UK, **57% of all educational institutions offered further maths in 2009**, comprising 56% of maintained schools, 72% of independent schools and 85% of sixth form and further education colleges.
- DfE data also show that in 2009, 13% of A level maths students at state schools also took A level further maths, whereas at independent schools the figure was 21%.

Ideas for improvement

- It can be difficult for schools with small numbers taking A levels to sustain subjects like physics and further maths where numbers may be particularly low. School governors and leaders may have to decide whether to support uneconomical numbers, or to make arrangements for their students to take these subjects in other local schools or colleges.

[24] Direct communication, *DfE*, 2012.

- The Institute of Physics works to help schools promote physics during education and into employment.
- The Further Maths Support Programme exists to support students and schools to take further maths even when numbers are low.

Back to question list

C3. What proportion of students choose to continue each of the sciences (physics, chemistry and biology) and maths at A level?

Note that this figure may be harder to get hold of in schools which have no post-16 provision, because they would have to get the data from the post-16 institutions which they feed into.

Why this is important

- A level is the gateway to university study, and there is strong evidence[25] that people with STEM (science, technology, engineering and maths) qualifications are better paid and more employable.
- By and large, students are more likely to choose a subject for A level study if it has been well taught, by a teacher who inspires interest, as well as getting good exam results. A level choice is a 'thermometer' for inspirational and effective teaching. It is quite common for schools to do much better in one science than another on this measure, and this can be revealing about the relative strengths of the science departments.
- An Ofsted report from December 2013, 'Maintaining Curiosity', stated that school governors should be monitoring the progression of students to science A levels in their school against national averages, and taking action to tackle any shortfall.

Benchmarks

Chart 4 and Table 8 show the percentages of students that took A levels in each of the sciences and maths in England in 2012[26] Please note that these levels are not necessarily ideal – if your school performs at or above these benchmarks, it may still wish to increase the number of students taking science and maths A levels.

[25] 'The labour market value of STEM qualifications and occupations', *Royal Academy of Engineering*, 2011.
[26] Direct communication, *DfE*, 2012.

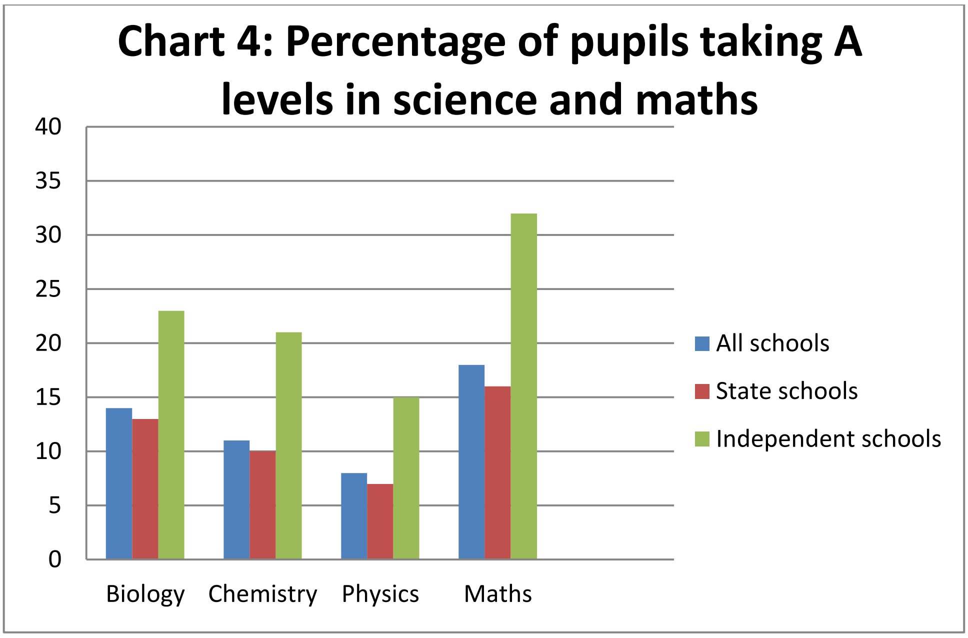


Table 8: Percentage of students taking A levels in science and maths		
	All schools	**State schools**
Subject	**% students**	**% students**
Biology	14	13
Chemistry	11	10
Physics	8	7
Maths	18	16

NB These figures may be slight over-estimates. ***All schools with <5 students taking a subject have been rounded up to 5.***

Ideas for improvement
If governors think that not enough students in their school are choosing science A levels, they could ask school leaders to report on some of the questions below.

- Are we spending too much time preparing for GCSEs, and so putting learners off science and maths?
- Are we doing enough interesting hands-on practical work? (See T4.)
- Do our teachers have up-to-date subject knowledge and teaching skills?
- Are we placing science and maths in the context of careers and the world around us? (See question C7 for information on careers.)
- Could students become more motivated to learn about science and maths if they engaged with them more informally, outside of science lessons, for example in extracurricular trips or other enrichment activities?
- Does the school convey to students that, although maths and sciences may seem harder than some other A levels, they have additional value in opening doors to future courses of study and future careers?

Back to question list

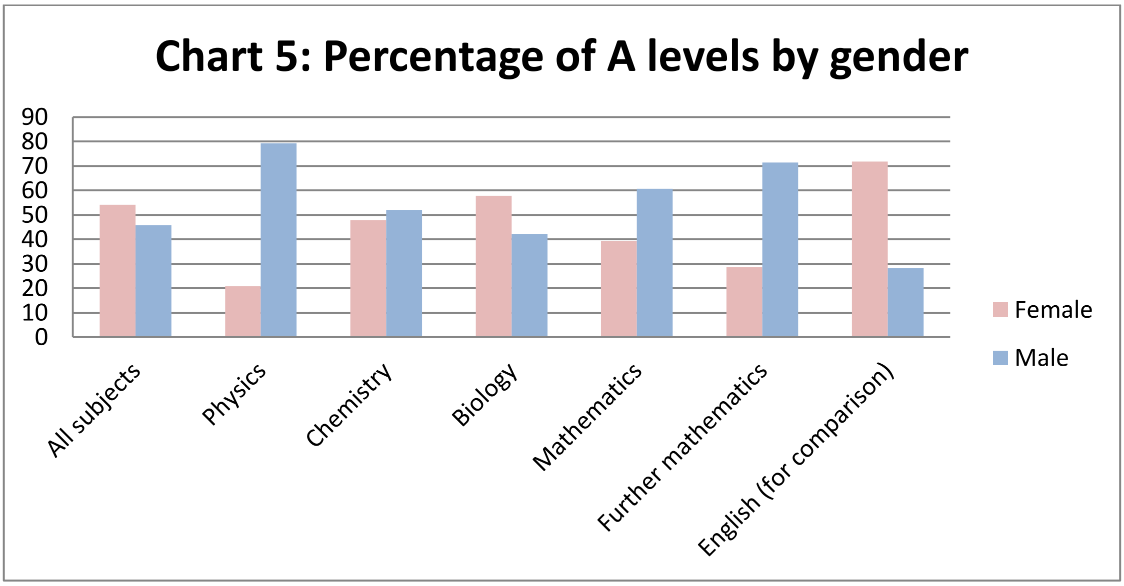
C4. What proportion of students choosing each of physics, chemistry, biology and maths are female?

Why this is important

- It is common for there to be differences in the gender breakdown of students choosing science and maths A levels, particularly physics and further maths. The low proportion of girls taking A level physics is a serious concern, given the shortage of physics graduates for the economy in general and in teaching in particular.
- As A level study leads on to university applications, gender differences at this stage can continue through higher education and into careers.
- Given the evidence[17] that STEM (science, technology, engineering and maths) qualifications lead to a wider range of well-paid and interesting jobs, gender imbalances suggest that in some subjects girls are closing down their options to a greater extent than boys.

Benchmarks

Chart 5 and Table 9 show the percentages of all A levels that were taken by male and female students in England in different subjects in 2013. They illustrate the lower uptake of female students taking physics and maths A levels compared with male students (with the opposite trend for English, for comparison). These gender differences are not inherent – in single sex schools the differences are reduced[27], as well as in some independent schools, and they are not evident or sometimes occur in the other direction in different countries. We hope that schools will aspire to perform better than our national benchmarks and strive to eliminate gender differences in the uptake of different subjects.



[27] 'It's different for girls', *Institute of Physics*, 2012.

Table 9: Percentage of A levels in different subjects taken by female students

Subject	Percentage of A level taken by female students
All subjects	**54.2**
Physics	20.7
Chemistry	47.9
Biology	57.8
Maths	39.2
Further maths	28.6
English (for comparison)	71.7

Ideas for improvement

- In the Ofsted report from December 2013, 'Maintaining Curiosity', school governors were advised to monitor the gender differences of students taking A levels and tackle any significant imbalances.

There are many ways that school leaders may begin to address gender imbalances.

- The Institute of Physics has done extensive research[28] into gender imbalance, and possible ways to improve it, which will be of interest to the school's physics teachers.
- It is important that all options are extended to all students – worryingly, only 59% of the female 14-to-19-year-olds questioned felt they were able to choose their preferred science options, compared with 76% of male respondents, in a nationally representative survey of the UK (Wellcome Trust Monitor in 2012).
- Schools should work to ensure that they do not reinforce negative stereotypes and be aware of and work against any unintentional subconscious biases that may do so.
- See WISE for more resources and ideas to address gender imbalance.

Back to question list

C5. What proportion of students choosing A level science and maths qualify for the pupil premium? How does this compare with all pupils?

Why this is important

- It's important for all students to have equal opportunities and encouragement to study all subjects at A level, including science and maths.
- A level choice leads on to university and employment opportunities, so decisions students make at this stage influence their options later in life.
- Students from disadvantaged backgrounds still make up a lower proportion of entrants to academically selective universities[29].
- The Sutton Trust report says "poor advice may contribute to the low progression rates in many comprehensive schools and Further Education colleges".

Benchmarks

[28] 'Closing Doors: exploring gender and subject choice in schools', *Institute of Physics,* 2013.
[29] 'Sutton Trust submission to Sir Martin Harris', *Sutton Trust,* 2010.

In Table 10 we are using Free School Meals (FSM) pupils to benchmark, as this is a very similar group to those on pupil premium. The data shows the progression of FSM and non-FSM pupils who achieved at least grade C at GCSE for students progressing to A level in 2013.

Table 10: Progression rates for FSM and non-FSM pupils who achieved at least grade C at GCSE

		Proportion of pupils progressing from GCSE to A level	Proportion of pupils progressing from GCSE additional science to A level
Biology	Non-FSM	26%	7%
	FSM	22%	6%
	Total	26%	7%
Chemistry	Non-FSM	23%	5%
	FSM	21%	5%
	Total	23%	5%
Physics	Non-FSM	16%	3%
	FSM	10%	2%
	Total	15%	2%
Maths	Non-FSM	14%	-
	FSM	8%	-
	Total	14%	-

- Your school should have data on the proportion of students eligible for pupil premium, and the number of students taking science and maths A levels. If the proportion of pupils eligible for pupil premium studying science and maths is much lower than the total proportion, you should look at why those students are not choosing science and maths.
- It may also be useful to compare your percentages to similar local schools.

Ideas for improvement

- Pupil premium spend should be allocated appropriately to improve the education of those students eligible for it. If there are issues around the number of students choosing science and maths A levels, you may want to look again at how the pupil premium funding is allocated.
- In a 2012 Ofsted report on effective pupil premium spending, active involvement of governors was listed as a key factor for effectively using pupil premium. Governors were encouraged to:
    - be fully involved from the outset in where funding should be allocated
    - have a clear policy on how pupil premium is spent
    - ask challenging questions of the headteacher to ensure pupil premium is spent effectively
    - have effective monitoring and evaluation procedures in place.
- If students eligible for pupil premium aren't choosing science and maths A levels, it is important to find out why. It is beneficial to try to build strong relationships with parents and the local community, and to promote the benefits of maths and science to them.
- One aspect that has been seen to influence students' choices is their aspirations[23]. A report from the Wellcome Trust (to be published soon) details the issues associated with low aspirations, especially from socially disadvantaged young people, in relation to science and maths. It also identifies how some schools improved their students' aspirations with:

    - a clearly communicated school ethos
    - awards for good behaviour and achievement
    - strong links with parents and the local community.
- The Russell Group has produced guidelines[30] for choosing what subjects to study at A level, and came up with a list of 'facilitating subjects' – those which they think offer the best range of choices for study at university. This list of subjects includes physics, chemistry, biology, maths and further maths, as well as English literature, geography, history and languages.

Back to question list

C6. (For schools with post-16 provision) What proportion of A level students choose to study STEM (science, technology, engineering and maths) subjects at university?

Why this is important

- There is evidence[17] that, on average, STEM higher education qualifications lead to a wider range of well-paid and interesting jobs.
- Students are more likely to choose to continue with a subject at university if they have enjoyed it and felt successful at A level. The number of students choosing to continue with STEM subjects at university could indicate the quality of STEM teaching at A level, and the extent to which their teachers have inspired them to continue with a subject.

Benchmarks

- Table 11 shows the average percentage of acceptances for subjects related to science and maths to UK universities in 2012. As shown, **biology, chemistry, physics and maths each make up 1-1.7%** of the total number of accepted university places. With percentages so low, it is unrealistic to expect schools to be able to monitor numbers of applicants for individual STEM subjects in any given year, so it would be best to look at numbers over several years or to look at the STEM subject group.

[30] 'Informed choices', *Russell Group*, 2013.

Table 11: Percentage of accepted UK university places in science and maths related subjects (2012)

Subject	Percentage of total acceptances
Medicine and dentistry	2.1
Subjects related to medicine (includes ophthalmics, pharmacology and nursing)	10.1
Biological sciences	8.8
- **Biology**	- 1.2
- **Psychology**	- 3.7
- **Sport science**	- 2.2
- **Zoology**	- 0.4
- **Other**	- 1.3
Vet science and related	0.9
Physical sciences	4.2
- **Chemistry**	- 1.0
- **Physics**	- 1.0
- **Other**	- 2.2
Mathematical sciences	1.9
- **Mathematics**	- 1.7
- **Other**	- 0.2
Engineering	5.6
Computer sciences	3.9
Technologies	0.5
Total STEM subjects	**38**
Law (for comparison)	5.0
English (for comparison)	2.2

Ideas for improvement

- If school governors or leaders have concerns about numbers going on to take STEM subjects at university, you may want to look at your school's career guidance policies and UCAS applications processes, as well as the way A levels are taught.
- It is equally important (though not always easy) to track the progress of students who are following vocational and technical routes rather than the university route. See C7.

Back to question list

C7. Are students able to easily access post-16 vocational courses in the local area for science, engineering and technology? What proportion of students choose to go on to vocational study or an apprenticeship in a scientific or technical field?

Why this is important

- Vocational courses or apprenticeships are great alternatives to A levels for many students and can lead to a wide range of employment opportunities in STEM (science, technology, engineering and maths) fields, for example becoming a science technician. This is also a very popular route into engineering.

- The number of students choosing these alternatives to academic routes indicates the popularity of STEM, and how well teachers understand the needs of students of all academic abilities.
- Vocational courses are not often offered at schools, so it is important that students have enough information about where and what vocational courses are available locally to decide whether to pursue them.
- School leaders should be concerned if their leavers are choosing to go to university when they would be better off on a vocational course or an apprenticeship.

Benchmarks

- Further education is a huge sector with many options for young people and adults. As a result, benchmarking data is very difficult to get hold of, particularly for vocational qualifications. **The most important thing is that students have full access to information about the opportunities available to study for vocational qualifications in further education.** Usually these opportunities will be in further education colleges rather than in the school.
- The DfE's tables on employment[31] destinations should make it possible to benchmark your school against others on employment destinations as well as universities. They show the number of school leavers continuing with education, entering sustained employment, and not in education, employment or training (NEET). This will be useful to see what routes students are choosing after they leave school, not just those choosing to go to university.

From 2016 onwards, the new vocational qualifications (see tables 12 and 13) will be included in Key Stage 4 performance data[32].

Table 12 shows the different levels of qualifications in England, and examples of each, taken from the QCF (Qualifications and Credit Framework).

Table 12: Levels of qualifications in England

Example qualification	Level
Doctoral degree	8
Master's degree Postgraduate study	7
Bachelor's degree	6
NVQ level 4 Vocational qualification level 5	5
AS and A level NVQ level 3	3
GCSEs grade A*-C Vocational qualifications level 2 NVQ level 2	2
GCSEs grade D-G NVQ level 1 Vocational qualifications level 1	1
Functional skills entry level Entry level certificates	Entry

Table 13 is a guide to the range of further education pathways that came out of recent post-16 education reform and some examples of what is available.

[31] 'Destinations of key stage 4 pupils and key stage 5 pupils', *DfE,* 2011.
[32] 'Key stage 4 performance tables', *DfE,* 2013.

Table 13: Further education pathways available post-16

	Apprenticeships	Academic	Applied general	Technical level
Description	Combines practical training in a job with study. Gains job-specific skills and works towards a related qualification. Earns a wage.	Advanced qualifications in a subject, usually leading on from GCSEs. Achieves broad knowledge base in chosen subject.	Broader study than technical level, offering advanced study through applied learning.	Leads on to recognised occupation and is specific learning for that occupation.
Qualification	Intermediate (equiv 5 GCSE passes), Advanced (equiv 2 A levels), Higher (leads to NVQ level 4)	AS and A levels (all level 3)	All level 3 vocational qualifications e.g. NVQ level 3	All level 3 vocational qualifications e.g. NVQ level 3
Examples	Huge range from many sectors including: laboratory and science technicians, engineering (chemical, automotive etc.), nursing.	Physics, chemistry, biology etc.	DfE have produced a list of Applied General qualifications, including diplomas in engineering, health care and science.	DfE have produced a list of Technical Level qualifications, including in engineering and health care.
More information	Apprenticeships.org.uk	DfE info on A levels	DfE info	DfE info

Ideas for improvement

- Leaders will want to make sure that their guidance policies give students full access to a wide range of vocational as well as academic courses, and that they have a chance to visit colleges and meet their students, as well as visiting universities. For more information see C7 and E2.

Back to question list

C8. What opportunities do students have to find out about further and higher education (A levels and university courses) or careers that they could follow in STEM?

Why this is important

- Students need to be fully informed of options that are available to them after education.
- Science and maths are essential for many areas of work, not just for students who hope to become scientists or mathematicians.
- Young people often have a limited and stereotyped view of job and study opportunities in STEM (science, technology, engineering and maths). Showing such opportunities at first hand helps to widen their view and can break down stereotypes by providing role models.

- Offering students encounters with employers helps them when applying for university, further education, apprenticeships and employment. See E1 for more information on enrichment opportunities. Universities also look for extra-curricular commitments and work experience in a student's personal statement.

Benchmarks
The Gatsby Charitable Foundation has produced a report on benchmarks of good practice in school career guidance (to be published in May 2014). There are several benchmarks that may be useful for science and maths career guidance in your schools. Table 14 shows how well secondary schools in England that took part in the survey met each element within the benchmark.

Table 14: How well schools meet career guidance benchmarks

	% of schools that meet each element within the benchmark
1 A careers programme	
Every school should have a structured careers programme that has the explicit backing of the senior management team, and has an identified and appropriately-trained person of authority responsible for it.	71%
The careers programme should be published on the school's website in a way that enables pupils, parents, teachers and employers to understand the school's offer in this area.	19%
The programme should be regularly evaluated with feedback from pupils, parents, teachers and employers as part of the evaluation process.	66%
2 Learning from career and labour market information	
By the age of 14, all pupils should have accessed and used information about career paths and the labour market to inform their own decisions on study options.	20%
Parents and carers should be encouraged to access and use information about labour markets and future study options to inform their support to their children.	72%
3 Addressing the needs of each pupil	
A school's careers programme should actively seek to challenge stereotypical thinking and raise aspirations.	73% (stereotypes) 88% (aspirations)
Schools should keep systematic records of the individual advice given to each pupil, and subsequent agreed decisions.	56%
All pupils should have access to these records to support their career development.	42%[D]
Schools should collect and maintain accurate data for each pupil on their education, training or employment destinations after they leave school.	79%
4 Linking curriculum learning to careers	
By the age of 14, every pupil should have had the opportunity to learn how the different STEM subjects help people to gain entry to, and be more effective workers within, a wide range of	20%

careers.	
5 Encounters with employers	
Every year, from the age of 11, pupils should participate in at least one meaningful encounter with an employer.	39%
6 Experiences of workplaces	
By the age of 16, every pupil should have had at least one experience of a workplace, additional to any part-time jobs they may have.	46%
By the age of 18, every pupil should have had one further such experience, additional to any part-time jobs they may have.	30%
7 Encounters with further and higher education	
By the age of 16, every pupil should have had a meaningful encounter with providers of the full range of learning opportunities, including 6th forms, colleges, and apprenticeship providers. This should include the opportunity to meet both staff and pupils.	23%
By the age of 18, all pupils who are considering applying for university should have had at least two visits to universities to meet staff and pupils.	21%
8 Personal guidance	
Every pupil should have at least one such interview by the age of 16, and the opportunity for a further interview by the age of 18.	44% (age 16) 22% (age 18)

Engagement with STEM professionals

Every guideline agrees that **all secondary school students should have some interaction with employers before they leave formal education**. This is expected to be organised through the school, outside of the normal curriculum.

- STEM Ambassadors are a network of professionals from STEM related careers and areas of study that visit schools to inspire young people. A study[33] showed that 9 out of 10 secondary schools engaged with STEM ambassadors at least once a year.
- All parts of the UK have national programmes to promote employee and professional engagement with schools, particularly between the ages of 14 and 19.

The Education and Employers Taskforce works to research best practice and support schools and colleges. The following data shows results from a survey they carried out with 368 students in 2009:

- 83% had undertaken a week of work experience or more
- 58% had taken part in a workplace visit
- 34% had been involved with an enterprise activity
- 46% had listened to a visitor from a business environment.

This does not represent the whole population, and is not STEM focused. However, it is particularly important for students to meet STEM professionals as choices that are made at quite young ages about STEM open doors to a range of careers later in life.

[33] 'An evaluation of the impact of STEMNET's services on pupils and teachers', *NFER*, 2011.

In the Wellcome Trust Monitor, 61% of 14-to-19-year-olds questioned had taken part in work experience, and 28% said their work experience was in a STEM field. Fewer young women than young men have done STEM work experience.

Ideas for improvement

- All schools should have a careers plan that governors are aware of and that careers guidance is monitored against. The benchmarks listed in the Gatsby Charitable Foundation report may help guide your career plan.
    - Every school and college should have an embedded programme of career education and guidance that is known and understood by pupils, parents, teachers, governors and employers.
    - Every pupil, and their parents, should have access to good-quality information about future study options and labour-market opportunities. They will need the support of an informed adviser to make best use of available information.
    - Pupils have different career guidance needs at different stages. Opportunities for advice and support need to be tailored to the needs of each pupil. A school's careers programme should embed equality and diversity considerations throughout.
    - All teachers should link curriculum learning with careers. STEM subject teachers should highlight the relevance of STEM subjects for a wide range of future career paths.
    - Every pupil should have multiple opportunities to learn from employers about work and employment and the skills that are valued in the workplace. This can be through a range of activities such as visiting speakers, mentoring, enterprise schemes and a range of other enrichment activities.
    - Every pupil should have first-hand experiences of the workplace through work visits, work shadowing and/or work experience to help their exploration of career opportunities and to expand their networks.
    - All pupils should understand the full range of learning opportunities that are available to them. This includes both academic and vocational routes and learning in schools, colleges, universities and the workplace.
    - Every pupil should have opportunities for guidance interviews with a career adviser, who could be internal (a member of school staff) or external, provided they are trained to an appropriate level. These should be available whenever significant study or career choices are being made, timed to meet the individual needs of each pupil.
- Governors can often use their own professional networks to help students connect with employers and perhaps provide work experience.
- STEM Ambassadors are professionals working in science, technology, engineering or maths fields who can come and talk to students about career options. For more information, see question E1.
- Speakers for Schools is a charity that provides state schools with talks from industry-leading figures for free.
- The National STEM Centre has many career focused resources to help promote STEM careers in the classroom.
- Many enrichment activities also have career focused aspects, for example the Big Bang Fair.

Back to question list

Facilities: What science and maths facilities are available to your students?

For a high quality science education, it is essential to give students plenty of hands-on practical experience. To do this, your school needs to have adequate facilities to carry out those practical investigations (F2) and sufficient budget allocated (F1) to provide the equipment and technician support (F3).

F1. Is a reasonable amount of the school budget spent on science and maths equipment and facilities?

Why this is important

- A high quality science education should include well-resourced practical work using scientific equipment where appropriate. Practical work is an essential component of science education, as discussed in question T5.

Benchmarks

SCORE (Science Community Representing Education) has produced detailed information[34] on equipment and consumables that schools should have as part of their science provision.

The list is broken down into the following categories:

- Equipment type (consumables, general, glassware, IT, modelling, safety etc.)
- Curriculum category (electricity, plant biology, energy, microscopy etc.)
- Whether the school requires a single item, a class set, technician support or mains electrical power.

In a report[35] using a representative sample of English secondary schools, the **average per student spend on science for 2011/12 was £11.16** for secondary schools and sixth form colleges (with **state schools spending an average £8.81** and **independent schools spending £27.29).** Overall, the percentage of science budget spent on different areas was 39% equipment, 27% reprographics and 13% textbooks. Of course, schools' budgets differ, and these averages may not be ideal; it is important to ensure that a sufficient proportion of the budget is spent on science and maths.

It may be useful to ask your head of science what proportion of the budget is spent on science and in what different areas, recognising that the budget might vary year to year if significant hardware is invested in.

Ideas for improvement

- School leaders and governors need to decide together how to allocate resources between the competing priorities of the school. CLEAPSS have produced several buying guides for more expensive equipment to provide advice on the best value for money.
- One way of making up for lack of equipment is effective collaboration between schools, sharing equipment where possible, and building links to local employers and universities.
- Many enrichment activities enable students to get hands-on experience with expensive equipment (e.g. Hands on DNA, 'Spectroscopy in a Suitcase' from the RSC, and a recent partnership to inspire young people in the physical sciences from

[34] 'Practical work in science', *SCORE,* various dates.
[35] 'The state of resourcing of practical science in secondary schools and sixth-form colleges in England', *Pye Tait and SCORE,* 2013.

the Science and Technology Facilities Council and the Association for Science and Discovery Centres).

Back to question list

F2. Does your school have enough specialist science laboratories so that every timetabled science lesson can take place in one?

Why this is important

- A high-quality science education should include a significant proportion of practical work to equip students with the skills needed to continue with STEM (science, technology, engineering and maths) education or enter into employment in a related field. It is difficult to do effective practical work without specialist laboratories and, of course, practical work is still assessed at both GCSE and A level.

Benchmarks

SCORE (Science Community Representing Education) benchmarking states that every school should have **enough laboratories so that every timetabled science lesson can take place in a lab**.

- The science department should also have a prep room, chemical store rooms, a store cupboard for radioactive materials, storage space and IT provision.
- A 2013 report[36] by SCORE also highlighted the importance of outdoor space for a full pre-16 provision of practical science. For example, over 60% of respondents reported having no access to a pond. SCORE suggests that students "must have access to… a range of outdoor learning environments".

Ideas for improvement

- Governors may find SCORE information useful for higher level strategic planning when thinking about budgets for science equipment, see F1 for more information.
- SCORE information would probably be most useful for science leaders, in order to check the equipment in their own laboratories and classrooms, as well as the outdoor spaces that students have access to. If your school is found to lack essential equipment, it is important to highlight this to school leaders.
- The Field Studies Council has advice and opportunities for schools and colleges on how outdoor practical work can be incorporated into the school curriculum.

Back to question list

F3. Does your school employ an adequate number of full time equivalent laboratory technicians?

Why this is important

- Laboratory technicians are essential members of staff to ensure the practical provision offered to students is high quality and that equipment is well maintained.
- As well as looking after equipment, science technicians can be a direct support for teachers, especially newly-arrived teachers who will be looking for guidance on what is available and how practical work is carried out in the school.

Benchmarks

[36] 'Resourcing practical science at secondary level', *SCORE*, 2013.

In a 2006 NFER study[37], 25% of schools across England were surveyed about their science workforce. The numbers of laboratory technicians working in the science department **ranged from one to nine**, but all did have at least one technician.

The Association for Science Education, CLEAPSS (a membership organisation which offers support for practical science and technology) and the Royal Society have developed the idea of a 'service factor' as a guide for schools for the total number of technician hours necessary for secondary practical science. They suggest calculating the minimum number of technician hours per week using a service factor of 0.65.

Laboratory technician hours per week = 0.65 x hours of science teaching per week.

Many schools are not yet reaching this figure. In a 2002 report[38], the average service factors for different types of school and college were as follows:

- **Comprehensive – 0.47**
- **Grammar – 0.58**
- **Sixth form college – 0.62**
- **Further education college – 0.70**

In 2010, an ASE survey showed the average for England and Wales across schools was 0.51, suggesting minimal change between 2002 and 2010.

The majority of technicians are employed in term-time only. However, employing technicians during the holidays gives them an opportunity to catch up on general maintenance that may not be easy to do during term.

Ideas for improvement

- School leaders and governors need to decide together how to allocate resources between the competing priorities of the school. You may wish to use the equation above to work out the service factor of the technician support in your school.
- How does it compare to the rest of the country? It may be useful to check whether any technicians at your school are employed out of term time.

Back to question list

[37] 'The Deployment of Teachers and Support Staff to Deliver the Curriculum', *NFER,* 2006.
[38] 'Supporting success: science technicians in schools and colleges', *Royal Society and ASE,* 2002.

Enrichment: What science and maths related extra-curricular or enrichment activities are available for students, and how are they encouraged to participate?

Learning outside of the classroom can reinforce students' understanding of science and help to get them more engaged with science in the real world. Extra-curricular activities can take place inside school, or outside on visits to universities, businesses or science centres (E1).

E1. What science and maths extra-curricular opportunities are there for students to engage with in and out of school?

Why this is important

- Informal learning[39] can build students' knowledge and skills and improve attainment, either through direct learning or through a change in attitude towards science and learning about it. It can stimulate interest in science and maths, as well as an appreciation of its social, cultural and historical context, and can come from a huge range of experiences (zoos, science centres, games, festivals, theatres and museums).
- The Wellcome Trust Review of Informal Learning (2012) shows that 89% of students who did practical workshops at a science centre reported increased interest in science afterwards, and 60% of secondary school students achieved higher marks in a classroom assessment after visiting a museum or gallery.
- Science and maths clubs are a good way of improving students' interest and knowledge outside of the classroom and creating fun environments for getting involved with these subjects.
- In order for young people to make a range of informed decisions about their options for Key Stage 4 and post-16, it is important for them to get an idea of what higher education and employment opportunities their choices could influence.
- Making links with local universities and businesses not only gives students an opportunity to find out what options are available, but also creates beneficial relationships for work experience, university application advice and support in the future.

Benchmarks

- In an Ofsted report from December 2013, 'Maintaining Curiosity', the best extra-curricular activities were listed as those that "complemented learning by extending students' experiences", including extra experiments, projects and visits to scientific organisations.

STEM Clubs

STEMNET is an organisation that helps schools to inspire students in STEM (science, technology, engineering and maths) through extra-curricular activities and support. They offer advice for schools wanting to set up a STEM Club, and are building a network of them.

A STEMNET evaluation[40] carried out by the National Foundation for Educational Research (NFER) found:

- for teachers, key impacts included:
    - an increased ability to relate STEM lessons to real world applications of the subjects

[39] 'Exploring the impact of informal learning', *Wellcome Trust*, 2012.
[40] 'An evaluation of the impact of STEMNET's services on pupils and teachers', *NFER*, 2011.

    - personal development (for example changes in confidence, motivation, enthusiasm, attitudes, aspirations) in relation to teaching STEM subjects
- for students, key impacts included:
    - increased enjoyment of, and interest in, STEM subjects
    - increases in what they knew about the STEM subjects
    - increased awareness of careers that involve STEM
    - increased interest in studying STEM subjects post-16 or in higher education.

In 2013:

- **65%** (2,285 schools) **of UK secondary schools** had STEM Clubs (registered with STEMNET) that have been active for at least half a term in the past year, with some schools running just one club, and others running up to a maximum of six.
- It is difficult to estimate the numbers of students accessing these STEM Clubs, but STEMNET estimate that typically clubs have between 6 and 20 students attending on a regular basis.
- In the 2014 Public Attitudes to Science[41] survey, 53% of 16-to-24-year-olds recall having science or engineering clubs at their school, and within this, 37% had attended these clubs.

Ideas for improvement

- Governors should be aware of how much extra-curricular activity is going on in the school. It can be useful for governors to use their own professional networks to promote these experiences, for example, by carrying out an audit of governors' links with businesses and universities and other STEM organisations. This can also be useful for careers advice, see C7.
- Your school is very likely to have someone responsible for co-ordinating outside visits and speakers as part of a whole school policy, and it may be worth asking your headteacher to find out more about what's on offer.

School leaders may find the following ideas useful:

- Teachers have many competing priorities for their time, but you might like to discuss the potential benefits of STEM clubs with science leaders. STEMNET has supporting information to help people wanting to set up clubs.
- It might be useful to try to understand why some individuals attend STEM clubs, and why others don't.
- The British Science Association offer CREST awards to recognise students' achievement in STEM projects outside of the classroom.
- The STEM Ambassador website has useful information on engaging with science and maths related professionals.
- Competitions run by a range of organisations (e.g. the Royal Society of Chemistry, Society of Biology, Rolls Royce Science Prize, UK Mathematics Trust) can help engage students with science and maths.

Outside the classroom:

- Students can benefit from science learning experiences outside of school, such as visits to science centres and museums or trips to science fairs, many of which are free, for example the Big Bang Fair.
- Most universities have 'access' and outreach programmes to encourage applicants with diverse background. To find out more, visit the university's website or search the web for '[university name] widening participation', for example, 'UCL widening participation'.

[41] 'Public Attitudes to Science 2014', *Department for Business, Innovation & Skills*, 2014.

Back to question list

The future of science depends on the quality of science education today.

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