PRACTICAL WORK IN SCIENCE:

A REPORT AND PROPOSAL FOR A STRATEGIC FRAMEWORK

http://www.score-education.org/media/3668/report.pdf

The Science Community Representing Education (SCORE) is a partnership of seven organisations, which aims to improve science education in UK schools and colleges by influencing government and policy-makers and supporting the development and implementation of effective education policy and projects. SCORE partners share a sense of common purpose and maximise their impact by harnessing the expertise, influence and resources of key independent organisations.

KEY FINDINGS

1. There is overarching agreement that 'practical activities' can be put into three broad groups: core activities, directly related activities and complementary activities. Practical work in science includes the core activities and the directly related activities. The complementary activities are important in supporting the development of conceptual understanding in science through practical work. **Practical work in science Core activities** Investigations Laboratory procedures and techniques Fieldwork **Directly related activities** Designing and planning investigations Data analysis using ICT Analysing results Teacher demonstrations Experiencing phenomena **Complementary activities** Science-related visits Surveys Presentations and role play Simulations including use of ICT Models and modelling Group discussion Group text-based activities

2. The importance of practical work in science is widely accepted and it is acknowledged that good quality practical work promotes the engagement and interest of students as well as developing a range of skills, science knowledge and conceptual understanding.

3. There is a strong commitment to high quality practical work in science among teachers, technicians, and other stakeholders alike.

4. There is a wide range of good practical work in science taking place across the UK but there are indications that the situation could be improved by extending good practice and focussing on the quality, rather than just the quantity, of practical work.

5. Effective pedagogy is at the heart of improving the quality of practical work in science. When well planned and effectively implemented, practical work stimulates and engages students' learning at varying levels of inquiry challenging them both mentally and physically in ways that are not possible through other science education experiences.

6. Many teachers indicated that they felt confident doing practical work but there was a very strong indication that this was because they had been able to gain experience over a period of time.

7. There is well-documented evidence of the shortcomings of equipment funding and replacement of laboratories which require continued monitoring and should be addressed as part of wider strategy and improvement in facilities.

8. Although there are currently no serious threats to practical science from health and safety requirements, there is a negative impact resulting from perceptions as to the restriction imposed by health and safety concerns, particularly regarding field trips. This latter situation needs to be addressed and kept under review as new legislation, pupils' behaviour and a lack of technical support can result in signifi cant reductions in practical work in science.

9. Although many teachers expressed dissatisfaction with the amount of time and resources for practical work in science and reported falls in provision, the time devoted to it is still substantial, with 80% indicating they spent more than 40% of lesson time at KS3 doing practical work, though only 56% and 45% reporting that they spent more than 40% of time at KS4 and KS5 respectively.

10. There was concern expressed that teachers did not necessarily feel confident in carrying out practical work outside their specialist discipline. The importance of mentoring of inexperienced teachers was noted as a way of building confidence.

11. Subject-specific professional development, or rather the lack of it, has been highlighted in other reports. More specifically the questionnaire responses indicated that, although 21% of teachers had engaged in CPD specifically related to practical work in the last year, over 40% indicated they could not remember 'ever' receiving CPD on practical work. Opportunities for training and professional development for teachers and for technicians, to support practical work, need to be improved and teachers and technicians engaged with these.

12. The use of ICT is a vexed question that exposes inherent tensions. There is, however, an underlying consensus that ICT should supplement and enhance practical work not replace it. How this is to be done is not well understood and many respondents to the questionnaire did not see ICT as a way of improving practical work.

13. Current assessment demands are damaging and restricting practical science; 66% of the respondents to the questionnaire indicated that the amount of practical work at KS4 had been reduced in recent years. Lack of experience and/ or understanding of the aims of the new GCSE courses appear to have adversely affected the amount of practical work at KS4 in a considerable number of schools.

Another report

http://www.score-education.org/media/11805/score%20resourcing%20secondary.pdf

RESOURCING PRACTICAL SCIENCE AT SECONDARY LEVEL

BBC News report
Pupils at many state-funded schools in England are missing out on practical science experiments because of a lack of basic equipment, a report suggests.

A survey of 845 schools by the group Science Community Representing Education highlights "acute" shortages. On average, secondary schools have 70% of the necessary equipment and primaries just 46%, it suggests.

The Department for Education commented that schools were responsible for deciding how to manage their budgets.

Prof Julia Buckingham, of Science Community Representing Education (Score), said: "Practical science is a low priority when it comes to allocating budgets."

The survey found that levels of resourcing were poorest for biology, with 37% of secondary schools reporting too little equipment for effective practical work. Almost half said they lacked sufficient ecological sampling equipment such as beakers and nets and more than 60% said they didn't have enough items such as thermometers or blood pressure meters to measure changes in the body.

Teachers funding purchases

In chemistry, some 60% of secondary schools reported too few pH monitors for the study of acids and alkalis. In physics, 40% of schools and sixth-form colleges lacked enough magnets even for pupils to work in pairs. Schools also reported shortages of microscopes, eye protection and connecting leads for circuits.

Some 70% of secondary and 37% of primary teachers said they regularly paid for practical science equipment out of their own pockets - "with very few expecting to be reimbursed", says the report.

It raises concerns "that over 80% of state-funded schools do not formally allocate part of the science budget specifically for practical work".

Money spent on photocopying

A representative group of 448 secondary and 397 primary schools were polled on their practical science spending for 2011-12.

In state secondary schools, funding varied from 75p per student to £31.25. The highest-spending independent school put £83.21 per student into practical science. The lowest-spending state primary allocated just 4p.

The report also found that an average of 28% of the practical science budget was spent on photocopying.

School laboratories were inadequate in a fifth of state secondary schools, according to the report, with "insufficient bench space, a lack of access to fume cupboards... and insufficient space to run and store long-term experiments".

Some 60% of secondary schools said they did not have access to a pond for ecology sampling.

'Source of frustration'

Prof Buckingham said: "Low resourcing for practical work is a long-term problem and not one that is a simple matter of lack of government funding.

"Schools must share part of the responsibility for allocating funding for this important aspect of science learning."

She called for school leaders to use a set of benchmarks developed by Score that outline minimum quantities and standards for equipment and facilities. "We need to ensure that all pupils are exposed to the excitement and increased understanding of science that carrying out practical work can bring."

Marianne Cutler, of the Association for Science Education, said the issues highlighted in the report were a source of frustration for many teachers.

"At primary level, in particular, the frustration is that the equipment list is pretty basic and inexpensive. There is no excuse for schools not to have sufficient supplies of objects like batteries, stopwatches and magnets."

'Vital for future prosperity'

Russell Hobby, of the National Association of Head Teachers, said that practical science skills were vital for an understanding of scientific method and for many technical careers, adding: "It is not just lack of equipment, however, that stands in the way, but lack of time in a crowded but narrow curriculum."

Malcolm Trobe, of the Association of School and College Leaders, agreed there were "major issues with resourcing in some areas" but cautioned that "benchmarking levels can only be reached if funding to schools and colleges is sufficient".

A spokesman for the Department for Education said: "Score is right that practical work is essential for high-quality science teaching. The best schools teach science as a practical as well as a theoretical subject.

"It is of course down to schools to decide how best to manage their budgets so that pupils get the best possible education, but we are clear of the importance of science as a subject vital for our future prosperity.

"That is why it is a compulsory subject in schools and we are raising its importance. Practical work is prioritised in our new curriculum."

Comments on a Times Educational Chat Forum: It all started with the question *"should students write up practicals".*

http://community.tes.co.uk/tes_science/f/42/t/655008.aspx?pi2132219857=2

- My HoScience, however, is against the write-up. He thinks they don't need it till they get to university, so why should we teach it to them? He's not even completely sold on doing practicals, reckoning that often it is the case that a You tube video or animation gets the message across just as well or better.

- I'd be more concerned at your HODs dislike of practicals, science should have as many as possible, otherwise the lesson becomes an "about science" lesson rather than a science lesson. What is his classroom discipline like? This is often the main reason for not doing them, there are some I have/will do with well behaved classes that I wouldn't dream of doing when there are kids with behaviour issues in the class. Unfortunately the attitude that you don't need to do practical seems to be increasing, as does the lack of ability to get kids to do a practical successfully. There seem to be more and more science teachers who don't really understand how to get things to work themselves, so it fails when the kids try.

- I asked my daughter, who was studying GCSE science, what she thought about the reaction of sodium with cold water. Reply: 'It was okay but we only saw a video of it, not the actual thing! ' Definitely a case of technology taking education in the wrong direction. (And a lazy chemistry teacher.)

- As for practicals: my Science Advisor 35y ago would descend unannounced and give you a roasting if there wasn't a practical activity in every lesson. His major argument, even more valid today, was that laboratories were much more expensive to provide than classrooms: they are larger, have more services, more expensive furniture, require more heating and cleaning. Why should he fight the authorities if all you wanted was chalk n talk? He also espoused the mantra which I met on my PGCE: "I heard and I forgot, I saw and I remembered, I did and I understood".

- I could not agree with you more! Sadly, especially in the last decade or so, I suppose to cut equipment and technician time costs, the amount of practicals done in science lessons seems to be diminishing. I think the rot might have started over thirty years ago, when physics and chemistry teachers were not plentiful, which lead to things like ILEA's 'Insight to Science', which was a set of work cards with simple experiments, which could (hopefully) be taught by non-specialists. The rather simplistic nature of most of these 'experiments' devalued the worth of practical science, in many eyes. My last HoD, too, was all for reducing the number of experiments, often going through our practical requisitions books and then suggesting that X, Y & Z could be done more easily by 'showing a video' or, latterly, 'using a Youtube clip'. We used to rib him that he would rather watch Judith Chalmers *(a television presenter in the UK)* going on a holiday rather than go there himself.

- Yes I worry about this but do recognise that behaviour and safety is a big factor in whether you do a practical or not. Having said that I always feel we should do practicals and could probably find more creative ways to do them. Unfortunately we don't get enough time to practice or develop these usually.

- You will often find teachers stating that they do not work "9 'til 3.30". I know there is always marking and meetings, but surely many can find 1 hour per week to try out "new" experiments? (There are plenty of lists of tried and tested ones, if you don't want to be too creative.) In a few weeks time, Y11, Y13 (and possibly Y12) lessons will cease. I always managed to get at least one lesson per week put aside for CPD and that was when we did invigilation! If the will exists, get all/most/many of your department to work together showing each other their favourite experiments (include the technicians!). I worked in one school where hundreds-of-pounds-worth of equipment was still in boxes, bought but unused. Doing practical work requires a state of mind. It is easy to believe that the pupils will benfit more from a wonderful exposition, a well-written worksheet or textbook, a fascinating video BUT nothing compares to handling the equipment yourself, finding out what is needed to make it function and then comparing your results to the accepted answers. Science teachers are very fortunate in having this wonderful opportunity and the understanding developed by pupil involvement outweighs the time constraint which practical work imposes. Returning to the title of this thread: please don't put too much emphasis on the written reports. In my first lessons with bottom set Y9s 4 decades ago, they built pinhole cameras, drew diagrams to show light travelling in straight lines, took photos with pinhole cameras and lensed cameras then developed and printed them over the course of 4 weeks. It was only when they wrote a couple of sentences that they thought they had "done some work". What a sad place school can be

CLEAPSS Hazcard for sulfuric(VI) acid

98A Sulfuric(VI) acid H_2SO_4

Corrosive		R35: Causes severe burns. Solutions equal to or stronger than 1.5 mol dm^{-3} should be labelled CORROSIVE. Solutions equal to or stronger than 0.5 mol dm^{-3} but weaker than 1.5 mol dm^{-3} should be labelled IRRITANT. **WEL (mg m^{-3}):** 1 (LTEL), 3 (STEL). **Always add the concentrated acid slowly to cold water, *or preferably ice*, when diluting, never the reverse. Stir frequently to ensure thorough mixing.**

The substance is dangerous with:	WATER. A vigorous reaction occurs when the concentrated acid is diluted. HYDROCHLORIC ACID, CHLORIDES. Hydrogen chloride is given off. CHLORATES, MANGANATES(VII) (permanganates). Spontaneously-explosive products are formed. PHOSPHORUS (WHITE). Ignition can occur. SODIUM, POTASSIUM and many other metals. Dangerous reactions can take place.

Emergencies: see standard procedures on *Hazcard* E, BUT ALSO:

If spilt on skin or clothes:	Remove contaminated clothing and quickly wipe as much liquid as possible off the skin with a dry cloth before drenching the area with a large excess of water. If a large area is affected or blistering occurs, seek medical attention.

Store: CLa Once open, the acid will absorb water from the atmosphere. Full bottles of liquid are very heavy. Fuming sulfuric(VI) acid (oleum) is even more dangerous to use and is **not** recommended for use in schools.	**Disposal:** W1, WSpec Wspec: Wear goggles or a face shield and chemical-resistant gloves. Add **slowly** no more than 10 cm^3 of concentrated sulfuric(VI) acid to 1 litre of 1 mol dm^{-3} sodium carbonate solution (containing indicator) which should be constantly stirred. Let the mixture cool (or add ice), before adding more acid. Pour the solution down a foul-water drain.

For emergencies, see *Hazcard* E as well as more detailed information which may be on this *Hazcard*.

98A Sulfuric(VI) acid — Model risk assessments

Activity	User	Control measures	Experimental points
General use	Y7	Wear eye protection.	For many purposes, 0.4 mol dm^{-3} is adequate. Use solutions no strong- er than 1.5 mol dm^{-3}. See Guide L195.
General use of more concen- trated acid	Y9	Wear goggles. Consider the need for dispos- able nitrile gloves.	Concentrations greater than 1.5 mol dm^{-3} can be used. With concen- trated acid, quantities should be as small as possible. No large contain- ers should be left on a bench or in unused fume cupboards. Bottles have been stolen. Bottles should not be carried by pupils.
Addition to copper(II) sulfate(VI)	Y9	Wear goggles. Wear disposable nitrile gloves.	Use 0.5 g of hydrated copper(II) sulfate(VI) in a dry test tube and cover it with concentrated sulfuric(VI) acid. The colour change is gradual. Disposal: Pour the contents of the test tubes into a bowl of cold water.
Electrolysis of sulfuric(VI) acid	Y9	Wear eye protection.	Usually, a Hoffman voltameter is used with 1 mol dm^{-3} sulfuric(VI) acid to obtain hydrogen and oxygen in a 2:1 ratio. Platinum electrodes must be used; (if carbon electrodes are used, carbon dioxide is produced at the anode). 2 mol dm^{-3} magnesium sulfate(VI) solution is a safer, alternative electrolyte. See *Handbook* 11.4.
Reaction with chlorides, brom- ides & iodides	Y12	Wear goggles. Use a fume cupboard. Wear chemical-resistant gloves.	Use about 0.3 g of potassium or sodium halide with about 5 drops of the concentrated acid. With chlorides, hydrogen chloride is formed. With bromides and iodides, the acid forms the halogen and is itself reduced to sulfur dioxide and, with the iodide, hydrogen sulfide as well.
Reaction with copper	Y12	Wear goggles. Use a fume cupboard. Wear chemical-resistant gloves.	Warm about 1 g of copper turnings with 1 cm^3 of concentrated acid. Sulfur dioxide is evolved. Disposal: After cooling, place the test tubes with their contents in a bowl of cold water.
Reaction with sucrose	TT	Wear goggles or a face shield. Use a fume cupboard. Wear chemical-resistant gloves.	Half-fill a 100 cm^3 beaker with sucrose and add concentrated sulfur- ic(VI) acid to just saturate the sugar. After a delay of a minute or two, the mixture goes black and begins to rise, producing sulfur dioxide and carbon monoxide. Do not touch the carbon mass formed unless gloves are worn. Disposal: Plunge the beaker and carbon into an excess of water when cool. The carbon is placed in the normal refuse.
Diluting concentrated acid	TT	Wear goggles or a face shield. Wear chemical-resistant gloves.	The concentrated acid must be added in small amounts to a beaker (twice the capacity of the final volume) of water or, better still, ice with lots of stirring. See *Recipe Book* 98 and Guide L195.
For drying gases	TT	Avoid this use, especially for hydrogen. See *Handbook* 13.2 for suitable alternative drying agents.	

For emergencies, see *Hazcard* E as well as more detailed information which may be on this *Hazcard*.

CLEAPSS Recipe card for sulfuric(VI) acid

98 Sulfuric(VI) acid

The procedure below uses ice made from distilled or deionised water. Make sure you have a supply of this in the freezer.
Do not make dilute solutions for the first time without seeking practical advice from a more-experienced colleague.

Formula: H_2SO_4 **Molar mass:** 98.07 g mol^{-1}

General Hazards	See *Hazcard* 98A. Addition of acid to water produces a lot of heat. NEVER ADD WATER TO THE ACID; serious accidents have occurred when this has been done.

Concentration required	Volume (ml) of solution required			Hazard warning label
	500	1000	2500	
0.01 M	Ten-fold dilution of a 0.1 M solution with water			-
0.1 M	Ten-fold dilution of a 1 M solution with water			-
0.4 M	11	22	54	-
1 M	27	54	136	IRRITANT
Battery acid	115	230	575	CORROSIVE
5M	135	270	680	CORROSIVE

Procedure

- Wear goggles (a face shield is preferable when handling large volumes) and chemical-resistant gloves.
- Measure out the indicated volume of concentrated sulfuric(VI) acid in a measuring cylinder.
- Fill the beaker or laboratory jug half to two thirds full with ice, add 200 ml of water and a stirrer bar.
- Set the stirrer running on a magnetic stirrer and add the concentrated sulfuric(VI) acid slowly onto the ice.
- Keep stirring the solution until the ice melts.
- Pour the solution from the beaker into an appropriate measuring cylinder or laboratory jug and add water to the required level.
- Pour the solution into a labelled bottle and mix well. Add a hazard warning if appropriate.