SCORE
SCIENCE COMMUNITY REPRESENTING EDUCATION

REPORT

RESOURCING PRACTICAL SCIENCE AT SECONDARY LEVEL

CONTENTS

BACKGROUND

Taking part in practical work is an integral and essential part of learning in the sciences. It provides experiences through which students can develop their understanding, enabling them to make the link between subject content and the physical and living worlds by experiencing and observing phenomena; practical work teaches techniques and skills for handling equipment and materials safely; as well as promoting the development of scientific reasoning, so that students can understand, through direct experience, the importance of evidence in supporting scientific explanations and theories. Therefore it is essential that practical work is properly resourced and that all students have access to the equipment, facilities and opportunities necessary for a complete and authentic education in the sciences.

In 2008, SCORE published the first of its reports on practical work[1]: The associated research revealed concerns about the provision of resources for activities in schools. With this in mind, SCORE commissioned Pye Tait Consulting to investigate the levels of resourcing in schools and sixth form colleges. This report is a response to their findings[2].

WHAT IS PRACTICAL WORK?

SCORE defines practical work in science education as learning activities in which students observe, investigate and develop an understanding of the world around them, through direct, often hands-on, experience of phenomena or manipulating real objects and materials.

In order for enough of these sorts of activities to take place, schools need resources. To assess how many schools and sixth form colleges in England have sufficient resources, SCORE created benchmarks[3] in four areas:

- equipment and consumables, including an estimation of the quantity required;
- laboratory facilities;
- access to outside space; and
- technician support.

These benchmarks were designed to represent an acceptable level of resourcing, between a bare minimum and an aspirational 'gold standard'. From the equipment and consumables benchmarks, a sample of indicative items was identified. These represent the minimum requirement for carrying out practical work in the laboratory.

METHODOLOGY

SCORE commissioned Pye Tait Consulting to carry out a survey of schools and sixth form colleges in England, to gather evidence on the extent of the resourcing of practical science. The research used a mixed methods approach, combining quantitative and qualitative research instruments. It comprised online surveys for primary schools, secondary schools and sixth form colleges, with follow-up telephone interviews and onsite visits to a sample of establishments to explore some issues in greater depth. The surveys garnered a total of 552 responses from 448 secondary schools and sixth form colleges.

RESOURCING AT SECONDARY LEVEL – MAIN FINDINGS

Many state-funded secondary schools and sixth form colleges lack sufficient equipment for basic practical work:

- **Basic equipment for practical work is missing or not working**
- **State-funded schools and sixth form colleges do not have enough funding to buy equipment**
- **The amount spent on science varies greatly between different institutions**
- **Nearly half of secondary school teachers feel they do not have enough funding for practical science.**

Inadequate facilities are limiting the practical work that can take place in schools and sixth form colleges:

- **Schools and sixth form colleges do not have access to appropriate facilities for practical work**
- **Over a quarter of respondents across all schools and sixth form colleges are dissatisfied with their laboratory facilities**

Inadequate technician support is limiting practical work:

- **Just over a quarter of respondents within state-funded schools report that they need at least one additional technician.**
- **Good technician support is being lost because of poor working conditions.**

[1] SCORE's research on practical work can be found at **http://score-education.org/policy/curriculum/practical-work-in-science**

[2] The full reports from Pye Tait, *Under the Microscope*, can be found on the SCORE website at **http://score-education.org/policy/curriculum/practical-work-in-science**

[3] The benchmarks are available on the SCORE website to assist schools with their resourcing; they can be found at **http://score-education.org/policy/curriculum/practical-work-in-science**

MAIN FINDINGS

1. Many secondary schools and sixth form colleges lack sufficient equipment for basic practical work

1.1 Basic equipment for practical work is missing or not working

On average, state-funded secondary schools have just 70% of the equipment and consumables they need to teach science subjects, with four in ten state-funded schools having less than 70% of the equipment and consumables they require.

A wide range of equipment is necessary for the effective delivery of practical science at secondary level. Schools and sixth form colleges were asked to indicate whether they had enough sets of some commonly used and important pieces of equipment such as microscopes, eye protection and connecting leads for circuits. Although some equipment is accessible in almost all schools, there are inconsistencies in terms of the availability of other specialist items and this is a cause for concern.

The following sections provide more detail on equipment specifically required for practical work in biology, chemistry and physics. However, it is worth noting that:

- more than 35% of secondary schools and sixth form colleges do not have enough data loggers with a range of sensors for small group work;
- 10% do not have eye protection for every pupil;
- More than 30% do not have enough bathroom scales (in Newtons) for students to work in small groups to measure their weight; and
- 50% do not have enough ± 0.001g balances for students to measure mass to an appropriate accuracy at post-16.

Biology

Levels of resourcing across the sciences were poorest for biology. At pre-16, 37% of schools do not have access to sufficient quantities, in full working order, of the indicative items needed to carry out effective practical work in biology. At post-16, fewer than 44% have sufficient quantities of these items in full working order.

Specifically:

- Over 60% of schools and sixth form colleges cannot provide reasonable access to equipment to measure changes in the body for pair work.
- Almost 50% of schools and sixth form colleges lack sufficient ecological sampling equipment for pair work.
- 45% of schools and sixth form colleges do not have access to water baths for small groups to carry out controlled temperature experiments.
- Nearly 40% of schools and sixth form colleges are not enabling their post-16 students to carry out basic genetic experiments (due to the lack of gel electrophoresis equipment).
- 30% of schools and sixth form colleges do not have enough example slides for pair work.

Chemistry

29% of schools and sixth form colleges do not have the indicative items in sufficient quantities. In chemistry practical work, students need to make accurate measurements, whether that be the volume of liquids used in an acid-base titration, ensuring they have the correct mass of reactants required for a chemical synthesis, or determining the pH of a solution. However:

- 35% of schools and sixth form colleges are unable to provide sufficient 0.01g balances for small group work at pre-16 for those doing core and additional science; the figure rises to over 45% for the 0.001g balances required for triple science chemistry.
- Nearly 60% of schools and sixth form colleges lack sufficient pH meters, preventing accurate pH measurements for the study of acids and bases.
- 40% of schools and sixth form colleges lack enough colorimeters for students to work in small groups to carry out measurements of concentration.
- In over 40% of schools and sixth form colleges, molecular modelling kits, which help to illustrate complex molecular concepts, were not present in sufficient quantities at for pre-16 students.
- At post 16, about 30% of schools and sixth form colleges lack sufficient thin layer chromatography plates for students to analyse samples individually, and about 40% lack enough heating mantles for pair work.

Physics

Some of the mainstays of pre-16 physics practical work are activities measuring forces, speeds and acceleration, building circuits and investigating light. For each type of activity, at least a fifth of schools are unable to run the activity with pairs of students.

Specifically:

- 20% of schools and sixth form colleges do not have the equipment to do simple experiments measuring forces.
- 25% of schools and sixth form colleges do not have enough equipment for their students to work in pairs to build circuits.
- 40% of schools and sixth form colleges do not have a variety of magnets for pair work.
- Around 20% of schools and sixth form colleges do not have LV power supplies in sufficient quantities for pair work.

1.2 State-funded schools do not have enough funding to buy equipment

With limited resourcing and many demands on the money that is available, practical science must prove its worth. It is therefore concerning that over 80% of state-funded schools do not formally allocate part of the science budget specifically for practical work. Equipment and consumables account for 39% of the science budget in state-funded schools. Given the average funding per student, this amounts to approximately £4 per head to spend on consumables and equipment. These limited funds are needed to:

- buy consumables (chemicals, plant specimens, batteries, etc.);
- purchase new items or types of equipment (for example, an air track costing around £215);
- replenish or restock equipment supplies (for example, a pair of safety spectacles for approximately £10, meaning £300 for a class set; a microscope for £300 or more; a digital meter for approximately £35, meaning £700 to provide enough for a class to measure resistances using two meters per group).
- provide apparatus for controlled assessment.

It is interesting to note that independent schools spend more than £10 per student. However, there is no reason to assume that these schools are being overly generous with their funding. Instead, taking into account responses on staff satisfaction with spending, it is reasonable to assume that the extra spending is something that staff consider necessary to provide the practical opportunities that contribute to students' education in the sciences.

In state-funded schools and sixth form colleges, an unexpectedly large amount is spent on photocopying – on average, around 28% of the science budget, compared with around 7% in independent schools. Purchasing textbooks also accounts for around 14% of schools' expenditure on science. Respondents identified the amount spent on photocopying to be a major barrier to the resourcing of practical science, preventing them from being able to fund large capital pieces of equipment; to increase the quantity of or

Figure 1: Resourcing levels for biology – equipment and consumables

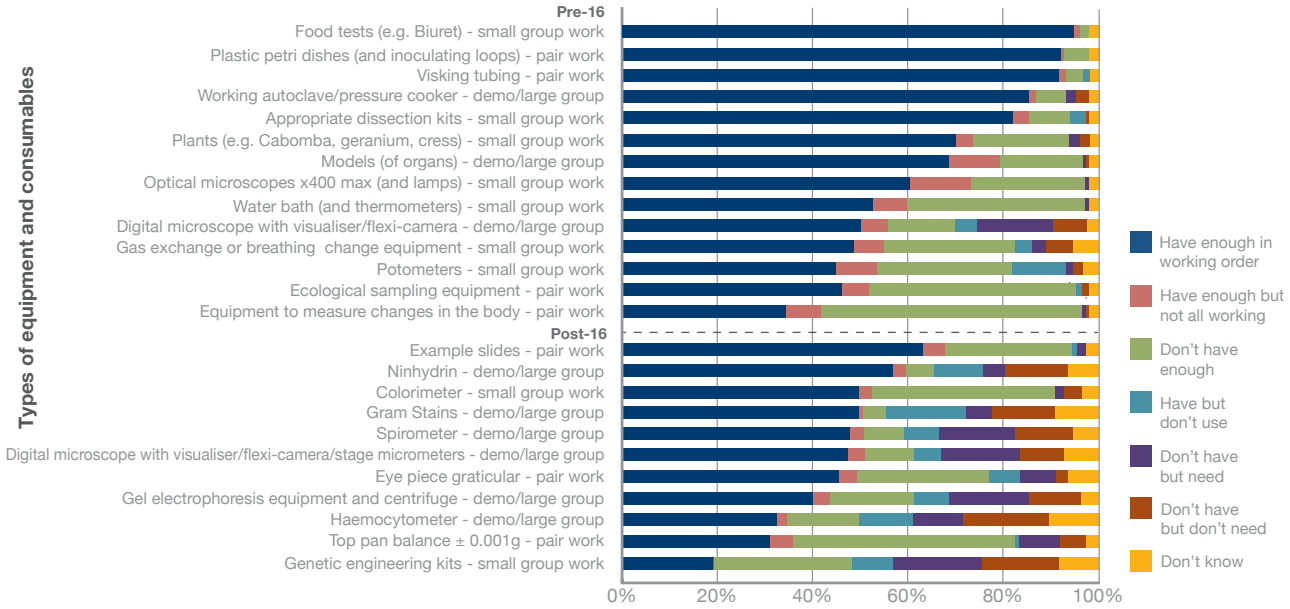


Figure 2: Resourcing levels for chemistry – equipment and consumables

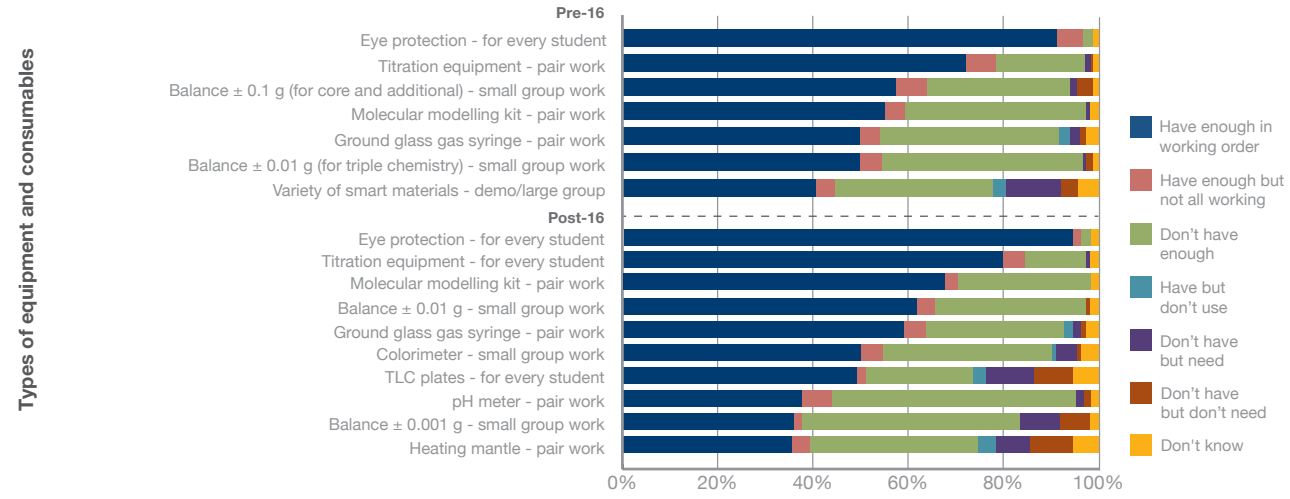
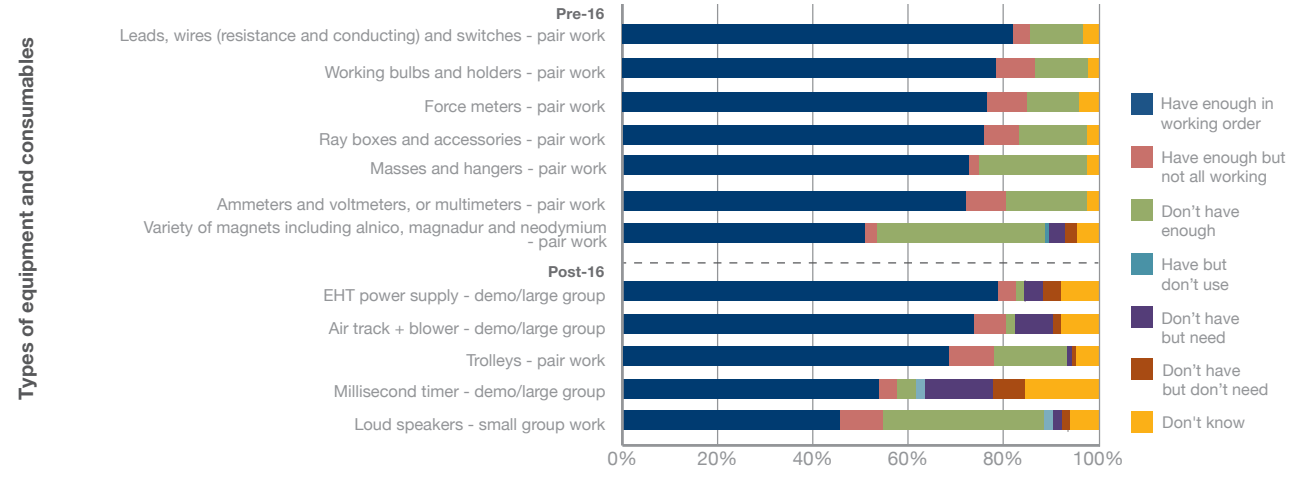


Figure 3: Resourcing levels for physics – equipment and consumables



upgrade existing equipment; or invest in different types of equipment and consumables.

The need for budgets to be spent within a single year also limits the opportunities for schools and sixth form colleges to save up in order to invest in more costly equipment.

> ***"The cost of resourcing a science department is usually underestimated, as it is expensive to replace worn out equipment, and often money has to be spent to comply with safety regulations. We have existed on a culture of 'make do and mend' for too long"***
>
> *Head of science, an academy*

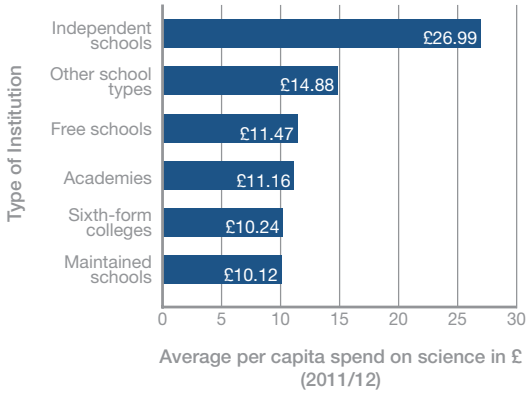
1.3 The amount spent on science varies greatly between different institutions

One school reported spending only 75p per capita on science in 2011/12.

In state-funded schools, the average per capita spend on science (academic year 2011/12) was £8.81, compared with £27.29 for independent schools. The average per capita spend by school type is shown in *figure 4* (institutions with pupils aged 11-18 only).

These averages, however, conceal large differences between schools within the same sector. Among the state-funded schools that took part in the survey, the per capita spend on science varied from £0.75 to £31.25. For the independent schools that took part, funding varied from £7.18 to £83.21. The variation in per capita spend across schools suggests a worrying inconsistency in the way funding is allocated both to and by schools, which will have serious knock-on effects on the experience of their students.

Figure 4: **Average per capita spend on science in the academic year 2011/12 (by school type, schools with pupils aged 11-18 years only)**



Nearly 70% of schools reported that staff had contributed to the core science budget for normal curricular activities by paying for items themselves, for which they are not always reimbursed.

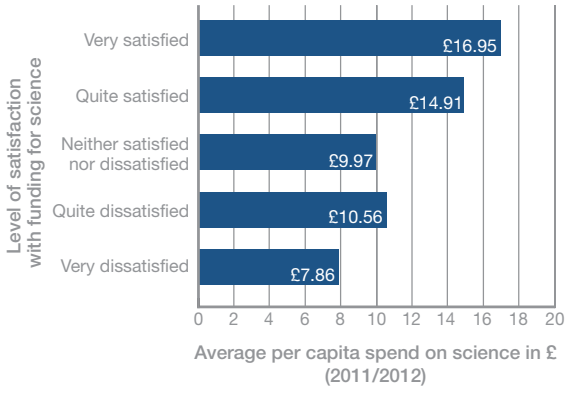
Given the increasing control schools have over their own budgets, some variation in spend between schools might be expected. However, the survey revealed a notable variation by region, with state-funded schools in the North East spending an average of only £8.30, compared with £11.64 being spent in London (2011/12).

1.4 Nearly half of secondary school teachers feel they do not have enough funding for practical science.

Nearly half of the respondents from maintained schools felt there was not enough funding for practical science, stating that they were quite or very dissatisfied with levels of funding.

Not surprisingly, levels of satisfaction rose with the amount spent on science; respondents who reported being very satisfied have, on average, just over double the per capita spend on science as those who state they are very dissatisfied, as shown in *figure 5.* Given that funding is higher in independent schools than in state-funded schools and in schools with sixth forms, the satisfaction in these schools was generally higher, with 44% of maintained schools reporting being quite or very dissatisfied, compared with 7% of independent schools. No independent schools or sixth form colleges reported being very dissatisfied with the available funding for science.

Figure 5: **Average science budget by level of satisfaction (state-funded schools and sixth form colleges only):**



Qualitative feedback obtained through the survey suggests that, among state-funded schools, funding has remained relatively static for the last five years. This is against a backdrop of rising costs and increasing student numbers, meaning that there has been a real-terms cut in funding per student. Schools do not anticipate any increase in funding to take account of these changing circumstances. More than 60% of respondents were concerned about their ability to effectively run practical work in the future, and nearly a quarter expected funding changes to mean less science practical teaching. Again, this varied by school type, as highlighted in *figure 6*.

When considering their levels of resourcing of equipment and consumables, around 46% of respondents stated that they were quite satisfied with what they had, though levels of satisfaction were much lower in state-funded schools (10% very satisfied) than in schools in the independent sector (61% very satisfied). This could indicate a culture of tolerance and coping with the levels of resources available.

2. Inadequate facilities are limiting the practical work that can take place in schools and sixth form colleges

2.1 Schools and sixth form colleges do not have access to appropriate facilities for practical work

Teaching effective practical science lessons does not only depend on sufficient apparatus being available; they also require the appropriate environment. This means pupils being taught in laboratories or given the opportunity to access an outdoor space for learning.

As with the equipment and consumables benchmarks, SCORE asked schools and sixth form colleges about their ability to access a range of facilities associated with practical science, including appropriate storage space, fume cupboards and the proximity of prep rooms to laboratories. Respondents were also asked whether their institutions had separate laboratories for each science, general science laboratories or a mix of the two.

Laboratory facilities

Nearly a fifth of state-funded schools had access to less than 70% of the laboratory facilities benchmarked

Figure 6: Expected impacts on practical science as a result of future anticipated funding over the next two academic years (by school type):

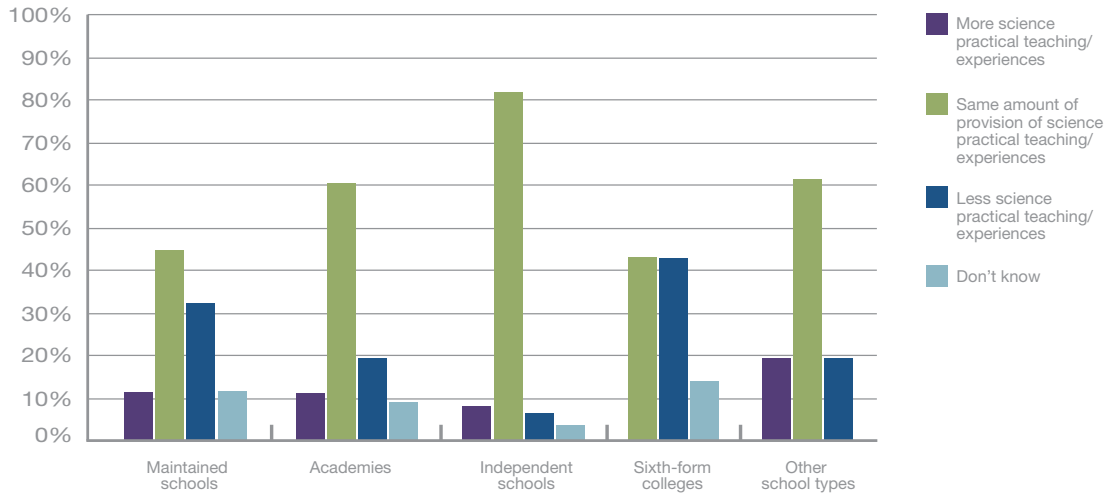
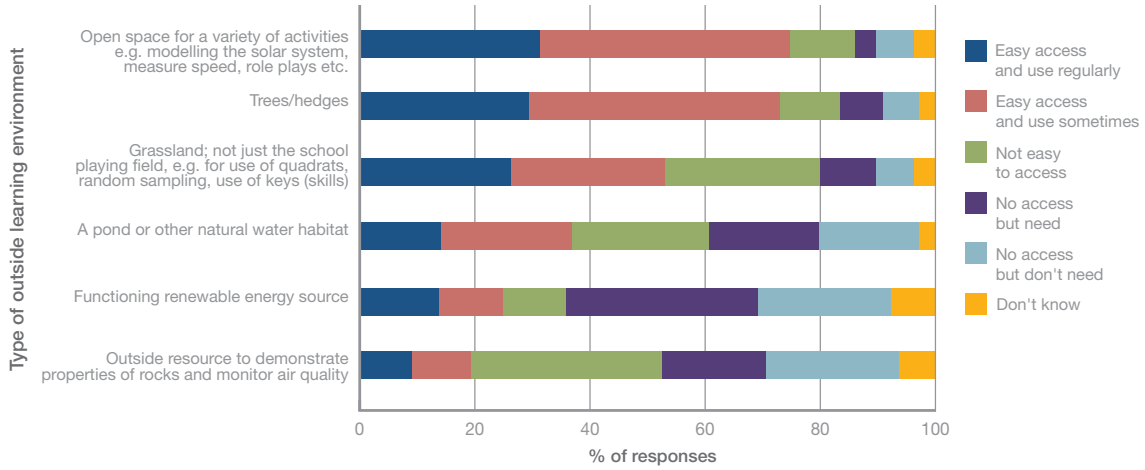


Figure 7: Access to outside learning space at pre-16 institutions



in the survey. All of the reported problems in this area related to the design and set-up of laboratories, in particular insufficient bench space, a lack of access to fume cupboards, the inability to black-out laboratories and insufficient space to run and store long-term experiments.

Outdoor space

Approximately half of the respondents reported difficulty accessing each of the outside learning environments for pre-16 provision, with over 60% of respondents reporting that they do not have access to a pond, and 80% saying they have no easy access to space for demonstrating properties of rocks or to measure air quality (see *figure 7*). This is of significant concern. Students must have access to, and be able to experience, a range of outdoor learning environments in order to engage with and understand the natural world, observe and model phenomena first hand, and develop their fieldwork skills.

The survey also identified problems with the provision of appropriate learning facilities at post-16 level, with no schools reporting that they have access to more than half the learning environments identified. Furthermore, nearly 60% reported that they only have access to less than 10% of the outside learning environments needed.

2.2 Over a quarter of respondents across all schools and sixth form colleges were dissatisfied with their laboratory facilities

Over a quarter of respondents across all schools were quite or very dissatisfied with their laboratory facilities.

However, there was considerable variation within the state-funded sector, with no sixth form colleges (which have specialist laboratories for each subject) expressing dissatisfaction.

There are further difficulties caused by inadequate facilities, especially in relation to safe storage of chemicals, insufficient numbers of gas taps and inappropriate siting of the prep room and/or fume cupboards. Technicians reported that prep rooms are often too small, with inadequate storage and preparation space, particularly in new buildings.

In fact, a number of respondents reported that facilities in new build schools (including those built through the Building Schools for the Future programme) were often not fit for purpose. There were issues too with older school laboratories, which often had to be used for more students than they were designed for. In addition, pressure on the number of laboratories means that a significant proportion of science lessons are being taught in classrooms instead of laboratories, where practical work cannot take place.

Schools were less likely to feel dissatisfied about the access to outside learning environments, despite the lack of access in many cases (see section 2.1), suggesting that respondents may not have a clear idea of what 'good access' looks like. This is of particular concern as it suggests a need for Continued Professional Development on effective science teaching using facilities outside the laboratory. Without access to outside space, science teaching is limited to studying only laboratory-based aspects of science.

3 Inadequate technician support is limiting practical work

3.1 Good technician support is being lost because of poor working conditions

> ***"Often schools overlook the need for decent technical support and are happy to employ someone 'just to do the washing up'. A good technician will stretch the budget by making sure equipment is used, stored and maintained properly, carry out repairs, even making equipment from scratch if necessary, and ensuring new purchases are appropriate and good value for money"***
>
> *Senior science technician, maintained school*

The survey found that technicians are poorly paid and hard to replace, particularly physics specialists. A particular problem was highlighted with training provision and career pathways, which make recruitment and retention difficult. Despite the fact that many technicians were highly qualified, their central role in science departments is often not recognised, with schools seeking cover for absent technicians via caretakers, kitchen or cleaning staff.

3.2 Just over a quarter of respondents within state-funded schools stated that they need at least one additional technician

A number of schools, however, recognise the value that effective technician support can add to their science departments in terms of facilitating practical work, for example, ensuring that equipment is used and stored correctly, and playing an active role in preparing experiments. Some schools are also making increasing use of their technical staff to:

- give advice on effective practical work and assemble complex equipment;
- demonstrate practical science to pupils;
- support the development of inexperienced teachers; and
- ensure that practical experiments can be managed effectively and within budget.

DRIVERS INFLUENCING RESOURCING OF PRACTICAL SCIENCE

1. Curriculum changes

Ongoing change to the curriculum was the most commonly cited factor driving the resourcing of practical science (by 65% of respondents), causing wasted expenditure on textbooks that needed replacing regularly, a rising proportion of the budget being spent on photocopying, and an inability to plan ahead.

2. Controlled assessments

Controlled assessments present a particular burden for schools, because they require specific pieces of equipment in sufficient quantities for all students to use at the same time, which many schools struggle to provide. Over 68% of schools reported that controlled assessments were a major driver of the amount and type of equipment resourced for practical science. Controlled assessment is currently being reviewed by Ofqual, so it is not yet clear what the impact will be of anything replacing this form of assessment.

3. Economic factors

Over 45% of respondents reported reduced or static budgets, despite rising numbers of students taking sciences. This is having wide-ranging impacts on the number of technician working hours, the type and volume of equipment and consumables that can be purchased and on investment in training.

RECOMMENDATIONS

1. The research has highlighted an acute shortage in schools and sixth form colleges of essential equipment and consumables for practical work in science, as well as access to outside space. SCORE recommends:

1a. The Department for Education should carry out further work to identify the number of schools in each of three categories: a severe shortage of equipment, a shortage of equipment, and meeting the benchmark. They should determine remedial funding needed for the science departments in each category to bring them up to a satisfactory level of provision.

1b. The Department for Education should develop a proposal for equitably funding the necessary remedial action across all schools.

1c. Schools should give higher priority to ensuring adequate access to outside learning space, and provide CPD to support teachers in identifying opportunities for effective outdoor learning experiences in science.

2. Every student should have to access the equipment necessary to carry out a core set of practical activities in biology, chemistry and physics. To ensure this happens SCORE recommends:

2a. Those responsible for setting resourcing levels in schools and sixth form colleges should be expected to use the benchmarks provided by SCORE to determine their resourcing needs.

2b. The adequate resourcing of practical science and its impact on the quality of teaching and learning should form part of Ofsted inspections. There should be high expectations of 'outstanding' schools, and it is anticipated that 'good' schools will have met the benchmark criteria outlined by SCORE.

2c. Awarding organisations should include the printing, photocopying and assessment requirements for schools in their headline qualification costs.

3. Technicians play an integral role in science departments in schools and sixth form colleges, but they are often less valued than their teaching colleagues. The role of technicians needs to be fully and properly recognised and funded. SCORE recommends:

3a. Terms of employment for technicians should be improved, in particular salary and working hours.

3b. Senior leadership teams should be made more aware of the value of investing in their science technicians, particularly in supporting their career development towards Registered Science Technician status, and ensure that their institutions have sufficient technician provision in line with the benchmark factor established by the Association for Science Education, and supported by SCORE.

3c. The Department for Education should publish disaggregated data on science technicians in the annual School Workforce Census.

4. Access to laboratories in schools and sixth form colleges is essential for practical work to take place, but too many lessons are taking place in classrooms rather than properly equipped laboratories. SCORE recommends:

4a. Science lessons should be timetabled in laboratories rather than classrooms, and school facilities, where possible, brought up to a standard that meets the SCORE benchmarks.

4b. Architects and suppliers who have responsibility for designing school laboratories should refer to existing best practice and consult with science teachers and technicians to ensure the designs meet their – and the legal – requirements.

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Association for Science Education
www.ase.org.uk

Institute of Physics
www.iop.org

Royal Society
www.royalsociety.org

Royal Society of Chemistry
www.rsc.org

Society of Biology
www.societyofbiology.org

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