SCORE

SCIENCE COMMUNITY REPRESENTING EDUCATION

# Laboratory and field work

A SCORE response to the Science and Technology Committee's (Commons) inquiry into practical experiments in school science lessons and science field trips

11 May 2011

SCORE is a collaboration of organisations working together on science education:
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Institute of Physics (cc Charles Tracy)
Royal Society (cc Nick von Behr)
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**About SCORE**

SCORE member organisations aim to improve science education in UK schools and colleges by supporting the development and implementation of effective education policy. SCORE is chaired by Professor Graham Hutchings FRS and comprises the Association for Science Education, Institute of Physics, Royal Society, Royal Society of Chemistry and Society of Biology.

SCORE welcomes the opportunity to provide evidence for the Science and Technology Committee's inquiry into practical experiments in school science lessons and science field trips.

In summary the SCORE response covers the following:

- The importance of practical work[1] in the teaching of the sciences to the 5-19 cohort. Good quality practical work develops a range of skills, science knowledge and conceptual understanding and it promotes the engagement and interest of students - all of which is likely to impact positively on learner progression in the sciences, both into higher education and careers. This is vital in meeting the growing demand from employers for STEM[2] skills, and in maintaining the UK economic competitiveness.
- The enablers of practical work in the sciences for the 5-19 cohort. Appropriate teacher and technician support, resourcing and assessment are essential if science departments and primary teachers are to use good quality practical work in the teaching of the sciences.
- Improving the quantity and quality of practical work in the sciences. It is suggested this is through: evidence based research to inform the design, assessment and resourcing of practical work; accountability to ensure all young people have access to good quality practical work; and the promotion of good practice and resources.

## 1. Importance of practical work in the teaching of the sciences to the 5-19 cohort

1. SCORE members regard high quality practical work as an integral element of all teaching and learning in the sciences. This was also noted in the recent report from Ofsted[3]. SCORE considers practical work to encompass learning activities in which students observe, investigate, and develop an understanding of the world around them through:

    - having direct, often hands-on, experience of phenomena or manipulating real objects and materials, and
    - where primary data/observations are not possible or appropriate, use secondary sources of data to examine experimental observations (for

[1] In this document the term practical work refers to practical laboratory and classroom activities and field work.

[2] STEM (Science, Technology, Engineering and Mathematics)

[3] Ofsted *Successful Science* Jan 2011 http://www.ofsted.gov.uk/Ofsted-home/Publications-and-research/Browse-all-by/Documents-by-type/Thematic-reports/Successful-science

example: aerial photographs to examine lunar and earth geographic features: spectra to examine the nature of stars and atmosphere: sonar images to examine living systems)[4].

2. Good quality practical work should have three overarching purposes[5]:

    - It enables and enhances the learning of scientific concepts and explanations and ensures students have seen what they ought to have seen in order to understand a scientific idea; sometimes this is by giving them an experience or feeling of a phenomenon, particularly an abstract one such as inertia. Much of the practical work that takes place in schools will be intended to bridge the conceptual gap from the world that students see around them to the more abstract representations used by scientists.

    - It engenders an understanding of scientific process, enabling students to experience and understand the difference between the knowledge claims made by the sciences and those made by the humanities. Through practical activities students experience what it is like to 'think like a scientist' and have a 'cultured' approach towards science education, understanding 'why they know what they know' and 'how they know what they know' and not merely accepting knowledge as fact[6].

    - It develops laboratory skills. Students should be given opportunities to develop their manipulative skills through the use of apparatus and by following protocols.

3. As well as developing these essential skills, good quality and appropriate practical work is widely acknowledged to promote the engagement and interests of students towards the sciences, which is also likely to impact positively on learner progression in the sciences, both into higher education and careers.

4. In addition, practical work contributes specifically to the teaching and learning of biology, chemistry, physics, and primary science:

    - The Society of Biology regards high quality practical work in biology as activities that: illustrate the beauty and complexity of the living world; promote an understanding of how to extract information from complex living systems; provide an experience of testing hypotheses and analysing and evaluating variable data; support the teaching of mathematical, statistical and modelling skills; highlight and promote discussion of ethical issues; give students the foundation of skills to

[4] Lunetta, V N, Hofstein, A and Clough, M P *Teaching and learning in the school science laboratory. An analysis of research, theory, and practice* 2007 pg 394

[5] The Gatsby submission to the Government's Call for Evidence for the review of the National Curriculum April 2011

[6] The SCORE submission to the Government's Call for Evidence for the review of the National Curriculum April 2011 http://www.score-education.org/media/7650/scorencevidence.pdf

continue into academic or vocational training and ultimately enable them to tackle global challenges[7].

- The Royal Society of Chemistry regards high quality practical work in chemistry as activities that: allow students to experience the wonder of chemistry; are integral to teaching rather than extension activities; deliver learning outcomes; provide opportunities to illustrate scientific ideas; allow students to apply their knowledge and understanding to investigate and test scientific theories; reinforce the theoretical concepts and content in a way that generates enthusiasm and excitement in the students; allow students to interpret the reliability of data and the validity of scientific claims; provide students with the opportunity to develop the skills necessary to meaningfully interact with chemical issues and challenges in their future lives either as scientists or as informed citizens.

- The Institute of Physics regards high quality practical work in physics as activities that: illustrate the concepts taught theoretically in lessons e.g. interference, diffraction, thermal expansion, latent heat from a cooling curve, ray optics; stimulate skills in independent investigation; develop laboratory skills in physics and handling laboratory apparatus; reinforce the idea that physics is an experimental discipline and that many of the major theoretical and experimental advances have been stimulated by unexpected experimental results; and develop an appreciation of the need to think about accuracy in measurement and of experimental errors.

- The Association for Science Education regards practical work activities to lie at the heart of primary science. Children need opportunities to develop practical and enquiry skills in order to engage with the world in a scientific way and to make sense of what they are learning about living things, the environment, materials and physical processes. Hands-on experience promotes curiosity and engagement and provides opportunities for the discussion and questioning which develop understanding. Practical work can take place inside or outside the classroom, and can happen at any point in a unit of work or lesson. It may be a five minute demonstration, a short activity to practice using an unfamiliar piece of equipment or an extended enquiry. What it must be is a varied and integral part of the learning process via appropriate learning objectives which promote progression in both skills and content knowledge, through activities for thinking as well as doing.

[7] Society of Biology *Practical biology position statement* December 2010 http://www.societyofbiology.org/policy/policy-statements/practical-biology

5. SCORE acknowledges that in the UK more practical work takes place in science lessons than in most other countries (indicated by international comparisons such as TIMSS). However, there remains concern among the science community that schools in general are not doing enough (or doing the right kind of) practical work and that its quality is uneven[8].

6. High quality practical work develops the skills which employers (STEM and non-STEM related) and Higher Education Institutions demand. It stimulates creativity, curiosity and critical thinking; illustrates concepts, knowledge and principles; underpins knowledge formation; promotes student engagement with the scientific method; encourages active learning and problem solving; allows collaborative working; and provides opportunities to collect and analyse data and apply mathematical skills.

7. In a recent CBI report, 43% of employers in the UK were reported to be having difficulty recruiting staff with skills in STEM, with manufacturers and science-related businesses having the most difficulty finding highly-skilled people to fill their posts. Even more companies (52%) expect to have difficulty finding STEM-skilled people in the next 3 years[9]. The education system must support young people in developing STEM skills not only for the individual learner to progress but for the UK to maintain its commercial competitiveness in the world.

8. While the importance of practical work is well documented, all education policy must be based on strong evidence. SCORE would therefore like to see further commitment to research designed to ascertain the impact of practical work on students' attitude, attainment and progression in the sciences. A greater understanding of the role that practical work plays in the learning process at all stages of science education would enhance our ability to design, assess and resource good practical work in the future.

## 2. Enablers of practical work in the teaching of the sciences for the 5-19 cohort

### 2.1 Appropriate resourcing of facilities, consumables and equipment

9. If the Government is to maintain its commitment to STEM and to increase the number of young people progressing in science education, it must be prepared to appropriately resource science education. The sciences are a statutory requirement in the National Curriculum. They are practical subjects and by this very nature often more expensive than other school subjects.

10. There is well-documented evidence of the shortfalls in funding for equipment and upkeep of laboratories. These funding inadequacies should be addressed within a

[8] SCORE *Practical work in science: A report and proposal for a strategic framework*, 2008 http://www.score-education.org/media/3668/report.pdf

[9] CBI Building for growth: b*usiness priorities for education and skills, Education and skills survey 2011* May 2011 http://www.cbi.org.uk/ndbs/press.nsf/0363c1f07c6ca12a8025671c00381cc7/f14c02961d1d92ac8025788800442fdb/$FILE/CBI_%20EDI%20Education%20&%20Skills%20Survey%202011.pdf

wider strategy aimed at improving laboratory facilities.[10] All secondary schools should have access to well-maintained, well-equipped, well-designed, dedicated laboratories and adequate access to functioning ecosystems to support field work. Primary schools should also have appropriate access to practical work, including access to functioning ecosystems.

11. To the best of our knowledge, despite recent government initiatives in England such as Building Schools for the Future and Project Faraday which aimed to improve laboratory facilities, there has been no monitoring on the improvements achieved. There are also concerns that these programmes were not sufficiently informed by science teachers' and technicians' needs[11].

12. At secondary level, senior school management must ensure that science departments have adequate funds to maintain and refurbish laboratory facilities. At primary and secondary level, senior school management must ensure their schools can afford the purchase and upkeep of consumables and equipment that enable practical work activities. It is important schools also budget for scientific field work activities. These may include transport costs to sites and payment to field studies centres. It should be noted there are also a number of ways that schools can undertake field work activities without incurring these costs.

### 2.2 Technician support

13. School science technicians are essential to the delivery of laboratory and field work in secondary schools and therefore in providing a high quality science education. In their report[12] CLEAPSS (Consortium of Local Education Authorities for the Provision of Science Services) state that 'experienced and skilled technicians can give direct support to practical activities ... by ensuring that a wide range of apparatus and materials is available, appropriately maintained and stored effectively. Technicians not only contribute to the health and safety, economy and efficiency of the department, but they also enable science teachers to offer varied and stimulating science lessons'.

14. In 2002 the Royal Society and the Association for Science Education estimated that up to 4,000 additional science technicians were required to provide adequate technical support to all school science departments[13]. There is already a known shortfall in technician support and there is concern among SCORE members that the devolution of funding from central

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[10] RSC *Laboratories, Resources and Budgets: Provision for science in secondary schools* April 2004 http://www.rsc.org/ScienceAndTechnology/Policy/EducationPolicy/Laboratories2004.asp and RSC *Improving school laboratories? A Report for the Royal Society of Chemistry on the number and quality of new and re-furbished laboratories in schools* October 2006 - http://www.rsc.org/images/Labsreport_tcm18-65943.pdf

[11] RSC *Improving school laboratories? A Report for the Royal Society of Chemistry on the number and quality of new and re-furbished laboratories in schools* October 2006 - http://www.rsc.org/images/Labsreport_tcm18-65943.pdf

[12] CLEAPSS *Technicians and their jobs* Updated August 2009 http://www.cleapss.org.uk/attachments/article/0/G228.pdf?Free%20Publications/

[13] The Royal Society and The Association for Science education *Supporting success: science technicians in schools and colleges* January 2002 http://royalsociety.org/Supporting-success-science-technicians-in-schools-and-colleges/

government to schools may result in an increased shortfall. Anecdotal evidence suggests that reductions in technician staff time as well as redundancies have already occurred in a number of science departments.

15. The Association for Science Education collects technician workforce data every 10 years[14]. The 2010 data, in comparison to the 2000 data set, suggests a number of trends which the Select Committee should consider:

    - The school technician workforce represents an aging population with numbers between 50-60 years of age up by 50%.
    - An increasing number of school technicians (up to 29%) are the only wage earner in the household.
    - In 2000 the majority of technician posts required O-level or GCSE qualifications. In 2010 this number has fallen and posts are now more likely to be advertised for graduates. In addition the number of graduate technicians has changed from 22% to 37%, but there are now fewer graduates from City and Guilds.
    - There is also a noticeable difference in the duties carried out by technicians, particularly in demonstrating practical activities to teachers (87% from 37%), to students (69% from 38%) and to other technicians (73% from 32%). In addition, 96% commented that one of their duties was to try out new practical activities (an increase of 11%) and 85% stated that they were responsible for setting up IT equipment, up from 70%.

16. It is crucial that senior school management recognise and support the need for a high quality science technician service. Senior school management should, for example, be aware of the minimum requirement for technician time which was developed by CLEAPSS and Association for Science Education[15]. This calculation is based on the service factor of 0.65 (or ideally 0.85) recommended by the Association for Science Education to ensure adequate technical support in the science curriculum.[16]

17. **I**t is essential technicians are supported in their work and accorded the professional status they deserve. There should be substantial investment in technician continuing professional development (CPD)[17]. The CLEAPSS guide explores this in further detail.[18]

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[14] ASE *UK School Technicians Survey* 2010 – 486 respondents IN PRESS

[15] CLEAPSS *Technicians and their jobs* Updated August 2009 http://www.cleapss.org.uk/attachments/article/0/G228.pdf?Free%20Publications/

[16] The Royal Society and The Association for Science education *Supporting success: science technicians in schools and colleges* January 2002 http://royalsociety.org/Supporting-success-science-technicians-in-schools-and-colleges/

[17] The Royal Society and The Association for Science education *Supporting success: science technicians in schools and colleges* January 2002 http://royalsociety.org/Supporting-success-science-technicians-in-schools-and-colleges/

[18] CLEAPSS *Technicians and their jobs* Updated August 2009 http://www.cleapss.org.uk/attachments/article/0/G228.pdf?Free%20Publications/

## 2.3 Health and safety

18. The 2008 SCORE report[19] and the 2011 report by the Outdoor Science Working Group of the Association for Science Education[20] found that although there are currently no serious threats to practical science from health and safety requirements, there is a negative impact resulting from perceptions of the restrictions imposed by regulations, particularly in the arrangements for field trips. Health and Safety legislation was never intended to inhibit the teaching of practical science but to ensure that it is carried out with minimum risk. It was designed to protect the health and safety of employees (e.g. teachers and laboratory technicians) and those affected by those work activities (students), not to prevent them from undertaking practical work in school laboratories.

19. The Health and Safety at Work Act (1974) as amended, applies to all workplaces, including schools. This means that the schools via their employers (the Local Authorities) have a duty to ensure the health and safety of teachers, technicians and students. In fulfilling this duty, schools and their governing bodies need to be satisfied that adequate arrangements are in place to ensure that laboratory activities are carried out safely. Practical science can be taught in schools without risk to the health and safety of students provided appropriate precautions are taken.

20. The Royal Society of Chemistry 2005 report 'Surely that's banned?' illustrates in detail the level of misconceptions of assumed banned experiments and the implications this has on practical work[21]. The risks associated with the teaching of practical science need to be kept in perspective. Public understanding suggests that Health and Safety legislation is the main reason why chemistry experiments are prohibited, even though very few cases of injury to children have been recorded. In fact, legislation does not 'ban' any chemicals or procedures likely to be used in school chemistry. The fear of litigation has led to health and safety legislation being used as an excuse to avoid the teaching of practical chemistry skills.

21. Laboratory-based classes make a positive contribution to understanding the sciences and should be actively encouraged. Governing bodies should be reassured by knowing that, even in today's risk-averse society, provided that proper risk assessments have been carried out and appropriate risk controls or precautions are in place, all reasonable steps have been taken to safeguard the safety of students. Evidence suggests that practical science in schools does not and has not, posed a significant risk to students.

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[19] SCORE *Practical work in science: A report and proposal for a strategic framework*, 2008 http://www.score-education.org/media/3668/report.pdf

[20] Outdoor Science: a report from the Association for Science Education Working Group, January 2011 http://www.ase.org.uk/news/ase-news/the-uks-leading-science-education/

[21] RSC *Surely that's banned* October 2005 http://www.rsc.org/images/Surely_thats_banned_report_tcm18-41416.pdf

22. Specifically for chemistry, the more specific Control of Substances Hazardous to Health (COSHH) Regulations apply. The COSHH Regulations (2003) require the assessment and control of risks associated with work activities involving the use of hazardous substances, which includes most chemicals. All that is required to teach practical chemistry safely is to look at the way in which chemicals are used and to consider how to control the exposure to these chemicals by students (and teachers) so that any risks to health and safety are acceptably low. The COSHH Regulations do, however, prohibit the use of a very limited number of specified substances that are not, in any case, used in schools. The COSHH Regulations do not imply that the use of other chemicals are "banned" or that experiments are "prohibited". Nevertheless, anecdotal evidence suggests that some Local Authorities (LAs) and school governing bodies are citing legislation as a reason to discontinue practical chemistry teaching. Anxious parents have contributed to this situation by expecting a risk-free environment for their children.

23. There is, however, a need to be vigilant that amendments to existing regulations and new proposed legislation do not unintentionally restrict the teaching of practical science.

24. Guidance should also be provided to teachers and their employers (LAs) about what is and is not permitted with regard to practical teaching and in this regard information on the hazards likely to be found in school laboratories is given in the data sheets published by CLEAPSS, the Association for Science Education, SSERC (Scottish School Equipment Resource Centre), Heath and Safety Executive and the Royal Society of Chemistry. Specifically for primary schools the Association for Science Education has developed the publication *Be Safe!*[22] to provide guidance on health and safety matters for those teaching primary science.

25. With respect to scientific fieldwork, it should be noted by the Committee that field work in geography is commonplace in schools and colleges, despite facing the same apparent barriers encountered by science.[23]

### 2.4 Teacher support

26. In the SCORE practical work report[24], the main reasons cited for teachers' confidence in undertaking practical work were experience (including experience gained e.g. as a scientist, prior to becoming a teacher), knowing the subject and having enthusiasm for it. Teachers surveyed in the SCORE report also responded that they did not necessarily feel confident in

[22] Association for Science Education *Be Safe! Fourth Edition* 2011
[23] Tilling, S. *Fieldwork in UK secondary schools: influences and provision. Journal of Biological Education*, 38(2), pg 54-58 2004
[24] SCORE *Practical work in science: A report and proposal for a strategic framework*, 2008 http://www.score-education.org/media/3668/report.pdf

carrying out practical work outside their specialist discipline, and in a recent ASE survey[25], 33% of teachers felt inexperienced in practical work.

27. As teachers should feel confident in the learning objectives of each practical activity and be confident in undertaking the activity with the students, it is important that practical pedagogy is embedded at Initial Teacher Education level. It is also vital that all science department staff (teachers and technicians) and primary teachers and subject leaders have access to high-quality CPD to enable them to respond to changing student needs but also to changes in the curriculum, changes in available equipment/technology and changes in legislation regarding health and safety.

28. SCORE supports the Getting Practical programme, hosted by the Association for Science Education, which provides professional development to support teachers, technicians and high level teaching assistants at primary, secondary and post 16 levels in the delivery of effective practical work in the sciences. The Department for Education has unfortunately decided not to continue funding this programme beyond July 2011. SCORE regards it as essential that the work and messages of the Getting Practical programme should continue[26].

29. Although practical work across the sciences has many similarities, there are also differences. For instance in each of the sciences there are specialist pieces of apparatus, specific techniques as well as different learning outcomes in terms of knowledge and ways of thinking. Therefore, whilst there is overlap in the skills needed to carry out and manage effective practical work in each of the sciences, there are also subject-specific skills which are more likely to be associated with subject specialists.

30. The severe shortage of chemistry and physics specialist teachers has resulted in much of the responsibility for students' secondary science education falling on the shoulders of teachers with biology or general science qualifications. For the immediate future this will continue to be the case (it is estimated by the Institute of Physics that even if an extra 1000 physics teachers a year are recruited, it will take 15 years to address the current imbalance of specialist teachers in the sciences). This is likely to have an impact on the quantity and quality of the specialist laboratory and field work that takes place in the individual sciences and therefore on the student's attitude towards these subjects. There is, therefore, a long term need to encourage and support teachers in using practical work outside of their specialism.

31. Subject-specific CPD should be an entitlement for science teachers as part of their overall CPD entitlement, including instructions on contemporary science and developments in research techniques. For specialist subject teachers this should provide them with opportunities to remain engaged with their subject and to grow and develop teaching expertise in their specialism. For non-specialist teachers, subject specific CPD should help to address

[25] ASE survey on practical work and fieldwork - 388 respondents April 2011

[26] Getting Practical *A report on the achievements of the programme 2009-2011* May 2011 http://www.ase.org.uk/documents/getting-practical-report/

any relevant gaps or misconceptions in their subject knowledge and pedagogical content knowledge. At secondary school level the Stimulating Physics Network and Chemistry for Non-Specialists programme aim to tackle this specifically. In a report from the Royal Society it was recommended that there is a similar need for a 'science for non-specialists' course at the primary and lower secondary level. This would help develop teacher confidence in using practical activities in the teaching of the Key Stage 2/3 science curriculum[27].

32. SCORE would like to see a commitment to ensuring that individual school and college science departments have a balanced and full complement of science subject specialist teachers to teach courses in physics, chemistry and biology. This would enable science departments to support the delivery of practical work by less experienced teachers, training teachers and those teaching outside their specialism, through mentoring schemes, sharing good practice and observation. At primary school level it is equally important non-science specialist teachers are supported to use practical work in their science teaching.

### 2.5 Assessment

33. There are concerns that the current assessment demands are damaging and restricting for practical work. In the SCORE report[28] and a recent survey from the Association for Science Education[29], exams and assessment were listed by secondary teachers as the second most common constraint to the delivery and quality of practical activities in science lessons (exceeded only by constraints in the curriculum). Assessment should not drive the science curriculum (of which practical work are integral) yet with league tables and accountability it continues to do so.

34. SCORE recommends the following points are considered on how practical work should be assessed:

- There are arguments that the assessment of practical work ensures its place in the science curriculum and helps protect the provision of facilities.

- While SCORE supports the removal of national tests at the end of Year 9, it has led to the secondary science curriculum being increasingly driven by the assessment requirements of GCSE. SCORE also supported the removal of the Key Stage 2 National Tests for science, as they distorted the primary science curriculum. However, an unintended impact of this change led, in some cases, to less time being spent on science. There is a perception in some schools that science is no longer important (or core).

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[27] Royal Society *Science and mathematics education, 5-14 – a state of the nations report* July 2010 http://royalsociety.org/State-of-the-Nation-Science-and-Mathematics-Education-5-14/

[28] SCORE *Practical work in science: A report and proposal for a strategic framework*, 2008 http://www.score-education.org/media/3668/report.pdf

[29] ASE survey on practical work and fieldwork - 388 respondents. April 2011

- Since its introduction in 1988, the National Curriculum has required students to undertake their own investigative work at Key Stage 4. While SCORE supports the intentions of such investigative work in developing practical skills, assessment targets encourage schools to concentrate on investigations which maximise student performance rather than develop a range of laboratory skills. In many cases this has resulted in practical activity that is narrow in scope and variety and quite often repetitive.

- Controlled assessments have contributed to the limited scope and breadth of practical work. This is because practical tasks set by awarding organisations in controlled assessments must meet the following requirements; be deliverable within a 30-60 minute slot; 100% reliable; deliver results for every student; be prepared by a technician quickly; and use equipment available in every school in the country.

35. There is a need to explore and research effective ways to assess practical work, and to support awarding organisations in developing appropriate examination questions.

36. Teachers also require support in the assessment of practical work. Teachers need to be clear what it is that they would like students to know, understand and do, and whether their assessment approaches are fit for purpose. Teachers' understanding of the purposes, validity and reliability of the various approaches to assessment in all its guises still appeared to be a significant factor in what and how they teach.[30]

### 2.6 Time and variety

37. In order to be effective, practical work at primary and secondary level must be well planned, with an understanding of clear learning outcomes. This requires substantial time to be set aside for teachers and technicians to develop activities; under current pressures this time allocation simply does not exist.

38. In the SCORE report[31], and a recent survey from the Association for Science Education[32] time constraints were cited by teachers as a major barrier. A recent survey by Professor Justin Dillon[33] also found that teachers reported that time for planning individually and collectively was inadequate. This was particularly true of teachers who were not qualified in the subject that they found themselves teaching. This reinforces the need for an increased workforce of specialist science teachers. Schools have also commented on the amount of time allocated to science and the length of lessons.

[30] A SCORE commissioned study by Justin Dillon and Robert Fairbrother, King's College London and Robin Miller, University of York IN PRESS

[31] SCORE *Practical work in science: A report and proposal for a strategic framework*, 2008 http://www.score-education.org/media/3668/report.pdf

[32] ASE survey on practical work and fieldwork - 388 respondents. April 2011

[33] A SCORE commissioned study by Justin Dillon and Robert Fairbrother, King's College London and Robin Miller, University of York IN PRESS

39. The science curriculum in schools should allow sufficient time and space for teachers to undertake a wide range of practical activities with their students. Practical work in schools should include, but not be restricted to, investigations and enquiry activities. Students should experience authentic investigations during school science where students formulate meaningful hypotheses (i.e. in contexts where they have not been taught the expected answer already) and where there will be more than one cycle of activity. There is already some expertise around in this regard, for example the British Science Association's CREST scheme, but it is classed as extra-curricular, and is not available to students unless schools opt-in.

40. Other practical activities should include assembling apparatus, pre-defined procedures, observation and measurement tasks, analysis, experience of phenomena, field work and teacher demonstrations.

41. It is important however to distinguish between quantity and quality. The quality of practical work experiences should be judged by the progress students make in their learning, and be measured against agreed success criteria. Practical work should not be judged by the quantity of time spent on it. For example, complete investigations will probably be rare activities, as elements of the investigative process and of the practical techniques can be studied in shorter time periods.

## 3. Improving the quantity and quality of practical work in the sciences through evidence based research, accountability and promotion of good practice

### 3.1 Evidence based research

42. SCORE is embarking on a major research project to investigate the resourcing of practical work that currently takes place in schools and colleges in England. This work will update existing datasets on the appropriate levels of resourcing required to enable practical activities to take place. A baseline for equipment and consumables was first developed by the Royal Society in 1997[34]. This was subsequently enhanced and updated by the RSC in 2004[35] and 2006[36] to include laboratory facilities. In addition, in 2008 CLEAPSS and ASE[37] developed a baseline for technician support.

43. Given the new levels of autonomy given to schools, this work will demonstrate to senior school management the resource requirements of a science department. On a national scale, the work will demonstrate the level of funding required to best support science education. It will also enable a wider scale investigation into how many schools and colleges in the UK currently reach an acceptable standard.

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[34] Royal Society *Science teaching resources: 11 – 16 year olds* 1997

[35] RSC *Laboratories, Resources and Budgets: Provision for science in secondary schools* April 2004 http://www.rsc.org/ScienceAndTechnology/Policy/EducationPolicy/Laboratories2004.asp

[36] RSC *Improving school laboratories? A Report for the Royal Society of Chemistry on the number and quality of new and re-furbished laboratories in schools* October 2006 - http://www.rsc.org/images/Labsreport_tcm18-65943.pdf

[37] CLEAPSS *Technicians and their jobs* Updated August 2009

### 3.2 Accountability

44. Good quality practical work is integral to science and all young people should have access to it through their science education. There should be a mechanism in place to ensure all schools and colleges are able to (and do) provide this.

45. Ofsted provides such a mechanism and SCORE welcomes the reference to practical work in the Ofsted subject specific guidance documents in science. However, these subject specific inspections operate on a very small scale. SCORE strongly recommends that Ofsted increases the number of subject specific inspections to provide statistically useful data on the impact of policies, structures and initiatives in school departments, particularly with respect to practical laboratory and field work.

46. Field work in geography is currently a statutory requirement within the National Curriculum and therefore is to be experienced by all students. Field work is just as vital to the sciences as it is for geography, particularly in the teaching and learning of biology, yet it and practical laboratory work are not given the same statutory protection. This is counterproductive to efforts to promote practical work in the sciences.

47. The recent SCORE submission to the Government's Call for Evidence on the review of the National Curriculum urged the content statements in the National Curriculum to be written in such a way as to recognise that the sciences are to a large extent practical subjects, and for the statutory guidelines to include explicit reference to procedural skills in the laboratory and in the field[38].

48. In 2004 it was reported by the RSC[39] that a quarter of all school science facilities were graded as unsafe or unsatisfactory, and a further 41% were basic/uninspiring. This is not acceptable and there is a strong case that schools should be held to account on their practical laboratory and field work facilities. The major SCORE research project referred to in Paragraphs 42 and 43 will provide essential information to ensure this is possible.

49. As part of its regulation of awarding organisations Ofqual should be held responsible for ensuring that specifications and all accompanying textbooks support high quality practical work.

### 3.3 Resources and promotion of good practice

[38] The SCORE submission to the Government's Call for Evidence for the review of the National Curriculum April 2011 http://www.score-education.org/media/7650/scorencevidence.pdf

[39] RSC *Laboratories, Resources and Budgets: Provision for science in secondary schools* April 2004 http://www.rsc.org/ScienceAndTechnology/Policy/EducationPolicy/Laboratories2004.asp

50. Since the publication of the SCORE strategic framework[40] for the enhancement of practical work in science in schools and colleges there has been a strong, coordinated approach from the science community to raise the profile of practical work and to maximise the awareness of the support that is available. This should continue to be the basis for any future work.

51. The framework produced by SCORE in 2008 was distributed to all primary and secondary schools[41]. The framework gave a definition of practical work in science, described the purposes of practical work and proposed ways to implement effective practical work in schools. Accompanying the framework were dedicated resources that linked the indicators of high quality practical work to selected biology, chemistry and physics activities for primary and secondary schools.[42]

52. These messages and showcasing of good practice are also supported by the Getting Practical website[43] and the Practical websites[44] which were developed by Nuffield Foundation and CLEAPSS in collaboration with the Society of Biology, Royal Society of Chemistry and Institute of Physics. These websites include tried and tested physics, chemistry and biology experiments, in sufficient detail that they will work in any school laboratory. In addition, the sites provide notes about teaching and learning, demonstrate an integrated approach to the development of mathematical skills and advice on health and safety issues. The sites support teachers and technicians who wish to develop their practical skills in the sciences, and are regularly updated.

53. Members of SCORE play a leading role in supporting the use of high quality practical work through a variety of schemes. SCORE members also actively promote collaboration between schools, colleges, universities and other stakeholders to facilitate sharing of practice aimed at enquiry based practical learning.

54. There are many resources available for teachers and technicians to support practical laboratory and field work. It has been reported to SCORE that a significant number of calls to the CLEAPSS Helpline refer to problems in published protocols for practical activities. While it would not be helpful to require specific practical activities in the National Curriculum Programme of Study, teachers need to be able to recognise good-quality material. Materials sent to CLEAPSS by publishers for health & safety checks often include activities that simply do not work. Resources on practical work should be checked for suitability and practicality before publication. The Practical websites mentioned in paragraph 52 provide one example of where this principle is already in place.

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[40] SCORE *Practical work in science: A report and proposal for a strategic framework*, 2008 http://www.score-education.org/media/3668/report.pdf

[41] http://www.score-education.org/media/3662/framework.pdf

[42] http://www.score-education.org/media/3677/secondary.pdf and http://www.score-education.org/media/3674/primary.pdf

[43] http://www.gettingpractical.org.uk/

[44] www.practicalbiology.com , www.practicalphysics.com , www.practicalchemistry.com