11 MAY 2011

PRACTICAL EXPERIMENTS IN SCHOOL SCIENCE LESSONS

SUBMISSION TO THE HOUSE OF COMMONS
SCIENCE AND TECHNOLOGY COMMITTEE INQUIRY

GATSBY

ABOUT GATSBY

1 Gatsby is a Trust set up in 1967 by David Sainsbury (now Lord Sainsbury of Turville) to realise his charitable objectives. We focus our support on a limited number of areas:

- Plant science research
- Neuroscience research
- Science and engineering education
- Economic development in Africa
- Public policy research and advice
- The Arts

INTRODUCTION

2 The Committee will no doubt receive considerable evidence regarding the importance of and possible barriers to practical work in school science. The Committee also has previous Select Committee reports to draw upon. We note in particular the 2006 House of Lords Science and Technology Committee report on 'Science Teaching in Schools' and the 2002 House of Commons Science and Technology Committee report on 'Science Education from 14 to 19', both of which address the issue of practical science.

3 Given the significant amount of evidence about the issues with practical work in school science, why do substantial concerns persist about its decline? Has there been an adequate response from the government and, where action has been taken, has it been successful? Perhaps most crucially, to what extent have government interventions specifically targeted practical work in school science rather than assume that general policies to support teaching and learning will somehow address the issues specific to laboratory-based science?

4 We sincerely hope that this current Inquiry – while almost certainly needing to reiterate the conclusions of previous Select Committee reports – will result in more significant and sustained action being taken to address the longstanding issues associated with practical science than has hitherto been the case. With schools facing significant constraints in the resources and support available to them, we believe there is only a small window of opportunity – perhaps the next 3 years – to put in place the necessary measures to protect the place of practical science in schools before irreversible decline occurs.

5 The Committee's Inquiry is timely therefore. Indeed, against the backdrop of Gatsby's longstanding support for practical work and concerns for its future health, we have recently embarked on a significant piece of work that, over the next 12-18 months, will seek to:

- establish an accurate picture of the current health of practical science in UK secondary schools and make international comparisons where feasible;
- unpick the current enablers and barriers to effective practical work that affect schools at a local level;
- identify the likely impact on practical work of the upcoming education policy changes, including the changes to the National Curriculum, funding mechanisms, Local Authority involvement and initial teacher education;
- make pragmatic recommendations on the action needed to ensure high-quality practical work occupies a central and sustained role in all secondary schools.

6 Practical work in Primary science education should build on the natural curiosity of children, enabling them to experience and explore the material and natural worlds. This process will continue in secondary schools, but it will be advanced by the development of discipline-specific skills and the use of specialist equipment enabling students to use a more abstract and measured approach. For brevity we refer to these as 'laboratory skills', although noting that this definition should include the skills that are developed outside of the laboratory through fieldwork.

7 In this submission we report on some of the early findings of our work. In particular we note the concerns of universities regarding the laboratory skills of first year science undergraduates and issues coming to our attention regarding the impacts of recent policy on practical work. As part of our work over the coming year we plan to explore the laboratory skills required by employers and to what degree employer needs are currently being met by science at school and college.

8 We would be pleased to share our findings with the Committee as they emerge, and to discuss how the work of Gatsby might complement the Committee's recommendations for action by other stakeholders, including the DfE.

PREPARING STUDENTS FOR SUCCESS IN SCIENCE AT UNIVERSITY

9 In April 2011 Gatsby commissioned a small piece of research exploring the perceptions of science staff in the 15 Russell Group universities in England (excluding the LSE) regarding the standard of laboratory skills possessed by new undergraduate students. 34 respondents from 12 universities completed an online survey and 12 respondents also participated in follow-up interviews.

10 Our results can only be indicative of issues that need further investigation, but the Committee might be interested in the headline findings and quotes from respondents. These are given in the four points (a) to (d) below. We are still analysing the results (and defining what a larger-scale study might look like) but would be willing to share the full report with the Committee on request.

(a) Across the board, respondents reported that new undergraduates lack at least some confidence in the lab (100%), and are not well equipped with lab skills (97%). Specific deficits in lab skills included manual dexterity, the ability to set up apparatus and making accurate observations.

"They find it difficult to diagnose and think through problems and are quick to blame equipment rather than their own technique."

"They can't apply these tools and these skills outside the narrow environment in which they were taught."

(b) While 29% of our respondents reported a decline in the last 5 years in new undergraduates' scientific knowledge, over half (57%) felt that the level of laboratory skills had declined in the same period. This was despite all respondents (100%) stating they had increased the grades required for entry to their courses.

"Although it fluctuates from year to year it is noticeable that at entry students lack confidence in the lab, and the situation is getting worse."

"With our increased entry requirements we have some excellent students with a deep understanding of concepts but our average to lower ability students struggle more now than 10 years ago."

(c) The largest factor contributing to the lack of lab skills was cited as students' limited exposure to practical work at school. Respondents reported teaching students who had done very little practical work and whose teachers relied heavily on demonstrations and/or videos.

"Many students are telling us that they have done no practical work at school so they struggle with basic skills like using a microscope, with which they previously would have had some experience."

"Many of them claim to never have carried out an experiment only watched teacher/videos of. Most of them have no idea how to act in a lab or where to even begin when carrying out an experiment, ie no idea what equipment is called."

(d) University teaching staff have made a number of changes to their lab-based teaching in response to the change in skills of new undergraduates, including: simplifying first-year lab courses by providing more step-by-step instructions, removing complex experiments or allowing more time; increasing the focus and/or time spent on basic skills; increasing the levels of support through more staff time or demonstrators; and introducing online pre-labs.

"We have redesigned the whole first year course - removing much of the material previously taught and starting at a lower level and with much less expected in each class."

"Progress through the [undergraduate] lab course is to an extent set back by the poor standard of skills among the intake. This has a knock-on effect on the types of experiments, and their complexity, that we can offer in the later years of the degree."

11 We believe that even this small-scale survey should elicit concern regarding how well schools and colleges are preparing students for entry into science degree courses. These indications become all the more stark when one considers that: (1) the universities surveyed are taking the best A-level students (the reported entry requirements ranged from BBB to A*AAA); and (2) that all universities are increasingly operating in a more competitive environment where finances are stretched and the pressure to widen their student intake will continue.

PRACTICAL WORK IN THE NATIONAL CURRICULUM

12 Gatsby recently submitted evidence to the government's current review of the National Curriculum in which we set out our thinking on the purposes for practical work and our recommendations for the review team. A copy of our submission is available on request; the points relevant to this Inquiry are provided below.

13 The main purposes of practical work in the curriculum are to:

- enhance the learning of science concepts and explanations;
- develop understanding of the processes of science; and
- develop laboratory skills.

14 Since the introduction of the National Curriculum there has been a steady erosion of the teaching of laboratory skills. This erosion is a cause of significant concern to industry and higher education institutions. Reversing this trend would also increase the engagement of young people in science and lead to greater participation in science post-16.

15 It is unacceptable that the assessment of laboratory skills has been reduced to the point where a GCSE student who is unable to, for example, use a microscope or heat measured volumes of liquid without breaking test tubes is still able to achieve maximum marks for their practical work as long as they can write about how they should have done it.

16 The current National Curriculum review is an opportunity to re-examine the role of practical work. In particular, the review must ensure that the Science Curriculum sets high expectations of attainment in the laboratory skills that employers and higher education value.

17 We recommend that:-

(a) The National Curriculum review team should provide an impact assessment to show explicitly how any changes to the Science Curriculum will actively encourage better practical work in schools.

(b) The Science National Curriculum should state explicitly the laboratory skills that students are expected to develop at each Key Stage.

(c) The review must ensure that the National Curriculum allows sufficient time and space for teachers to undertake a much wider range of practical activities with their students than is currently the case.

(d) The review must consider how the requirements of the National Curriculum regarding practical work at Key Stage 4 can be translated into assessment objectives across the range of science GCSEs.

(e) The review should involve higher education and employers in a much more meaningful way than has been the case in previous National Curriculum reviews. Included within these discussions should be a focus on ensuring that employer and HE requirements for laboratory skills are met, something we believe has been wholly absent from previous reviews.

BARRIERS TO PRACTICAL WORK – IMPACTS OF RECENT CHANGES

18 As part of our new study into practical work we have begun to visit schools and talk to Awarding Organisations, Local Authority advisers and CPD providers in order to better understand the barriers to practical work and what might be done to alleviate them.

19 In our preliminary work it is clear that recent changes to the educational landscape may well have an impact on practical work and we highlight some particular areas for further investigation below. We hope the Committee will engage the DfE in discussion on these issues.

Laboratories and preparation rooms

20 We still hear of too many schools where practical work is limited by the amount of laboratory, preparation and storage space available, despite many of these schools going through refurbishment or being new builds. Particularly worrying are reports that some Academies have reduced the number of labs and prep areas and therefore may be compromising the quality of their science provision.

21 We would be interested to hear what plans the DfE has to ensure all schools (including Academies and Free Schools) adhere to the guidelines it itself has produced on the accommodation necessary for practical science.

School budgets and science equipment

22 The cost of some equipment and consumables associated with practical work remains prohibitive for some schools, and the number of schools and range of equipment that fall into this category are both likely to increase in the coming years as schools' budgets come under increasing pressure. A school science department must balance the costs of kit essential for practical work with the substantial demands for photocopying, stationery and textbooks.

23 The constant upheaval in the curriculum will continue to divert funds away from practical equipment towards new textbooks and work sheets; schools would benefit from a period of curriculum stability in order to focus their resources on improving their science provision.

24 While we appreciate – and support – the government's commitment to devolve to individual schools decision-making on issues such as budgeting, it will be crucial in the coming years that headteachers,

senior management teams and governors are helped to understand the importance of practical science. Without government support for this – even if only in Ministerial announcements and the DfE guidance material issued alongside the new National Curriculum – it is likely that the status of practical science will continue to decline in schools.

25 Finally, some schools successful in increasing uptake of the sciences at A-Level are telling us they are likely to struggle to afford the extra equipment needed to provide these students with quality practical work. Some schools have told us that the decrease in post-16 funding for sixth forms from the Young People's Learning Agency (to bring schools into line with FE Colleges) will impact on practical provision, particularly in schools successful in motivating more students to continue with science into A-Level. More research is required to understand how widespread this effect is likely to be and we would encourage the Committee to explore this issue with its witnesses.

Teacher training and Professional Development

26 Teaching laboratory skills and undertaking practical experiments demands expertise and experience from science teachers, so it would be expected that it should form an explicit part of their training and professional development. For trainee teachers, however, it is not clear who has responsibility for this part of their training – their university or their placement schools. There is therefore a risk that it occurs in neither, or is overly dependent on the status of practical science in the trainee's school.

27 The DfE should use the review of standards for Qualified Teacher Status to clarify the expectations for science teachers to have appropriate competencies in practical work.

28 Local Authorities have traditionally played a pivotal role in networking science departments from different schools through the offices of a science consultant and/or adviser. At the height of the last government's 'National Strategies' programme this regional field force numbered around 300, but since the government decided to end the National Strategies and reduce the role for Local Authorities in school support, the number has dwindled to about 40. It is no longer clear from where schools can rely on getting advice on practical teaching, or who will take responsibility for networking science departments so that practice can be shared.

29 The Committee may wish to ask the DfE what plans it has to ensure that schools still have access to the support and advice on practical science (including health and safety) previously freely available to schools from Local Authority advisers and consultants.

Technicians

30 It is disappointing that successive governments appear to have had so little interest in supporting the role of school science technicians, despite the potential for developing them as key staff in supporting more efficient management of purchasing and use of equipment and materials.

31 School science technicians provide essential support for practical work, particularly in schools where the department is dominated by inexperienced teachers or where staff turnover is high. And yet the pay and conditions of technicians are appalling, including a lack of real career structure, term-time only contracts and lack of support for professional development.

32 This is as true now as it was in 2002, when the House of Commons Science and Technology Committee reported:

"The pay and conditions under which technicians are employed strike us as downright exploitative. We can see no reason why technicians should be paid during the term time only. Those technicians who prefer not to work during the holidays, carrying out essential tasks such as equipment maintenance, should be employed on part-

time contracts; others should be treated like teachers and paid an annual full-time salary. The lack of opportunities for career or pay progression needs to be addressed." [1]

33 Nine years on, we still agree. We hope that the current Inquiry will lead to more progress in this area than has hitherto been the case.

Health and Safety

34 Concerns regarding health and safety are often used to explain a reduction in the amount of practical work undertaken in a school. We have heard a number of science teachers, even some in high-performing schools, speculate on practicals which might or might not be banned. However, there are almost no national bans on practical work in science.

35 In the past, schools have been able to consult their Local Authority science adviser/consultant or the national organisation CLEAPSS for advice and support on risk assessments and safe management of practicals. With the demise of Local Authority advisory roles (see paragraph 28), we are concerned that decisions regarding health and safety, and on which science practicals are 'allowable', may be taken by individuals who do not have the necessary experience, or access to external expertise.

36 We would encourage the Committee to ask the DfE what sustainable mechanisms the Department proposes for ensuring that all school science departments have access to correct, authoritative advice on health and safety in practical work.

Curriculum, qualifications and timetabling

37 In an effort to strengthen science education at Key Stage 4 and increase progression to post-16 sciences the government has supported increased participation in Triple Science (three separate GCSEs in physics, chemistry and biology) among 14-16 year olds. We support these moves. However we have been told that many schools have not been able to allocate Triple Science any more teaching time than 'double science' (2 GCSEs), and that practical work has suffered as a result.

38 If this means that students studying physics, chemistry and biology at GCSE in order to progress to A-Level sciences and beyond are gaining fewer laboratory skills, this is clearly a situation that needs rectifying. We suggest the Committee might wish to investigate how widespread this issue is when questioning witnesses and also to press the DfE on what research it has undertaken or has planned on the curriculum time schools are dedicating to Triple Science and the subsequent effect on practical work.

CONCLUSION

39 We would welcome the opportunity to discuss with the Committee the points raised in this submission. In the meantime, any questions regarding its content should be directed to:

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[1] 'Science Education from 14 to 19' (July 2002), House of Commons Committee on Science & Technology.