Sir John Holman on Good Practical Science:

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Experimentation gives science its identity

Experimentation gives science its identity, and the appeal of practical science is the reason that many scientists, technicians and engineers chose their career path. Science uses experiments to discover the realities of the world, and the appeal of this practical approach is as intrinsic for young learners as it is to professional researchers.

However, at a time when schools in England are under intense pressure to perform in written exams, practical science is at risk. Too many schools are under-using their often excellent practical science facilities. Although exams are undoubtedly important, there is more to science learning than grades alone.

Practical science is important for learning, beyond the fact that experimentation is a good way to learn scientific ideas and theories. In a nation already suffering a STEM skills shortage, we cannot afford to ignore the benefits of high quality practical science in schools. The UK needs more scientists, engineers and technicians if our knowledge economy is to flourish, and practical science gives students first-hand experience of how scientists and technicians work.

Practical science engages students to follow science further, whether on academic or technical routes. And for those who don't pursue further study or careers in science, it can still give them practical skills and attitudes that will be valuable in a range of jobs.

Good Practical Science

For these reasons, and many more, I was pleased to lead the Gatsby Foundation's new report, *Good Practical Science*, providing benchmarks and recommendations to outline how all secondary schools in England can achieve world class science education.

This has been one of the most interesting pieces of research that I have ever undertaken. 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.

We were able to collect evidence about practical science from eleven leading education nations, and to visit schools, teachers and pupils in six of them, including Finland, Singapore and Germany. In these countries, we found that practical science is alive and flourishing, and highly valued by professional scientists, teachers and, most importantly, by students.

We also collected evidence from 400 English schools, about 10% of the schools in England, showing us that the UK is well equipped with school laboratory facilities by worldwide standards. As a follow-up, in-depth interviews were conducted with 20 respondents, selected to give a cross-section of school types, sizes and regions. More than three-quarters of respondents were Heads of Science, and all types of maintained school were represented.

In addition, a costing exercise by consultants PwC confirmed that by far the greatest cost of practical science is staff time, mostly teachers' time. The capital costs of laboratories and equipment are small by comparison. Our benchmarks suggest how to make the best use of both capital investment and staff time.

What is the purpose of practical science in schools?

What is it about science that captivates the imagination of young people? For some, it's the excitement of new ideas, but for many it's about their experiences of hands-on experimentation and practical work in the science lab.

For the wider education system, our report identifies five purposes of practical science in secondary schools:

- To teach the principles of scientific inquiry;
- To improve understanding of theory through practical experience;
- To teach specific practical skills, such as measurement and observation, which may be useful in future study or employment;
- To motivate and engage students; and
- To develop higher-level skills and attributes, such as communication, teamwork and perseverance.

Ten benchmarks for Good Practical Science

We identified ten benchmarks for effective practical science education:

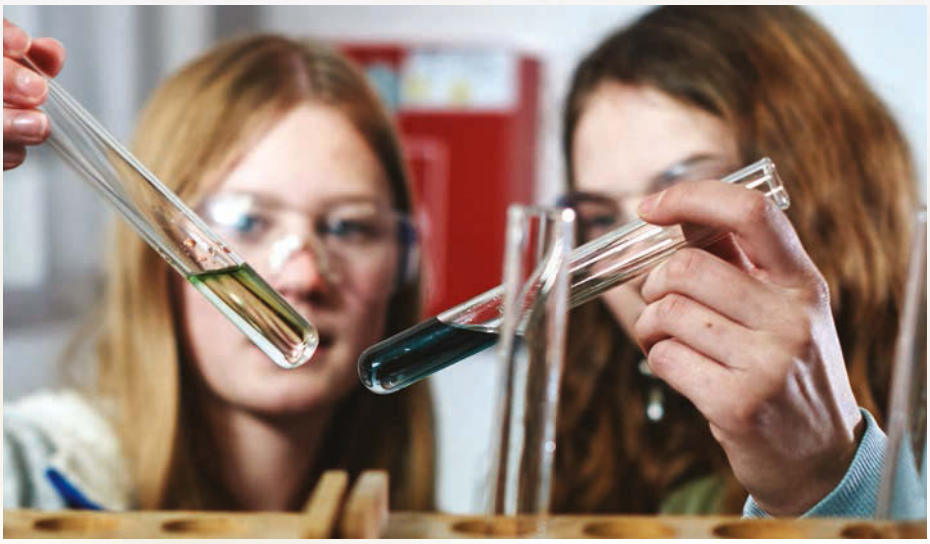
1. Planned practical science;
2. Purposeful practical science;
3. Expert teachers;
4. Frequent and varied practical science;
5. Laboratory facilities and equipment;
6. Technical support;
7. Real experiments, virtual enhancements;
8. Investigative projects;
9. A balanced approach to risk; and
10. Assessment fit for purpose.

Meeting all the criteria for all the benchmarks presented by *Good Practical Science* will be demanding. By international standards, schools in England are relatively well-provided for in terms of science labs but, even so, our

school survey confirms that many schools in England are falling short of achieving world class practical science measured by our benchmarks.

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

These three benchmarks highlight how schools can take simple and immediate steps towards improving their delivery of practical science.



Benchmark 1: Planned practical science

We believe that every school should have a written policy explaining why teachers use practical science, the outcomes that they expect from it and how they achieve those outcomes.

- The policy should be produced as a team effort by teachers and technicians across the science department.
- The policy should explain the differences in practical science between different age groups and key stages.
- Accommodations for special educational needs and disabilities (SEND) should also be included.
- The school should also consider opportunities for practical science outside of school, for example with universities, employers and science centres.
- The policy should be annually reviewed and a member of the senior leadership team should act as a 'sponsor' for practical science among other senior leaders.

Benchmark 3: Expert teachers

As ever, teachers are key. Ideally, teachers will have subject-specialist training on an initial and continuous basis in their teaching subject and age range. This allows them to carry out practical science with confidence and knowledge of the underlying principles, something that was strongly underlined in the teachers we met in countries such as Finland, Germany, the Netherlands and Singapore.

- At post-16 level, teachers should have a post-A-level science qualification relating to the science subject that they teach, together with relevant pedagogical training.
- At pre-16 level, teachers without the relevant post-A-level science qualification should be offered sufficient training to provide the confidence, knowledge and skills they require.
- Science departments should be reviewing their teachers' expertise annually, ensuring that individual needs are met. This should include specific training in practical science.

Of course, the recruitment of specialist teachers, particularly in physics and chemistry, is proving difficult for many secondary schools. But we are saying that schools should take a strategic approach to building a specialist science team, using professional development where necessary to give non-specialist teachers the knowledge and teaching skills they need to use practical science with confidence.

Benchmark 6: Technical support

The report found that the majority of science departments in England have enough technical or technician support to enable teachers to carry out frequent and effective practical science.

- Technical support saves teachers time and improves science department morale.
- For an average-size school, there should be specialist technical expertise to support practical work in each of biology, chemistry and physics.
- Technicians should be given regular opportunities for continuing professional development.

Getting the system right

In short, where science education is good, practical science is also good: well-planned, frequent and varied. The ingredients for good practical science are also the ingredients for good science teaching in general.

We believe that the 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.

However, ultimately it is up to Headteachers and Science Heads to take the lead in prioritising practical science. By achieving world class practical science when pursuing higher standards in the benchmarks outlined here, schools will engage students in the essence of what it is to be a scientist.

I would urge all educators with a stake in science learning and practical science to read the *Good Practical Science* report in full. Education research in science has its greatest impact when teachers and technicians work together to identify the best strategies for effective educational outcomes. I hope that that is what will happen in response to *Good Practical Science*.

A key ambition of the Gatsby Charitable Foundation is to strengthen intermediate science, technology, engineering and mathematics (STEM) skills within the UK workforce.

Download the full *Good Practical Science* report and appendices at: www.gatsby.org.uk/GoodPracticalScience

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