GOOD PRACTICAL SCIENCE

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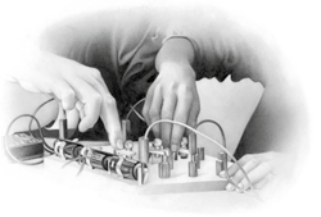


GATSBY

WHY PRACTICAL SCIENCE?

Experimentation gives science its identity. Science uses experiments to discover the realities of the world, and this practical approach is as intrinsic to young learners as it is to professional researchers.

Practical science is important for learning, not only because doing experiments is a good way to learn scientific ideas and theories. The UK needs more scientists, engineers and technicians if our knowledge economy is to flourish, and practical science shows students at first hand how scientists and technicians work. It engages students to follow science further, on academic or technical routes. It gives them practical skills and attitudes that will be valuable in their future careers.

Our study has shown that many of the ingredients of good practical science are the ingredients of all good science learning – expert teachers, well-planned lessons and technical support. So, much of what we recommend relates to good science teaching in general. We judge that by world standards, the UK is well equipped with school laboratory facilities, and our benchmarks suggest how to make the best use of them.

There is more to learning science than learning how to perform well in exams, important though that is. We carried out this international study to find out what 'good' looks like in practical science, visiting six countries where science education is highly successful. We found that, in these countries at least, practical science is alive and flourishing, and valued highly by professional scientists, teachers and, most importantly, by students.

THE PURPOSES OF PRACTICAL SCIENCE
(not in any order of priority)

A
TO TEACH THE PRINCIPLES OF SCIENTIFIC INQUIRY

B
TO IMPROVE UNDERSTANDING OF THEORY THROUGH PRACTICAL EXPERIENCE

C
TO TEACH SPECIFIC PRACTICAL SKILLS, SUCH AS MEASUREMENT AND OBSERVATION, THAT MAY BE USEFUL IN FUTURE STUDY OR EMPLOYMENT

D
TO MOTIVATE AND ENGAGE STUDENTS

E
TO DEVELOP HIGHER LEVEL SKILLS AND ATTRIBUTES SUCH AS COMMUNICATION, TEAMWORK AND PERSEVERANCE

THE SEARCH FOR 'GOOD' IN PRACTICAL SCIENCE

The full report and appendices are at: www.gatsby.org.uk/GoodPracticalScience

OUR METHOD AND TIMETABLE

Desk research · Analysis, drafting and consultation · Fieldwork

Rapid Evidence Assessment: desk research of the available research literature.

Preliminary survey of 11 countries to identify expert witnesses and to get a consensus on the purposes of practical science.

International visits to six countries – Australia (Victoria), Finland, Germany, the Netherlands, Singapore, the USA (Massachusetts) – to see practical science in schools and to meet teachers, students and officials.

First draft of benchmarks and three consultation workshops.

Second draft of benchmarks, used for school survey and costing exercise.

School survey, carried out by Pye Tait, to see how a 10% sample of schools in England measures up against the benchmarks.

Costing exercise, carried out by PwC, to produce an analysis and commentary on the costs of implementing each benchmark.

Analysis, writing and review.

THE BENCHMARKS FOR GOOD PRACTICAL SCIENCE

Benchmark	Summary
1 PLANNED PRACTICAL SCIENCE	Every school should have a written policy that explains why teachers use practical science, the outcomes they expect from it and how they achieve those outcomes. The process of producing the policy is as important as the policy itself.
2 PURPOSEFUL PRACTICAL SCIENCE	Teachers should know the purpose of any practical science activity, and it should be planned and executed so it is effective and integrated with other science learning.
3 EXPERT TEACHERS	Teachers should have subject-specialist training (both initial and continuing) in the subject (biology, chemistry, physics etc) and age range they teach, so they can carry out practical science with confidence and knowledge of the underlying principles.
4 FREQUENT AND VARIED PRACTICAL SCIENCE	Students should experience a practical activity in at least half of their science lessons. These activities can be short or long, but should be varied in type.
5 LABORATORY FACILITIES AND EQUIPMENT	Schools should have enough laboratories to make it possible for every teacher to do frequent practical science safely. Each laboratory should have sufficient equipment for students to work in small groups.
6 TECHNICAL SUPPORT	Science departments should have enough technical or technician support to enable teachers to carry out frequent and effective practical science.
7 REAL EXPERIMENTS, VIRTUAL ENHANCEMENTS	Teachers should use digital technologies to support and enhance practical experience, but not to replace it.
8 INVESTIGATIVE PROJECTS	Students should have opportunities to do open-ended and extended investigative projects.
9 A BALANCED APPROACH TO RISK	Students' experience of practical science should not be restricted by unnecessary risk aversion.
10 ASSESSMENT FIT FOR PURPOSE	Assessment of students' work in science should include assessment of their practical knowledge, skills and behaviours. This applies to both formative and summative assessment.

HOW DO SCHOOLS MEASURE UP?

Meeting all the criteria for all the benchmarks is demanding, and the school survey confirms that most schools are falling short of achieving world-class practical science measured in this way. But the detailed analysis of benchmark criteria shows that many schools are well on their way to achieving them.

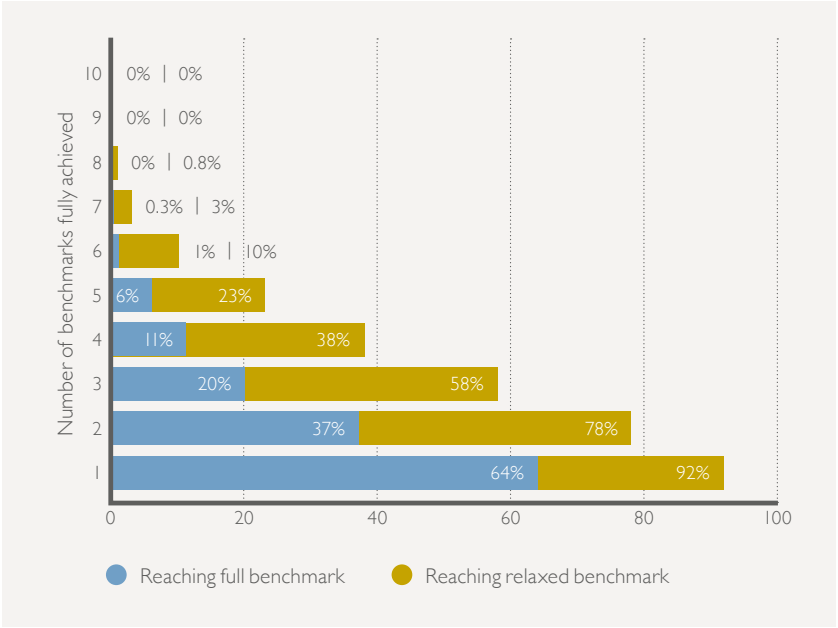
Notably, it looks as if most schools in England struggle to achieve the recommended frequency for practical science in Benchmark 4, and that this is particularly true for older students taking examined courses.

We judge that by international standards, overall English schools are well provided with laboratory facilities, so it is disappointing that many schools are not making full use of them.

The costing exercise confirms that by far the greatest part of the cost of practical science is staff time, the large majority being teachers' time. The capital costs of laboratories and equipment are small by comparison. The school is already paying the salaries of teachers, and if they were not doing practical science they would be doing some other kind of learning activity.

We believe that a school's progress in improving practical science can best be made by prioritising Benchmarks 1 (Planned practical science), 3 (Expert teachers) and 6 (Technical support), because these three benchmarks are strong enablers for others.

PERCENTAGE OF SCHOOLS REACHING DIFFERENT NUMBERS OF BENCHMARKS



RECOMMENDATIONS

The 10 benchmarks for good practical science are for schools. The recommendations below are mostly for those that can impact on the wider education system in which a school operates, namely: teacher trainers, policymakers, Ofsted, government, teaching unions, professional bodies, and Ofqual.

● Recommendations for all ● Recommendations for government and policymakers ● Recommendations for school leaders and member bodies

1 THE 10 BENCHMARKS	To schools, policymakers, Ofsted and teacher trainers	We recommend Benchmarks 1–10 as defining the elements of good practical science in secondary schools. Schools should use them, policymakers should be guided by them, and teacher trainers and professional development leaders should use them to help shape their programmes. Ofsted should guide schools towards them if their science needs improvement. Schools, and the science departments within them, should be funded adequately to enable them to achieve the benchmarks.
2 TRAINING EXPERT TEACHERS	To government and teacher trainers	Secondary science initial teacher training (ITT) should have a strong subject-specific component relating to the science they will teach, especially its practical aspects. This should be reflected in the standards for Qualified Teacher Status (QTS), which should apply to teachers in all state-funded schools, including academies. Government-funded Subject Knowledge Enhancement (SKE) courses for prospective science teachers should include sufficient laboratory time to develop practical skills. Courses that are only delivered online cannot provide this experience. Government should ensure that the Teacher Supply Model (TSM) accurately forecasts the number of specialist teachers required. Government should use the TSM to increase the number of specialist teachers in each of the sciences, through additional recruitment and through retention programmes, so that schools have enough high-quality applicants when they advertise posts.
3 CONTINUING PROFESSIONAL DEVELOPMENT FOR TEACHERS	To government, teaching unions, professional bodies and other stakeholders	Over the next five years, England should move towards an embedded system of continuing professional development (CPD) for teachers, with clear expectations of quantity and quality of CPD. Teachers' CPD should have a strong subject-specific focus and in the case of science teachers it should include practical work.

4 ACCOUNTABILITY AND PRACTICAL SCIENCE	To government	Government should review accountability measures compared with other nations, to assess how they could give teachers more autonomy and freedom to innovate in the way they teach, particularly in the case of practical science.
	To Ofsted	When inspecting school science departments, Ofsted should take particular note of the quality and frequency of practical science, and record it in the report on the school.
5 VALID ASSESSMENT	To government and Ofqual	Government and Ofqual should monitor current arrangements for assessment of practical science at GCSE and A level to check their impact on the quality and frequency of practical science. If negative effects are found, changes should be made.
	To research funders	Research should be done into valid, reliable and manageable ways of assessing practical science, in particular where assessment is indirect and by means of written questions.
6 PROJECTS IN THE CURRICULUM	To government and Ofqual	The curriculum should evolve to include more requirements for extended projects in science. In particular, an extended project should become an embedded, compulsory part of post-16 study for all students on pre-university courses. For those studying a majority of science subjects, the project should have a science focus.
7 RECRUITING, RETAINING AND DEPLOYING SPECIALIST TEACHERS	To school governors, headteachers and science leaders	Schools should take a strategic approach, using a combination of shrewd recruitment, retention measures and CPD, to get a better proportion of science subject specialists in their science team. Where subject specialists are scarce, they should teach within their specialism where possible, and schools should take a strategic approach to deciding which classes and age groups to use them with.
	To science professional bodies and funders	A study should be commissioned to produce practical recommendations for schools on how to achieve the above. The result of this study would be a practical guide for schools, illustrated with case studies, on how they can get a better proportion of science subject specialists, and how best to deploy them.
8 VALUING SCIENCE TECHNICIANS	To school governors, headteachers and science leaders	Technicians should be valued as an integral part of the science department. They should be given professional development opportunities to refresh their professional skills and their expertise in health and safety, and to give them new ideas for practical science. They should have opportunities to get professional recognition through Registered Science Technician (RSciTech) and Registered Scientist (RSci).
9 PLANNING FOR SUCCESS	To the Association for Science Education and science professional bodies	Drawing on the experience of schools, guidance should be produced on how to go about developing a written policy for practical science.
10 MANAGING RISKS	To school governors, headteachers and science leaders	All schools in England should belong to CLEAPSS, either individually or through their local authority or Academy Trust, and should use its expert advice to ensure a balanced approach to risk.

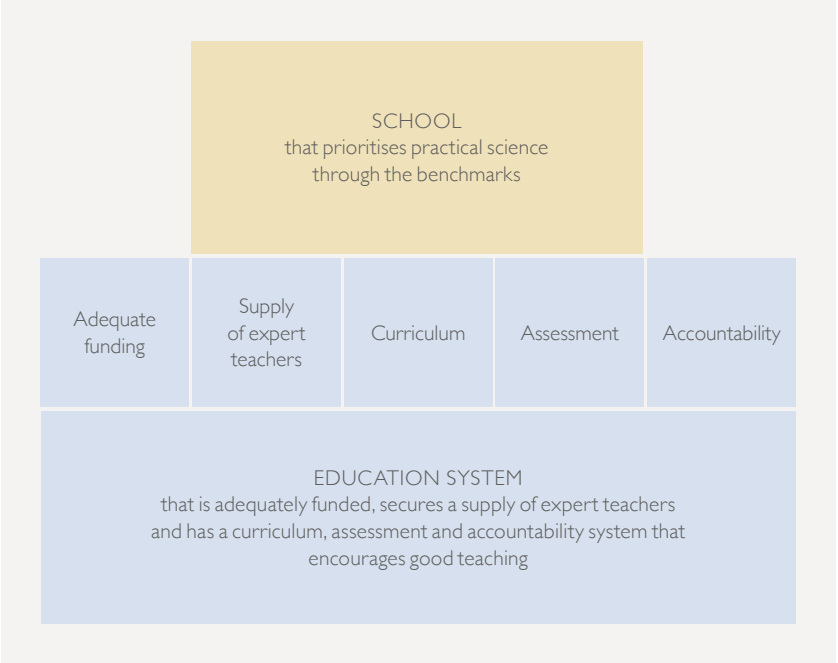
GETTING THE SYSTEM RIGHT

Our study has shown that many of the ingredients of good practical science are the ingredients of all good science learning – expert teachers, well-planned lessons and technical support.

Government needs to create the right environment, with adequate funding for schools, a good supply of trained specialist teachers and an accountability system that encourages learning beyond exams alone.

But in the end it is for headteachers and science heads to take the lead in prioritising practical science, and our benchmarks show what they need to do to get practical science that is world class. By achieving that, they will engage students, whether or not they pursue science in the future, in the essence of what it is to be a scientist.

FOR SCHOOLS TO EXERCISE THEIR AUTONOMY, THEY MUST BE BUILT ON A ROBUST EDUCATION SYSTEM



For the full Good Practical Science report and detailed appendices, visit gatsby.org.uk/GoodPracticalScience