Under the Microscope

The State of Resourcing of Practical Science in Secondary Schools and Sixth-Form College in England

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April 2013

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Acknowledgements

Pye Tait Consulting would like to thank all the schools and colleges that took the time to participate in this research. We would also like to thank all the members of the Expert Working Groups and Task and Finish Group for their time and valuable contributions, and in particular, Tamsin Barton and Fiona Miller at SCORE.
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### Glossary

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<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academy</td>
<td>Publicly-funded school with freedom from Local Authority control</td>
</tr>
<tr>
<td>ASE</td>
<td>Association for Science Education</td>
</tr>
<tr>
<td>BSF</td>
<td>Building Schools for the Future programme</td>
</tr>
<tr>
<td>CLEAPSS</td>
<td>Advisory service providing support in science and technology</td>
</tr>
<tr>
<td>CPD</td>
<td>Continuing Professional Development</td>
</tr>
<tr>
<td>Edubase</td>
<td>Database of educational establishments across England and Wales</td>
</tr>
<tr>
<td>FSM</td>
<td>Free School Meals (one of the indicators of pupil deprivation)</td>
</tr>
<tr>
<td>IOP</td>
<td>Institute of Physics</td>
</tr>
<tr>
<td>NSLC</td>
<td>National Science Learning Centre</td>
</tr>
<tr>
<td>NQT</td>
<td>Newly Qualified Teacher</td>
</tr>
<tr>
<td>Ofsted</td>
<td>Inspection body for schools</td>
</tr>
<tr>
<td>RS</td>
<td>Royal Society</td>
</tr>
<tr>
<td>RSC</td>
<td>Royal Society of Chemistry</td>
</tr>
<tr>
<td>SCORE</td>
<td>Established in 2006 to bring organisations together to tackle issues in science education</td>
</tr>
<tr>
<td>STEMNET</td>
<td>Science, Technology, Engineering and Mathematics Network providing resources for students, teachers and professionals. Its STEM Ambassador programme provides free resources for teachers and schools</td>
</tr>
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</table>
1. Executive Summary

This research has sought evidence about the nature of resourcing and funding of practical science within schools and colleges, in order to identify and understand the types of issues that may be encountered, and actions that may be taken to help remedy problems. This report presents the detailed findings of this research for secondary schools and sixth-form colleges in England. Findings in relation to primary schools in England are presented separately.

Evidence gathered from this research points to disparities between resourcing and funding levels between schools and within regions of England, contributing to variations in the practical science teaching and learning experience for students.

This report raises concerns about the levels of resourcing for practical science in comparison with the benchmark standards defined for the purpose of this research. In relation to schools surveyed for this research:

- The average state-funded secondary school has just 70% of the equipment and consumables it needs to teach science subjects, but four in ten state-funded schools have less than 70% of the equipment and consumables they require;
- A third of state-funded schools have 80% or more of the equipment and consumables they need;
- Biology at pre-16 level is the least well-resourced of the three sciences (63.1% of responses indicate schools have access to sufficient quantities of required items in full working order, compared with 70.7% for pre-16 chemistry and 72% for pre-16 physics);
- Less than 1 in 7 schools are able to access over 90% of the indicative items for pre-16 biology;
- Less than 12% of schools have access to more than 90% of the indicative items required for post-16 biology;
- Only a quarter of schools can access more than 90% of the indicative items for pre-16 chemistry;
- Less than 1 in 5 schools have access to more than 90% of the indicative items and 1 in 6 have access to less than 50% of the indicative items for post-16 chemistry;
- Nearly 1 in 3 schools that have access to more than 90% of the indicative items for pre-16 physics), and around 4 in 10 schools having access to less than 70% of the indicative items for post-16 physics;
- Compared with the individual science subjects, schools are relatively well-resourced in relation to general science equipment – however sufficient quantities of the indicative items are still not available to 15% of schools;
- Nearly a third of maintained schools and nearly a fifth of academies are either quite or very dissatisfied with resourcing of science equipment and consumables;
Laboratory facilities are not easily or not accessible to 23% of respondents. Nearly a fifth of schools have access to less than 70% of the indicative laboratory facilities;

Less than 7% of schools have access to indicative outside learning environments for pre-16 provision; there are substantially more concerns in relation to post-16 provision, where nearly 60% of schools only have access to less than 10% of the indicative items;

Around 70% of respondents employ technicians during term-time only. Nearly 30% of maintained schools and nearly a quarter of academies state they are quite or very dissatisfied with the amount of technician support available to them.

Impacts on teaching and learning of practical science as a result of inadequate resourcing include: changes to group sizes (for example work undertaken in groups of 3 or 4 rather than individually or in pairs); and fewer practical experiences undertaken where there is insufficient technician support to adequately resource this.

There is also substantial variation in the amount of funding allocated to science, and to practical science in particular, between schools and sixth-form colleges. The average per capita spend on science for the academic year 2011/12 is £11.16 across all school types. However within state-funded schools the average per capita spend on science is £8.81, compared with an average of £27.29 within independent schools.

Per capita spend on science within state-funded schools ranges from as little as £0.75 to as much as £31.25. Within independent schools the variation is even more apparent, ranging from per capita spend on science of £7.18 to £83.21.

In relation to schools surveyed for this research:

Over 80% of respondent state-funded schools do not formally allocate funding specifically to science practical work;

The highest proportion of the science budget is spent on equipment and consumables (at an average of nearly 40% in state-funded schools). However the proportion of the science budget spent on reprographics accounts for, on average, just over 28% of the budget in state-funded schools (compared with just over 7% within independent schools) which can substantially impact resourcing of science, as the monies allocated to reprographics can mean there is less available to purchase new or upgraded equipment;

Nearly 45% of respondents from maintained schools and just over 30% of respondents from academies that say they are quite or very dissatisfied with the funding available for resourcing science, compared with 6.5% of respondents from independent schools that indicate dissatisfaction;

Respondents in state-funded schools that are very satisfied with the funding available for resourcing science have, on average, just over double the per capita spend on science (£16.95 – academic year 2011/12), compared with those that report being very dissatisfied (average per capita of £7.86);

Science staff are, in some cases, supplementing the core science budget with contributions from their own pocket – however it is not possible to quantify the typical amount spent, and
the frequency with which this is occurring;
• Nearly a third of maintained schools expect to offer less science practical teaching and experiences in the next two academic years as a result of future funding levels.

Respondents in state-funded schools report impacts on science teaching and learning as a result of limited funding – notably a need to adapt to a culture of ‘make do and mend’ – cited as an issue by over a third of respondents.

Other drivers affecting resourcing of practical science include external factors outside of schools’ control – notably the uncertain economic climate and regular curriculum change (both of which have impacted on schools’ capacity to plan ahead for resourcing), as well as the requirements of controlled assessments (notably needing higher volumes of certain types of equipment to all be in use concurrently).
2. Introduction

2.1 About the research and why it was commissioned

“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”\(^1\)

SCORE, 2008

This document reports research into the resourcing of practical science in secondary schools and sixth-form colleges in England. It is part of a larger project that considers practical science resourcing across English schools and sixth form colleges that has been funded by SCORE\(^2\), a collaborative partnership of some of the UK’s leading science organisations.

Science and technology undoubtedly play a crucial role in the UK, contributing directly and indirectly to economic growth, global competitiveness and the management of environmental change as well as supporting individual quality of life through achievement and self-fulfilment. It is vital, therefore, that schools and colleges are able not only to develop their pupils’ knowledge and understanding of science, but also to engage and motivate them for long-term scientific study and employment.

It is widely agreed that hands-on, practical science experiences play a crucial role in developing pupils’ conceptual understanding and increasing their enjoyment of science lessons\(^3\). However, recent research into provision of practical science in secondary schools and sixth-form colleges points to an uneven distribution of practical work\(^4\) between institutions, which may in part be explained by variations in resources. A report from the House of Commons Committee of Public Accounts in 2011 stated that the numbers of pupils studying triple science at GCSE rose by almost 150% between 2004-05 and 2009-10, yet concluded that science facilities in many schools were “unsatisfactory and unsafe”\(^5\). Furthermore the Department for Education (DfE) had no plans at that time to collate or analyse information regarding the conditions of science facilities and had also abandoned facility improvement targets. Other research also conducted in 2011 highlighted that, in spite of a commitment to the provision of learning opportunities outside the classroom, these were not always taken up in practice\(^6\).

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\(^1\) SCORE (2008), *Practical work in science: a report and proposal for a strategic framework*
\(^2\) SCORE was established in 2006 to bring organisations together to tackle issues in science education. SCORE member organisations are the Association for Science Education, the Institute of Physics, the Royal Society, the Royal Society of Chemistry, and the Society of Biology [http://www.score-education.org/about-score](http://www.score-education.org/about-score)
\(^3\) SCORE (2008), *Practical work in science: a report and proposal for a strategic framework*
\(^4\) Ibid
\(^5\) House of Commons Committee of Public Accounts (2011), *Educating the next generation of scientists*
\(^6\) Royal Society of Chemistry (2011), *Outdoor Science*
SCORE therefore decided to commission research in response to concerns that there is a wide variation among schools and sixth-form colleges in the resourcing of practical science taught to pupils between the ages of 5 and 19, which Pye Tait Consulting was commissioned to carry out. SCORE considers that this variation is likely to affect the amount and quality of practical work taking place in schools. Practical work is integral to science education and should be intrinsic to the curriculum and, although adequate resourcing does not guarantee that high quality practical work will take place, insufficient resourcing could be a barrier to it happening at all. Moreover, the Government has a clear policy to increase the number of pupils taking Triple Science and Science A-levels, yet SCORE is concerned this commitment is not being matched with the necessary increase in resource to ensure that all of these pupils have access to high quality practical work.

SCORE has already undertaken a series of important investigations of science practical work in schools, most notably Practical Work in Science: A Report and Proposal for a Strategic Framework (2008). This report demonstrated the high importance attached to practical work as a pedagogical tool and sought to identify obstacles to the effective provision of practical work in schools. It identified resourcing as a critical issue, showing that among teachers and technicians, resources and facilities were cited as the second most important obstacle to undertaking high quality practical science in schools, and were also the most cited factors among individuals who gave detailed responses to the research. It also found that ‘school science departments differ in their resourcing levels and this affects their ability to equally offer high-quality practical work’.

The SCORE report advocated a five-strand strategy for improving the quality and availability of science practical work, with “Strand C” aiming ‘to bring together the best advice on facilities and resources to support practical work in science’. More generally, the report suggested that SCORE should lobby policymakers to ‘ring-fence department funding’ for science subjects to ensure that schools are able to fund high quality science practical work.

SCORE’s current four-module research project, Resourcing School Science, has been designed to provide the first robust enquiry into the funding and resourcing of practical science work in schools and sixth-form colleges in England. The first module consisted of background research into the resourcing of practical science. The second module updated the Royal Society’s benchmark list of resources needed to deliver the national curriculum in science. The benchmarks are explicitly intended to provide schools with guidance on an ‘appropriate’, rather than a ‘minimum’ or ‘gold standard’ level of resourcing.

The aim of our research - the third module within the project - is to gather and analyse evidence that will enable SCORE to further understand the nature of resourcing of practical science in schools and sixth-form colleges, and in particular to ascertain the extent to which schools are able to meet the standard set out in the benchmark list; to understand the impacts of the approaches to resourcing taken by schools and colleges; and consider how any issues might be addressed.

Research findings are intended to inform local school policies as well as national Government policy. The evidence is intended to influence national policy in relation to: 1) the level of resourcing required to ensure that every pupil has the opportunity to experience appropriate practical work in science; and 2) the potential need to protect funding for science departments within a devolved funding model. In addition, the research findings will assist school science departments by providing them with the evidence they need to make the case for appropriate resources, budgets and technical support to deliver good quality practical work.

This report presents our findings in relation to secondary schools and sixth-form colleges in England. Findings for primary schools and are presented separately.

2.2 Research objectives

The objectives for this research were to:

- ascertain the availability, accessibility and scope of the resources used for practical science work in schools in comparison with a series of indicative items drawn from a comprehensive benchmark list developed as part of the previous module of SCORE’s research project (subsequently refined in conjunction with an expert Working Group);

- use both the process and the findings of the research to test the robustness of the indicative items, suggesting revisions where appropriate;

- identify the amount and adequacy of historical, current, and likely future sources of funding for science practical work in schools;

- understand the relationship between funding and resource levels and the scope and adequacy of practical science provision;

- determine how new build science departments are resourced.

Consideration of the purposes and definition of ‘high quality practical work’ was out of scope for this research. For the purposes of this research, SCORE defines practical science as:

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.

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8 Pye Tait Consulting (2013), *Under the Microscope: The State of Resourcing of Practical Science in Primary Schools in England*

9 See Section 2.3.1 for more detail

10 Agreed in conjunction with a Task and Finish Group, see Section 2.3 for more detail
to examine experimental observations (for 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).

In addition, SCORE considers practical work to include fieldwork, class demonstrations and any computer simulations that generate experimental data. Practical work does not include watching videos, attending educational visits (for example to the science museum or a science workplace) or use of computer simulation for illustrative purposes.

The resources that are used to support practical work are clearly defined for the purposes of the research as:

a) laboratory facilities;  
b) equipment and consumables;  
c) technician support;  
d) access to outside learning environments for learning outside the classroom.

The geographical scope of this report is restricted to England; however similar research may be undertaken in the remaining UK nations in the future.

2.3 Research methodology

This research commenced in April 2012. Throughout the research Pye Tait Consulting remained in regular contact with the Task and Finish Group convened to provide oversight of the work. This Group comprised:

- SCORE’s Manager and Deputy Manager
- Representatives from all SCORE partner organisations: Association for Science Education; Royal Society of Chemistry; Royal Society; Society of Biology and Institute of Physics;  
- Teachers representing both primary and secondary education.

All fieldwork data collection tools (quantitative and qualitative) were submitted to SCORE and the Task and Finish Group for review and approval before they were used.

This piece of social science research utilised a mixed methodology, combining quantitative and qualitative research tools as follows:

- Desk-based review of relevant literature, including national and local resourcing and funding policies;  
- Selection of a set of indicative items (mapped to the relevant resource areas outlined above in Section 2.2) that could be used to assess the level of resources available to participant schools (see Section 2.3.1 for details);

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11 Classroom facilities in the case of primary schools
Design and facilitation of an online survey for secondary schools and sixth-form colleges with an objective of securing 460 respondents to gain evidence on a wide range of information relevant to the resourcing of practical science, including school characteristics, funding levels, and staff attitudes, as well as the extent to which schools were able to access the indicative items;

Follow up via in-depth qualitative telephone interviews and visits with a selected sample of schools to explore the resourcing of practical science in depth.

The research findings presented in this report are drawn from:

- quantitative data obtained from the online survey to define the current resourcing and funding levels for practical science in secondary schools and sixth-form colleges;
- qualitative data obtained from the interviews and schools visits to provide additional understanding of the impacts of current levels of funding and resourcing, and of the key drivers that shape them.

It should therefore be noted that the findings presented here are based on self-report from participating schools on the basis of selected indicative items; it is not an exhaustive audit. With this limitation, however, the research is the most comprehensive of its kind yet undertaken in England. Where feasible to do so, research data are presented by region; however it should be taken into consideration that there may be relatively low numbers of respondents per region and therefore these findings should be viewed as indicative only.

### 2.3.1 Development of list of indicative items used in the survey

The indicative items were drawn from a complete set of resourcing benchmarks developed by SCORE in the previous module of this research. The indicative items were selected from the benchmarks with the advice of an expert Working Group convened for this purpose. The Group comprised representatives from schools spanning all three sciences as well as CLEAPSS, the advisory and support service for science and technology. Discussions about the benchmarks were facilitated by SCORE and Pye Tait Consulting.

The workshop with the Working Group first identified a wide range of benchmark items as potential indicators. These were subsequently refined to a smaller set of indicative items that the Group considered would be necessary to deliver effective practical science. These lists (grouped into three: equipment and consumables; laboratory facilities; and outside learning environments) were used for the purpose of the survey. The list of indicative items used in the survey is included as Appendix 1.
2.3.2 Quantitative online survey

The sample frame for the survey was established using official statistics published by the Department for Education\textsuperscript{12} to define a representative sample spanning all types of school (maintained, academy, free, etc.) and a range of sizes and locations (urban/rural, regional).

The research sought a sample of \textasciitilde{}10\% of approximately 3,670 secondary schools (independent and maintained) and sixth-form colleges in England, therefore suggesting a target around 400 survey completions. A higher target of 460 responses was chosen to permit some flexibility for oversampling of any school/college types of particular interest (Table 1).

**Table 1: Sample frame for the online survey of secondary schools and sixth-form colleges**\textsuperscript{13}

<table>
<thead>
<tr>
<th>Population</th>
<th>Total Target Sample</th>
<th>Indicative Stratification</th>
<th>Number</th>
<th>Target Stratified Sample</th>
<th>Confidence level/interval (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,670</td>
<td>460</td>
<td>School type</td>
<td>3575</td>
<td>425</td>
<td>&gt;95/5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sixth-form college</td>
<td>95</td>
<td>35</td>
<td>85/10</td>
</tr>
</tbody>
</table>

The online survey went live on Monday 3\textsuperscript{rd} September, 2012. A variety of publicity for the surveys was used to encourage respondents to become involved. A random sample of 1500 secondary schools was initially mailed a formal invitation to participate from the then chair of SCORE, Professor Graham Hutchings. In addition, SCORE and its partner organisations used their own media channels and contact, primarily websites, email lists and press releases, to promote the surveys. Finally direct email contact was made with head teachers of all secondary schools in England to ask them to consider involving their schools in the research, and the link to the survey circulated to all Principals of sixth-form colleges in England.

The survey officially closed on Friday, 11\textsuperscript{th} January, 2013. At this point a total of 557 responses had been submitted. Responses were then collated and data cleaned using a combination of automated and manual methods.

During data-cleaning and cross-checking, the survey responses were found to contain a number of invalid and partially duplicated submissions, which were subsequently excluded from the dataset or cleaned. The final dataset was then defined, and the number of valid responses ascertained:

- 557 responses were submitted;
- 1 blank response was excluded;
- 15 responses from outside England were excluded;
- 2 responses from FE colleges and one from an HE institution were excluded;
- 4 responses were excluded from the main dataset because they had critical omissions;

\textsuperscript{12} http://www.education.gov.uk/rsgateway/DB/SFR/s001071/index.shtml
However, where there were literal comments these were retained for qualitative analysis;

- 12 respondents submitted duplicate responses – these were manually cross-checked; in each case, the most complete survey response was retained and the less complete excluded;
- 2 responses were not from schools or colleges, but represented the views of other stakeholders (a STEM ambassador and a home schooling association); these were excluded from the main dataset; however, where there were literal comments these were retained for qualitative analysis;
- 58 schools and colleges submitted multiple responses;
- The final dataset therefore consisted of a total of **522 valid responses from 448 unique schools and colleges**.

Much of the analysis was concerned with determining the situation at the level of schools rather than individual respondents. There were a total of 19 schools that submitted multiple responses from the same target group; if all these individual responses from the same target group within an individual school had been included in the dataset, the effect would have been to over-represent that school. For this type of analysis, therefore, multiple responses were consolidated to produce a single response per respondent type per school.

The regional distribution of responses from individual schools was checked against the actual distribution of secondary schools across England as reported in official statistics. The number of responses from all but two regions was well within the expected margin of error. It was nevertheless decided to weight the data during the analysis to equate more closely to the known regional distribution in order to ensure that the final statistics were as representative as possible of the overall national picture.

### 2.3.3 Qualitative in-depth fieldwork

Qualitative telephone interviews and visits were undertaken, to explore emerging findings in more detail, with secondary schools and sixth-form colleges as follows:

- 72 telephone interviews; and
- 11 visits.

These institutions were selected based on the following criteria:

- Agreement to participate in further follow up research (question posed within the survey);
- Spread by region, type and size; and
- Spread across spectrum of satisfaction levels with funding and resourcing of practical science.
3. Context of research findings

3.1 Background

There is broad consensus that practical experiences are of central importance to teaching secondary science in an effective and engaging way. Indeed, the recent report of the House of Commons Science and Technology Select Committee on Experiments and Practical Science concluded that ‘both practical lessons and learning outside the classroom are essential contributors to good quality science education’. The level of commitment within the science community to science practical experiences is also evident in the large number of grants and other resources provided by science societies and charitable foundations to support practical science provision.

This consensus is supported by teachers and by the schools inspectorate, Ofsted. Recent research shows that secondary teachers are committed to the importance of practical science, and convinced of its value for engaging students and increasing their understanding of scientific concepts and ways of working. Among participants in a teacher panel surveyed by the National Science Learning Centre (NSLC), there was a clear view that students enjoyed carrying out practical work as it offered different challenges from other types of learning. Moreover, 93% of participants said that practical techniques should be listed in the national curriculum, and a majority felt that it was important for practical techniques to be externally assessed at both GCSE and A-level.

Ofsted’s engagement with secondary schools that have succeeded in improving science education also emphasises the value of practical work. It found that among ‘schools which showed clear improvement in science subjects, key factors in promoting students’ engagement, learning and progress were more practical science lessons and the development of the skills of scientific enquiry’. Ofsted therefore recommends that secondary schools should ‘use practical work and scientific enquiry as the key stimulus to develop scientific knowledge, understanding and skills’.

Moreover, the increasing emphasis on ‘science literacy’ as one of the major goals of science education has also put practical work to the fore. Science literacy focuses heavily on understanding ‘how science works’, on the processes and procedures that underlie scientific knowledge. Active enquiry, practical experimentation and critical thinking are recognised as having great value in

14 SCORE (2008), Practical work in science: a report and proposal for a strategic framework
15 House of Commons Science and Technology Committee (2011), Practical experiments in school science lessons and science field trips
16 See: https://www.sciencelearningcentres.org.uk/WebPortal.aspx?page=1&module=DB920A53-01EA-4886-8878-F2CDF5FA8CFD&mode=101&newsId=DB920A53_01EA_4886_8878_F2CDF5FA8CFD=6207&returnPage=DB920A53_01EA_4886_8878_F2CDF5FA8CFD
17 Science Learning Centre Panel (2012), Practical Science Survey Topline Report
18 Ibid
19 Ofsted (2011), Successful Science
developing this understanding\textsuperscript{20}.

The importance attached to practical science is reflected in its prominence within schools. Practical science work, through experimentation, fieldwork, and demonstrations, has long been a particular feature of science education in the UK at secondary level\textsuperscript{21}. In the NSLC panel research, 84\% of teachers said that they use practical work frequently or very frequently, and only 1\% said that practical work was a rare occurrence. Overall, the participants also reported little change over the previous five years in the amount of practical work that took place\textsuperscript{22}.

Nevertheless, there have also been longstanding concerns across the science community that the quantity and quality of practical works in secondary schools may be insufficient\textsuperscript{23}. Such concerns have been explored in considerable depth by the House of Commons Science and Technology Committee in its 2011 report on practical science in schools\textsuperscript{24}. The committee particularly explored the reasons why there may be problems with practical science, initially focusing on the possible barriers that may be posed by health and safety concerns. This reflects a longstanding popular view that real or perceived health and safety issues have led schools to reduce the amount and quality of practical science learning they offer their pupils.

The Committee found little evidence of this. It did however express considerable concern about the professional preparation of teachers to undertake practical science teaching, the status and career prospects of science technicians, and the equipment and facilities available to them in schools. Their report concluded that ‘science teachers need fit for purpose facilities and the support of qualified and experienced technical support’\textsuperscript{25}.

This reiterates concerns that have been expressed within the science community for some years. In 2008, SCORE observed that ‘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’\textsuperscript{26}.

More detailed research into the resourcing of practical science has also identified potential issues in a range of areas, most notably in funding, laboratories, technician support, and access to fieldwork. The NSLC panel research found that 35\% of teachers believed that better quality equipment would do the most to help improve practical science, and 38\% of respondents cited lack of money for equipment or consumables as the most important limiting factor for practical work\textsuperscript{27}. Moreover, 39\% of respondents reported that the amount of funding they received had decreased significantly in recent years.

\begin{footnotesize}
20 2008 Report to the Nuffield Foundation - *Science education in Europe: Critical reflection*
21 SCORE (2008), *Practical work in science: a report and proposal for a strategic framework*
22 Ofsted (2011), *Successful Science*
23 SCORE (2008), *Practical work in science: a report and proposal for a strategic framework*
24 House of Commons Science and Technology Committee (2011), *Practical experiments in school science lessons and science field trips*
25 Educating the next generation of scientists 2011
26 SCORE (2008), *Practical work in science: a report and proposal for a strategic framework*
27 Science Learning Centre Panel (2012), *Practical Science Survey Topline Report*
\end{footnotesize}
Laboratories were identified as a particular area of concern by research undertaken in 2004 for the Royal Society of Chemistry\(^{28}\). On average, teachers reported needing an additional laboratory in every school, and found that existing laboratories were often inadequate. Indeed, the report made a conservative estimate that nearly £1.4 billion would need to be spent to bring all laboratories up to a ‘good’ standard.

It also found that that this would need to be backed up by a continuing commitment of resources if even a ‘minimum’ standard of provision was to be maintained. Subsequent research found that even where schools were given resources for new or refurbished labs, this did not always result in high quality facilities. In particular, there were complaints that new equipment and furniture were badly specified, often of poor quality and frequently deteriorated quickly under normal usage. Some respondents also reported that preparation areas often saw little improvement, or even deteriorated, during the refurbishment process\(^{29}\). Complaints were also noted in relation to facilities being better prior to refurbishment than afterwards.

The availability of appropriate technician support has also attracted attention. The Association for Science Education’s National Technician Survey, last carried out in 2010, found that, although most science technicians work full-time hours, many are on term-time only contracts. It also found that 60% of technicians worked overtime every week, and that most did not receive any compensation for this, either in pay or time off in lieu. This was a marked increase on the corresponding figure for 2000, when only 12% worked more than their contractual hours.

In addition, there was evidence that technicians were taking on a wider range of responsibilities, including increased involvement in dealing with finances; assisting with practical lessons; and undertaking demonstrations in class\(^{30}\). These issues have been noted by the House of Commons Science and Technology Committee, which has called for action ‘to address the pay and conditions of science technicians and create a career structure that will attract skilled and dedicated people to work as technicians’\(^{31}\).

Finally, fieldwork has recently been identified as an area for concern, with reports that there is a long-term trend of declining provision and quality of fieldwork in GCSE and A level science\(^{32}\). Science teachers have been found to value fieldwork less than their colleagues in geography, and there is also evidence of a state-funded/independent divide across schools, with independent schools making more use of fieldwork for science subjects.

In spite of all these concerns, however, there has been relatively little robust research into the resourcing of practical science in secondary schools. Indeed, almost all the existing literature raises concerns about the adequacy of the current evidence base. The Science and Technology Committee in particular noted that the Government does not routinely collect data on the

\(^{28}\) Royal Society of Chemistry (2004), *Laboratories, Resources and Budgets*
\(^{29}\) Royal Society of Chemistry/CLEAPSS (2006), *Improving School Laboratories*
\(^{30}\) ASE (2012), *National Technicians Survey 2010*
\(^{31}\) House of Commons Science and Technology Committee (2011), *Practical experiments in school science lessons and science field trips*
\(^{32}\) Royal Society of Chemistry (2011), *Outdoor Science*
availability or condition of practical science resources, and has noted the need for agreed basic standards for laboratory provision. The Royal Society has also stated in a recent report that policy making in science education more generally is hampered by ‘issues with data collection and insufficient consideration of research evidence’.

Before the research was undertaken, we lacked a clear, detailed understanding of:

- what resourcing standards secondary schools need to meet; and
- how many schools actually meet these standards.

These issues are particularly problematic given the current policy context. For example there is a clear Government commitment to incorporating science within assessment processes both inside and outside the laboratory. This is likely to have considerable resource implications, given there is evidence that only around two-thirds of pupils currently have to take practical assessments in science, with a similar proportion undertaking open-ended science investigations. The introduction of universal testing of practical skills would, therefore, be likely to lead to a substantial increase in the amount of practical science teaching.

In addition, the strong current focus on extending enrolments in triple science GCSE is likely to have similarly significant implications for science resourcing – not only in itself, but also because it is associated with increasing enrolments in A-Level science. No less significantly, finance and resource decisions are increasing being devolved to local schools – a development which will give schools more discretion to focus on their own needs and priorities, but which may also increase disparities in levels of practical science provision from one school to another.

Moreover, these changes are happening a time of financial stringency due to budgetary constraints. Recent Government proposals suggest that, in the future, all academic 16-19 qualifications could be funded at base rate, which would remove the 12% weighting for science.

The following sections will therefore seek to define more closely the level and degree of consistency of science funding across different schools; to consider the actual levels of equipment and consumables available; to assess the levels of technician support available; and to consider the accessibility of the outside environments needed to deliver appropriate fieldwork to secondary pupils. Taken together, these findings will provide the first comprehensive baseline of evidence on the resourcing of practical school science in secondary schools and colleges.

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33 House of Commons Science and Technology Committee (2011), Practical experiments in school science lessons and science field trips
34 The Royal Society (2010), Science and Mathematics Education 5-14
35 Government Response to Science and Technology Committee Recommendations 2011
36 ASE (2012), National Technicians Survey 2010
37 Broecke (2010), Does Offering More Science at School Increase the Supply of Scientists? The Impact of Offering Triple Science at GCSE on Subsequent Educational Choices and Outcomes
38 This was announced after the scope of this research was defined, and therefore survey questions were not designed to gain feedback in relation to this issue specifically, however the researchers were able to gain some evidence via the qualitative interviews about the potential impact of such changes
3.2 Breakdown of survey respondents

The majority of respondents to the survey came from academies (53.5%), followed by nearly a third of respondents (31.6%) from maintained schools (Figure 1). Other school types that responded to the survey included a small number of pupil referral units and studio schools.

Figure 1: Breakdown of survey respondents by school type

<table>
<thead>
<tr>
<th>School Type</th>
<th>Percentage</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintained school</td>
<td>31.60%</td>
<td>141</td>
</tr>
<tr>
<td>Academy</td>
<td>53.50%</td>
<td>240</td>
</tr>
<tr>
<td>Free school</td>
<td>9.30%</td>
<td>42</td>
</tr>
<tr>
<td>Independent school</td>
<td>0.90%</td>
<td>4</td>
</tr>
<tr>
<td>Sixth-form college</td>
<td>3.80%</td>
<td>17</td>
</tr>
<tr>
<td>Other</td>
<td>0.90%</td>
<td>4</td>
</tr>
</tbody>
</table>

Base: 449

Figure 2 shows the breakdown of respondents by geographical region.
The majority of respondents were either a Head of Science or Science Teacher (59.3%).

In general, Head teachers were less inclined to engage with the research (accounting for 4.9% of respondents) (Figure 3).

Respondents were asked about the types of science resources they use. All respondent schools...
report that they are members of CLEAPSS (175 responses to this question). The majority (62.1%) also make regular use of science associations, for example via membership of the ASE (Figure 4).

Figure 4: Use of science association membership

Base: 174
4. Funding

4.1 Key messages in relation to funding for practical science

The survey included specific sections on funding that asked respondents to disclose a range of budgetary, expenditure and other information connected with the funding of the science curriculum area in general and practical science in particular. The relevant questions were developed on the basis of background literature and qualitative research with secondary school and college science teachers, and were refined on the basis of the pilot survey and the advice of the SCORE Task and Finish Group. The final questionnaire sought information on:

- Annual expenditure on science;
- Whether spending on science was expected to increase or decrease in the current and future financial years;
- The way that science budgets are allocated to various types of expenditure;
- Whether any of the science budget was specifically allocated to science practical work;
- Any additional sources of funding used by the school;
- Levels of satisfaction with current science funding;
- The anticipated impact of future funding levels on the amount of science practical work that will be provided over the next two years.

Data gathered from these questions were used to build up a comprehensive picture of the funding of practical science in English secondary schools and sixth-form colleges on the basis of the predominantly quantitative survey data. This was then supplemented by additional qualitative evidence drawn from literal comments in the surveys and from the in-depth interviews. Where findings are derived from qualitative data, this is specifically indicated.

Key messages in relation to this funding section are presented in the box below.

- The average per capita spend on science for the academic year 2011/12 is £11.16 – across all school types. However there is considerable variation between school types – within state-funded schools the average per capita spend on science is £8.81, compared with an average of £27.29 within independent schools\(^\text{39}\);

- There is also a great deal of variation across schools in England in relation to the funding they allocate to science, and to practical science in particular. Per capita spend on science within state-funded schools ranges from £0.75 to £31.25. Within independent schools the variation is even more apparent, ranging from per capita spend on science of £7.18 to as much as £83.21;

\(^{39}\) Although it should be noted that only 18 independent schools provided data for this question
- Over 80% of respondent state-funded schools do not formally allocate funding specifically to science practical work;

- The highest proportion of the science budget is spent on equipment and consumables (at an average of nearly 40% in state-funded schools). However, the proportion of the science budget spent on reprographics accounts for, on average, just over 28% of the budget in state-funded schools (compared with just over 7% within independent schools) – qualitative feedback suggests this figure has risen in recent years and there are concerns it may continue to increase. This can substantially impact resourcing of science, as the monies allocated to reprographics can mean there is less available to purchase new or upgraded equipment;

- Around a third of all respondents report they are quite or very dissatisfied with the funding available for resourcing science; again there are differences between school type – with 44.4% of respondents from maintained schools and 30.3% of respondents from academies that say they are quite or very dissatisfied, compared with 6.5% of respondents from independent schools that indicate dissatisfaction;

- Respondents in state-funded schools that are very satisfied with the funding available for resourcing science have, on average, just over double the per capita spend on science (£16.95 – academic year 2011/12), compared with those that report being very dissatisfied (average per capita of £7.86);

- Science teachers and technicians are, in some cases, supplementing the core science budget with contributions from their own pocket – however it is not possible to quantify the typical amount spent, and the frequency with which this is occurring;

- Nearly a quarter of all respondents anticipate that future funding levels will mean they have to provide less science practical teaching and experiences; within state-funded schools the concerns are more prominent – with nearly a third of maintained schools expecting to offer less science practical teaching and experiences in the next two academic years;

- Respondents in state-funded schools report impacts on science teaching and learning as a result of limited funding – notably a need to adapt to a culture of ‘make do and mend’ – cited as an issue by over a third of respondents. Constraints on funding typically mean schools cannot purchase as much equipment as they need (whether to buy new items or upgrade or increase quantities of existing items) cited as an issue for over a fifth of respondents – this in turn then can impact on the delivery of practical science, for example equipment may have to be shared by small groups rather than individual or pair working (an issue for nearly a fifth of respondents).
4.2 Per capita and average budgets for science

Data on the overall budget for science were requested from all respondent schools. Where relevant data were available, they were used to calculate the per capita science spend at each of the participating schools. In 2011/12 across the schools that responded to this question, the average budget spent on science across all key stages for all surveyed schools and colleges is £11,896 per annum, per school\(^{40}\), with an average per capita spend on science of £11.16.

There are differences between state-funded and independent schools, with substantial variation within and between school types. In state-funded schools, the average budget spent on science is £10,265 per annum (academic year 2011/12), per school, with an average per capita spend on science of £8.81. However among independent schools\(^{41}\), the average budget spent on science per annum (academic year 2011/12), per school is £25,272, with an average per capita spend on science of £27.29.

Among the state-funded schools that participated in the survey, the per capita spend on science for the academic year 2011/12 ranges from as little as £0.75 to as much as £31.25. The annual budget allocated to science within state-funded schools for the same academic year ranges from £800 to £41,337.

Among independent schools the per capita spend on science for the academic year 2011/12 ranges from £7.18 to £83.21. The annual budget allocated to science within independent schools for the same academic year ranges from £4,000 to £80,383.

Figure 5 shows the differences in per capita spend on science by school type, for schools with pupils aged 11-18.

\(^{40}\) Surveyed schools reported a total combined science budget of £5.3m
\(^{41}\) These figures should be treated with a degree of caution given only 18 independent schools responded to the budgetary questions in the survey
There are some differences between regions (Figure 6) – however this should be treated with some degree of caution and considered as indicators only given the relatively low bases in each region.

42 Schools with pupils aged 11-18 only
4.3 Expenditure on practical science

The majority of schools (just over 80% of respondents) do not currently ring-fence part of their budget specifically for practical science (Figure 7).

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43 State-funded schools only
Qualitative feedback suggests that the majority of secondary schools have one overarching science budget that is not split between the sciences – it is common instead for the sciences to take turns in order of priority. So for example if a large sum is spent on biology one year, the following year chemistry equipment may be prioritised and the year after, physics.

Survey data shows the largest proportion of the science budget, on average, is spent on equipment and consumables at nearly 40%. This is followed by spend on reprographics at an average proportion of 27.12% (Table 2).
Table 2: Breakdown of average allocations of science expenditure (all schools)

<table>
<thead>
<tr>
<th>Type of expenditure</th>
<th>Mean (%)</th>
<th>Bases$^{45}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment &amp; consumables</td>
<td>39.20</td>
<td>215</td>
</tr>
<tr>
<td>Reprographics</td>
<td>27.12</td>
<td>217</td>
</tr>
<tr>
<td>Textbooks</td>
<td>13.78</td>
<td>199</td>
</tr>
<tr>
<td>ICT</td>
<td>7.20</td>
<td>182</td>
</tr>
<tr>
<td>Contingency</td>
<td>7.10</td>
<td>161</td>
</tr>
<tr>
<td>Science talks/external events</td>
<td>3.20</td>
<td>140</td>
</tr>
<tr>
<td>Fieldwork</td>
<td>2.40</td>
<td>145</td>
</tr>
</tbody>
</table>

There are some marginal differences in the proportion of expenditure types allocated to science when considering state-funded schools only (Table 3) – the proportion spent on reprographics is slightly higher and proportion spent on science talks/external events slightly lower.

Table 3: Breakdown of average allocations of science expenditure (state-funded schools only)

<table>
<thead>
<tr>
<th>Type of expenditure</th>
<th>Mean (%)</th>
<th>Bases$^{46}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment &amp; consumables</td>
<td>39.43</td>
<td>201</td>
</tr>
<tr>
<td>Reprographics</td>
<td>28.67</td>
<td>202</td>
</tr>
<tr>
<td>Textbooks</td>
<td>13.83</td>
<td>183</td>
</tr>
<tr>
<td>Contingency</td>
<td>7.26</td>
<td>150</td>
</tr>
<tr>
<td>ICT</td>
<td>7.17</td>
<td>170</td>
</tr>
<tr>
<td>Fieldwork</td>
<td>2.40</td>
<td>145</td>
</tr>
<tr>
<td>Science talks/external events</td>
<td>2.39</td>
<td>132</td>
</tr>
</tbody>
</table>

Respondents identified a growing proportion of spend on reprographics to be a major barrier for science resourcing – as the monies spent on photocopying can be at the expense of being able to fund large capital pieces of equipment, to increase quantities or upgrade existing equipment, or to invest in different types of equipment and consumables.

$^{45}$ Number of responses per option (expenditure type) within the survey

$^{46}$ Number of responses per option (expenditure type) within the survey
There are slight differences in the proportion of budget spend on reprographics by school size and whether or not it has a sixth form (Table 4).

**Table 4: Average proportion of science budget spent on reprographics by school age range and size**

<table>
<thead>
<tr>
<th>Age range 11-16</th>
<th>Age range 11-18</th>
<th>More than 1000 pupils</th>
<th>Less than 1000 pupils</th>
</tr>
</thead>
<tbody>
<tr>
<td>30.63</td>
<td>25.73</td>
<td>29.18</td>
<td>24.26</td>
</tr>
</tbody>
</table>

There are more discernible differences in the proportion spent on reprographics by school type (Figure 8) – in particular a comparatively lower spend within independent schools (7.67%) compared with that in maintained schools and academies (just over 30% and just under 30% respectively)\(^47\).

**Figure 8: Proportion of science budget spent on reprographics (by school type)**

A small proportion of respondents (16.5%) also identified other forms of expenditure or stated that they do not allocate to specifics (Figure 9).

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\(^47\) However these figures should be read with due regard to the differences in average budget between the different types of school
Figure 9: Other allocations of the science budget (all schools)

Base: 74

Qualitative feedback suggests that, typically, the Head teacher sets the science budget – sometimes in consultation with the Head of Science. The Head of Science, in turn, may consult with the Senior Technician to prioritise spending on equipment and with science subject teachers in curriculum and assessment planning. Often the Senior Technician is responsible for ordering equipment, usually requiring sign off from the Head of Department. In some instances the budget is finite, but in others the Head of Department can bid to the head teacher and/or the school governors for extra money, for example if a large and expensive piece of equipment breaks.

Survey data shows the majority of respondents (95.2%) also have the freedom to choose whichever supplier of science equipment they believe represents the best value for money (Figure 10).
Figure 10: Freedom to choose science supplier that offers the best value for money

Base: 294

4.4 Additional sources of funding

Survey data shows that schools also secure extra contributions from parents and in some cases, teachers and technicians supplement the core science budget by paying for items themselves, for which (according to qualitative feedback) they are not always reimbursed (Figure 11). It is not possible to quantify accurately the proportion of science budgets that are being subsidised by teachers and technicians however, as there is substantial variation between the amounts actually being spent, and the frequency with which this is occurring.
Other forms of contribution come from such sources as:

- External secondment/consultancy work;
- Payment for PGCE\(^{49}\) students;
- Fundraising (typically via the Parent Teacher Association);
- Via awards;
- Gifted & talented budget.

Qualitative feedback suggests that some schools appear to be much more knowledgeable than others when it comes to accessing additional funding for science. Certain schools face difficulties as they do not appear to know what types of opportunities are available, whilst others submit numerous bids which can raise thousands of pounds of additional money in a number of ways:

- Working collaboratively with local science centres to borrow equipment and acquire CPD\(^{50}\) for staff;

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\(^{48}\) State-funded schools only  
\(^{49}\) Postgraduate Certificate of Education  
\(^{50}\) Continuing Professional Development
- Attending CPD courses that provide money to schools for cover for the teachers attending the course as well as expenses and additional funds (usually between £150-200) to purchase equipment to replicate experiments demonstrated on the course;

- Acting as mentors to trainee and NQT status teachers;

- Entering science competitions.

4.5 Satisfaction with funding available for practical science

Around a third of respondents (33.3%) is either quite or very dissatisfied with the level of funding available for practical science, with just over 13% reporting they are very satisfied (Figure 12).

*Figure 12: Satisfaction that funding for science practical work is sufficient (all schools)*

There are clear differences by school type (Figure 13) – 44.4% of maintained schools report being quite or very dissatisfied with the funding available for science, compared with 6.5% of independent schools that are quite dissatisfied. No independent schools or sixth-form colleges report that they are very dissatisfied with the available funding for science.

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51 Newly Qualified Teachers
Figure 13: Satisfaction that funding for science practical work is sufficient (by school type)

There appears to be greater satisfaction with the available funding among schools that have a sixth-form compared with those that do not (17.4% of respondent schools with sixth forms reporting they are ‘very satisfied’ compared with 5.2% of respondent schools without sixth forms) (Figure 14).
Figure 14: Satisfaction that funding for science practical work is sufficient (by school age range)

Figure 15 below, drawn from survey data, shows that respondents who indicate they are very satisfied with funding for science have on average, just over double the per capita spend on science as those that state they are very dissatisfied.
4.6 Anticipated future changes in funding for practical science

Findings in this section are drawn purely from qualitative feedback, which indicates that among state-funded schools, funding has remained more or less static in money terms for at least the last five years, against a backdrop of rising equipment/consumables costs and increasing pupil numbers and class sizes. Where there has been an increase in funding it is usually because of a change in status:

- Taking up academy status provided some extra one-off funding. The majority of respondents report this extra money was spent quickly (because of a perception that it could be reallocated elsewhere if not immediately used);
- The addition of a sixth form to a school allows for extra funding to resource A-level science; however in some cases this appears to have been spent on science equipment and resources to benefit the whole school.

Qualitative feedback shows that respondents are concerned that there has not been, and does not appear likely to be any time soon, an increase in funding for science to reflect the pressures of rising costs and higher numbers of pupils.

“Science in the UK is dreadfully underfunded for a 21st century experience”

“Our budget has been cut EVERY year for the last five and will be cut in the next two years as well”

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52 State-funded schools only
“Our budget has been exactly the same for the last three years but the cost of resources is rising”

“It is expected that our budget will be reduced considerably next year and I am concerned as to how we will manage”

“Why aren't practical subjects given more money for resources than non-practical subjects?”

4.7 Impacts of funding levels on teaching and learning of practical science

Over 60% of respondents stated concerns about sufficiency of funding and equipment to be able to effectively deliver practical science in the future. Nearly a quarter of survey respondents (23.1%) considers that, over the next two years, the amount of funding available will mean they provide less science practical teaching and experiences (Figure 16). It should be noted when considering these findings however, that against a backdrop of an uncertain economic climate, respondents were only able to speculate about future funding levels rather than provide exact forecasts. This may account for the fact that the majority (56.3% of respondents) report they expect to provide the same amount of science practical teaching and experiences.

Figure 16: Expected impacts on practical science as a result of future anticipated funding over the next two academic years (all schools)

There are clear differences by school type (Figure 17) – notably nearly a third of maintained schools (32.3%) and nearly a fifth of academies (19.4%) expect to provide less science practical experiences as a result of future funding levels – compared with 6.5% of independent schools that anticipate providing less.
A slightly higher proportion of respondents within schools with no sixth form expect to provide more science experiences (16.1%) compared to schools with sixth forms (8.7%) (Figure 18).
Qualitative feedback\(^{53}\) suggests schools typically are not replacing items of equipment unless absolutely necessary. Where schools have to “save up” for expensive items, such as Van de Graaf generators, fume cupboards, microscopes and equipment for teaching radioactivity, they tend to keep the broken equipment for spare parts. If a piece of equipment is out of action for a long time teachers report using YouTube and other virtual visual demonstrations to at least partially fill in the gap (this is not considered a satisfactory replacement because pupils do not get personal experience of the experimental process or use of the equipment).

“Replacement of equipment which is worn out is probably our biggest issue”

Schools also report they are unlikely to be able to purchase ‘high end’ or high cost items of equipment unless there will be in regular usage. This links to a requirement, for many schools, to present a business case for financing new purchases.

Another barrier in some schools is the rule that budgets must be completely spent in the academic year or the surplus will be clawed back into central funds. Qualitative feedback strongly suggests that this approach has the effect of forcing spending on smaller items some of which may not be strictly necessary, while preventing science departments from “saving up” for higher end items.

“High end A-Level equipment that is only used once or twice a year is a luxury and one we cannot afford”

“There are pieces of equipment that require too much capital outlay to purchase and possibly have

\(^{53}\) State-funded schools only
"too high maintenance costs for us to justify, since they would be used for a specific teaching component, and then limited annual use thereafter”

Qualitative feedback indicates that many schools are now cash free and this has implications for the availability of petty cash to buy small one-off items for practical experiments. Some schools are creative in overcoming this issue – for example, one school charges learners 20p to borrow a replacement lab coat or text book if they forget their own and so builds its own petty cash coffers.

Respondents that participated in the qualitative phase of the research report that reduced funding and budget cuts can impact negatively on the teaching and learning of practical science, with areas of particular concern spanning:

- A culture of adapting and ‘making do’ due to widely held expectations of limited budgets and the prospects of further funding cuts (cited by 34% of respondents);

- Risk of running out of consumables and having to alter the delivery of lessons as a result (for example by cutting practical work and/or using class demonstrations when the pedagogical preference would be for work in pairs or small groups) (cited by 22.8% of respondents);

- Limited capacity to buy new or upgrade existing equipment, which can curtail the type of practical work that can be offered – appears to be a particular issue for physics (cited by 19.5% of respondents).

In a small number of cases (just under 7% of respondents), planned upgrades to existing stock levels or refurbishments have been abruptly halted as a result of policy changes such as the withdrawal of the Building Schools for the Future programme, or because of budget cuts.

“Just had a 30% cut to budget so am concerned about simply running out of consumables such as test tubes, chemicals etc."

“There is a lot of equipment that we would like to purchase, but due to a 54% budget reduction over the last 2 years, we have been unable to continue our programme of improvements”

“Very little ICT equipment is available due to a limited budget”

“We undoubtedly cannot do everything we want (because of funding shortages)”

“Pre and post-16 physics equipment have a high individual cost and keep getting put to the bottom of the list in favour of buying more lower cost equipment and consumables”

“Whilst we are well resourced at the moment, we no longer get the same level of funding that we used to, so updating equipment or repairing broken equipment may be a problem in the future”
“We have adapted to science on a shoe string”

“Our budget is so small that we always have to get the minimum number/cheapest of everything”

“Owing to a 50% cut in budget we are struggling to stand still let alone improve”

“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”

4.7.1 Expected impacts of the removal of weighting for funding of science provision (post-16)

A small proportion of respondents interviewed during the qualitative phase of the research (9%) provided feedback about the Government proposals to remove weighting of funding for science provision at post-16 level.

All felt that, if enforced, such proposals are likely to have a negative impact on science teaching and learning, potentially resulting in:

- Less money to buy equipment necessary for A-Level and A-Level equivalent curriculum delivery;

- Diminished quality in science teaching and learning, which could mean lower numbers of students apply to the institution to study science;

- Students insufficiently prepared to study at university as a result of severely curtailed practical science experiences.

“This [the proposals to cut the 12% weighting for science for 16-19 provision] concerns me greatly – we have had to manage with a tight budget for the past few years and have tightened our belts as much as we can, I really don’t know how we would cope if the weighting was lost”

“I am quite lucky at the moment but am concerned that the reduction in sixth form funding will impact on resourcing their lessons”

“My gut reaction is that it is an awful idea. It is fairly obvious that the practical requirements at A-Level require more costly equipment and surely if we are wanting to encourage young scientists to take up STEM careers we need to provide them with as good an education at school level as we possibly can”

“It [would be] disastrous. We would have to stop doing as many practicals”

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54 This this was not in the original scope of the research as proposals emerged after research had been started, therefore could only be tested with a small sample and these findings should be treated as indicative only.
5. Resourcing

5.1 Benchmarking against indicative items

In addition to quantifying the levels of funding available for practical science in secondary schools and sixth form colleges, the research sought to identify the availability of the full range of practical science resources: equipment and consumables; laboratory facilities; access to outside learning environments; and availability of technician support.

The starting point for this part of the research was the full benchmark list of resources developed by SCORE in the previous phase of the Resourcing School Science project. The full benchmarks represent a full and comprehensive list of the items required for appropriate delivery of the National Curriculum programme of study in science for Key Stages 3 and 4, and science A levels in biology, chemistry and physics. It was therefore not felt to be practicable to ask schools to report on the availability of all the various benchmark items.

For each of the main resource areas, a smaller list of ‘indicative’ items was therefore drawn from the full benchmark list by an expert Working Group convened by SCORE. These items were then incorporated within the main survey of secondary schools and sixth-form colleges.

Respondents to the survey were asked to consider the availability in their school of science equipment and consumables, for a) general science and for b) pre- and post-16 biology, chemistry, and physics. Respondents were asked whether they consider they have:

- **Enough of each item in working order** (‘enough’ in this context was clearly defined as either one per pupil, one between two pupils, one for small groups of three-four pupils, or one for a class demonstration);

- **Enough of each item but not all in full working order**;

- **Not enough to meet requirements**;

- **Not enough and respondents state they need items in question**;

- **Not enough, but respondents state they do not need items in question**;

- **Items not in use**.

For each of the laboratory facilities and outside learning environments, respondents were asked to state whether the facility or form of outside space is:
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- Easy to access and used regularly;
- Easy to access, and used sometimes;
- Not easy to access;
- Not accessible, and needed;
- Not accessible, but not needed.

The research also considered the availability of the technician support available to schools, using a combination of rating-scale questions and in-depth qualitative research to assess the adequacy of technician support within secondary schools and sixth form colleges.

It should be noted that the evidence gathered in both the quantitative and qualitative phases of the research strongly suggested that the indicative items represent an appropriate level of resource for secondary schools and sixth form colleges. Very few schools reported that they had any of the items but did not need them. In addition, just over 85% of respondents who took part in telephone or face-to-face interviews agreed that the indicative items outlined in the survey are fit for purpose and give an accurate picture of the items needed to offer an effective practical science learning experience.

The main areas where there was some disagreement were:

- The need for klinostats for the teaching of pre-16 biology. A significant proportion (just over 27%) of survey respondents stated that they neither have nor need them, and a further 16.1% stating that they have, but do not use them;
- The need for access to several of the indicative outside spaces, particularly at post-16 level. Several of the environments were reported as being inaccessible but not needed, most notably ‘access to a functioning renewable energy source’ at pre-16 level (although it should be noted that this finding must be contextualised against a still higher proportion stating that this was needed).

The frequency with which post-16 level outside learning environments were reported as not needed suggests that, with the sole exception of ‘access to varied habitats’, they currently play a relatively small role in the delivery of the post-16 curriculum at many English schools.

In addition to the sections of the survey dealing with the accessibility and availability of the indicative resources, respondents were asked to consider their satisfaction with current levels of resourcing; and their confidence that future levels of resource would enable them to sustain current levels of practical science experiences. A small number of open response questions were also included to allow respondents to raise additional issues that may not have been covered in the rest of the survey. Finally, the issues that emerged from the survey research were discussed in detail with a sample of respondents during the subsequent phase of in-depth qualitative research.

55 The list of equipment and facilities in the survey summarised indicative items and was not intended to be an exhaustive list of everything required (for a more comprehensive list of all items required readers should refer to the SCORE benchmarks)
Key messages in relation to resourcing of practical science are:

- There is considerable variation in the resourcing levels of secondary schools and sixth-form colleges, and also disparity between resourcing of individual science subjects;

- Nearly a fifth of schools have issues accessing over half or more of the indicative items needed for resourcing pre-16 biology and less than 1 in 7 schools are able to access over 90% of the indicative items. Biology at pre-16 level is the least well-resourced of the three sciences (63.1% of responses indicate sufficient quantities in full working order, compared with 70.7% for pre-16 chemistry and 72% for pre-16 physics);

- The average state-funded secondary school has just 70% of the equipment and consumables it needs to teach science subjects, but four in ten state-funded schools have less than 70% of the equipment and consumables they require;

- A third of state-funded schools have 80% or more of the equipment and consumables they need;

- At post-16 levels, resourcing for biology presents no smaller cause for concern – less than 44% of responses indicate access to sufficient numbers of the indicative items (compared with 66% for post-16 chemistry and 62% for post-16 physics). Less than 12% of schools have access to more than 90% of the indicative items for post-16 biology;

- The biggest issue for resourcing of pre-16 chemistry appears to be maintaining the indicative items in sufficient quantities, in full working order. For 4 out of 10 schools, less than 70% of the indicative items are easily available, and only a quarter of schools can easily access more than 90% of the indicative items for pre-16 chemistry;

- Less than 1 in 5 schools have access to more than 90% of the indicative items and 1 in 6 have access to less than 50% of the indicative items for post-16 chemistry;

- Nearly 1 in 3 schools that have access to more than 90% of the indicative items for pre-16 physics), and around 4 in 10 schools having access to less than 70% of the indicative items for post-16 physics;

- Compared with the individual science subjects, schools are relatively well-resourced in relation to general science equipment – however sufficient quantities of the indicative items are still not available to 15% of schools. The most frequently cited type of general equipment needed by schools are heated magnetic stirrers (not available to 40% of schools in sufficient quantities) and data loggers (not available to 36% of schools in sufficient quantities);
Nearly a third of maintained schools and nearly a fifth of academies are either quite or very dissatisfied with resourcing of science equipment and consumables. However, despite issues with resourcing of equipment and consumables, respondents appear somewhat tolerant of the situation, with the majority of state-funded schools (over 45% on average) reporting they are quite satisfied with resourcing levels;

Laboratory facilities are not easily or not accessible to 23% of respondents. Nearly a fifth of schools have access to less than 70% of the indicative laboratory facilities. Issues with laboratories relate predominantly to design, in terms of sufficient space and proximity to critical resources; for example the prep room. Just over 27% of respondents are either quite or very dissatisfied with laboratory facilities; however no sixth-form colleges report dissatisfaction – which may relate to the fact that 60% of sixth-form college respondents have specialist laboratories per science subject (compared with 1.7% of maintained schools and 3.8% of academies that do);

Less than 7% of schools have access to indicative outside learning environments for pre-16 provision; there are substantially more concerns in relation to post-16 provision, where nearly 60% of schools have access to less than 10% of the indicative items. In spite of this only 14.2% of maintained schools and 12% of academies report being either quite or very dissatisfied with access to outside learning environments – which may suggest a lack of awareness among schools about what ‘good’ access to outside space for learning actually looks like;

Around 70% of respondents employ technicians during term-time only. Nearly 30% of maintained schools and nearly a quarter of academies state they are quite or very dissatisfied with the amount of technician support available to them;

Impacts on teaching and learning of practical science as a result of inadequate resourcing include: changes to group sizes (for example work undertaken in groups of 3 or 4 rather than individually or in pairs); and fewer practical experiences undertaken where there is insufficient technician support to adequately resource this.
5.2 Equipment and consumables

A major objective of the survey research was to ascertain the extent to which schools are well resourced or otherwise in comparison with the indicative list of equipment and consumables.

These provided detailed information on indicative lists of equipment for:

- Pre-16 biology (fifteen items) and post-16 biology (eleven items);
- Pre-16 chemistry (fifteen items) and post-16 chemistry (sixteen items);
- Pre-16 physics (twenty-four items) and post-16 physics (twenty-one items);
- General science equipment relevant to all curriculum areas and phases (eleven items).

This section begins by outlining the detailed findings from the indicative lists of equipment by subject area and phase of education; it then summarises the overall availability of equipment and consumables; finally, it goes on to consider the satisfaction levels with current resourcing levels reported by respondents.

The detailed discussion in this section of the reports explores the level of resourcing in state-funded secondary schools and sixth form colleges in England in greatest detail, as these are SCORE’s primary policy focus. Most of the tables and the discussion are therefore based on the 152 responses from state-funded secondary schools and sixth form colleges that provided detailed information on resourcing levels. However, comparative data is given from other schools types where this is considered to be illuminating.

Overall the research has found that the average state-funded secondary school has just 70% of the indicative equipment and consumables it needs to teach science subjects, however four in ten state-funded schools have less than 70% of the equipment and consumables they require, while a third of state-funded schools have 80% or more of the equipment and consumables they need.
5.2.1 Biology

An initial overall view of the availability of equipment and consumables for biology practical science experiences can be provided by pooling all the responses for all the indicative items from all the respondents, and considering their distribution among the response categories.

At pre-16 level, 63.1% of responses stated that the indicative items were available in full working order and in sufficient quantities; a further 25.2% of responses stated that the items were available, but not in sufficient quantities or in full working order. The remaining 11.7% of responses were fairly evenly distributed among the remaining four categories of response (Figure 19). This suggests that, on average, biology is the least well-resourced of the three sciences at pre-16 level, as the corresponding figures for chemistry are 70.7% (sufficient quantities and full working order) and 19.4% (not available in sufficient quantities or in full working order); and for physics, 72% and 19.2% respectively.

Figure 19: Resourcing levels for pre-16 biology

![Bar chart showing resourcing levels for pre-16 biology](chart.png)

Base: 152
Further analysis was undertaken to establish the way that availability of equipment and consumables varies from one school to another. To do this, the percentage of the benchmark items available in sufficient quantities and in full working order was calculated for each of the respondent schools. A frequency distribution was then derived for the proportions of schools able to access a banded series of percentages of the indicative items (Figure 20 – please note this is scaled to 30% for ease of viewing).

**Figure 20: Pre-16 biology - distribution of schools by percentage of equipment & consumables fully accessible**

This shows that in nearly 55% of schools, less than 70% of the items are accessible in sufficient quantities; and fewer than 1 in 7 schools are able to access 90% or more of the indicative items without difficulty. In addition, a substantial minority – nearly a fifth – of schools report problems with accessing more than half of the indicative items.

There appears to be particularly high demand for digital microscopes and visualisers, with more than 16% of schools reporting that they do not have, but need them, and only 50% having them in sufficient quantities. There also appear to be issues with basic kinds of equipment for ecological sampling and for measuring changes in the body, both of which are available in sufficient quantities in well under half of schools, with the overwhelming majority of other schools reporting that they need more of them (Figure 23). Water baths were also frequently cited as being needed in greater quantities and respondents to the qualitative research attributed this to the large numbers of water baths needed for controlled assessments. Qualitative responses also indicated that optical microscopes and gas exchange or breathing exchange equipment can be subject to frequent breakages. In such cases, respondents report that there is rarely sufficient money left in the budget
to fund replacements.

There appear to be very few items of equipment for pre-16 biology that schools say they do not use. The main exception is klinostats, where more than 27% of schools stated that they neither have nor need them; in addition, this was the piece of equipment that schools least often state needing more of (Figure 23).

The analyses undertaken for post-16 biology show that schools report considerably more difficulty accessing resources at this level. By pooling all responses to provide an initial overview of the situation, less than 44% of responses stated that the indicative items were available in sufficient quantities in full working order. Furthermore, nearly a quarter of responses stated that the items were available, but not in full repair or in the quantities needed. In addition, nearly 10% of responses stated that items were unavailable but needed, although it should be noted that nearly as many responses suggested that unavailable items were not needed (Figure 21).

**Figure 21: Resourcing levels for post-16 biology**

These responses suggest that schools find it more difficult to provide sufficient quantities of equipment and consumables for post-16 biology than for pre-16 biology or, indeed, for any of the other sciences at any level. For example, for post-16 chemistry more than 66% of all responses stated that the indicative items were available in appropriate quantities and in working order, and for post-16 physics, just over 62%.

This evidence that there are particular issues with post-16 biology is strongly reinforced if variations in the accessibility of equipment between different schools are considered. Figure 22 shows a banded frequency distribution of the schools able to access varying proportions of the equipment in sufficient quantities and in full working order, calculated in the same way as that for
pre-16 biology. This clearly indicates that the level of variance between schools is extremely high. More than 43% of respondent schools had insufficient access to more than half of the benchmark items, and less than 12% of schools had sufficient access to more than 90% of the equipment.

Moreover, the notably even distribution of schools across the different bands forms a quite different pattern from other resourcing areas, which usually peak on the right side of the chart (indicating higher proportions of equipment available to a larger proportion of schools). This would seem to confirm that not only is post-16 biology the most poorly resourced curriculum area in terms of equipment and consumables, it is also the area where the highest levels of inequality are experienced between different schools (Figure 22 – please note this is scaled to 30% for ease of viewing).

**Figure 22: Post-16 biology - distribution of schools by percentage of equipment & consumables fully accessible**

There are, in consequence, more gaps in resourcing of specific items of equipment and consumables for post-16 biology. Even the indicative item most frequently reported as being accessible – example slides for pair work – was reported as being available in sufficient quantities in fewer than 65% of schools. Ninhydrin, a widely used chemical reagent, was the next most accessible item, and was sufficiently accessible in fewer than 57% of schools. All the remaining nine benchmark items were sufficiently accessible in fewer than half the schools.

As at pre-16 level, survey data shows particular difficulties with accessing digital microscopes with visualisers. However the single most difficult item to resource in sufficient quantities is genetic engineering kits. Fewer than half of respondent schools reported being able to access these at all,
and nearly a fifth of schools (18.8%) reported that they do not have, but need, them. Qualitative feedback indicates that the relatively high cost of these kits typically acts as a barrier. Respondents also report a need for more colorimeters and top pan balances, with the main concerns relating to purchasing them in sufficient quantities and then maintaining them in good working order (Figure 24).

No less striking than the relatively low levels of resource for post-16 biology is the relatively large proportion of respondents reporting that items are available but not used, or unavailable but not needed. For example, nearly 17% of respondents reported having, but not using, gram stains, and more than 13% that they neither had nor needed it, even though this is one of the basic procedures for bacteriological analysis. More than 18% of respondents reported that they neither have nor need haemocytometers, and a further 11.4% that they have these but do not use them; and nearly 20% of schools either do not use, or feel they do not need, spirometers (Figure 24). This would seem to suggest that, at least in a substantial minority of schools, practical work in post-16 biology may be much less varied and extensive than SCORE considers appropriate.

The overall picture, then, is that biology appears to be the ‘poor relation’ among the three sciences, with equipment and consumables levels being lower than in physics and chemistry for both pre and post-16 levels.
Figure 23: Resourcing levels for pre-16 biology – equipment and consumables

Base: 2123 responses
Figure 24: Equipment resourcing levels for post-16 biology – equipment and consumables

Type of equipment

- Example slides - pair work
- Ninhydrin - demo/large group
- Colorimeter - small group work
- Gram Stains - demo/large group
- Spirometer - demo/large group
- Digital microscope with visualiser/flexi-camera/stage micrometers - demo/large group
- Eye piece graticular - pair work
- Gel electrophoresis equipment and centrifuge - demo/large group
- Haemocytometer - demo/large group
- Top pan balance +/- 0.001g - pair work
- Genetic engineering kits - small group work

% of responses

Base: 1174 responses
5.2.2 Chemistry

As with biology, an initial approximate view of the availability of equipment and consumables for chemistry practical science experiences can be provided by pooling all the responses for all the indicative items from all the respondents, and considering their distribution among the response categories.

At pre-16 level, some 71% of responses state that the indicative items are available in sufficient quantities, and a further 18.1% of responses indicate items are not available in sufficient quantities. Only relatively tiny numbers of responses are to be found in the remaining response categories, indicating that the main issue with pre-16 chemistry equipment and consumables relates to securing sufficient quantities of the indicative items (Figure 25).

**Figure 25: Resourcing levels for pre-16 chemistry**

In order to understand the relative resourcing levels across schools, a distribution analysis was undertaken using identical methods to those employed for biology. The percentage of the benchmark items available in sufficient quantities and in full working order was calculated for each school. The relative proportions of schools able to access varying percentages of the equipment and consumables were then calculated in the form of a banded frequency distribution (Figure 26 – please note this is scaled to 30% for ease of viewing).
This analysis indicates that, while pre-16 chemistry appears to be significantly better resourced than pre-16 biology, it is still the case that in approximately 4 out every 10 schools, less than 70% of the indicative equipment and consumables are available in good working order and in sufficient quantities. Only around a quarter of schools (24.5%) have more than 90% of the indicative equipment and consumables in appropriate quantities, while just over 15% of schools report that less than half the indicative items are available in sufficient quantities.

The full data for the indicative items (reported in Figure 29) shows that there are very few items that schools state that they own but do not use, suggesting that all the indicative items are widely recognised as necessary for the delivery of appropriate pre-16 chemistry practical work. Smart materials, balances and ground glass gas syringes are the items reported to be hardest to resource in sufficient quantities. Less than half of respondent schools have these available in sufficient quantities and all are needed in greater quantities by more than a third of schools. Three items stood out as being unavailable but needed, each being reported in this category by approximately 10% of respondents: smart materials; heating mantles; and equipment for demonstrating electrolysis. It may be noted that these are often relatively costly pieces of equipment, varying from around £20 for a ground glass syringe to more than £200 for a heating mantle\(^56\). These represent considerable expenditures given the rates of per capita science funding discussed in section 4 of this report.

\(^{56}\) Based on prices given in the current catalogues of major suppliers of science equipment to schools as at January 2013
The least problematic resourcing areas seemed to be staple – and therefore relatively cheap items – such as glassware and plastic/ceramic items (conical flasks, measuring cylinders, spotting tiles, evaporating basins) and essential safety equipment (goggles), which are available in sufficient quantities to approximately 90% of schools. The overall picture for pre-16 chemistry, then, would appear to be of considerable variation in the availability of individual items, with relatively and uniformly high access to staple, standard equipment and consumables but issues with more complex, costly or delicate equipment.

At post-16 level a similar general picture emerges, but with slightly lower levels of resource availability across the board. Pooling all responses for all items it appears that just over 66% of responses state items are available in sufficient quantities in good order, and just over 23% of responses state that more are needed. As with pre-16 chemistry, there were relatively negligible proportions of responses in the other response categories. In particular, it is worth noting that the bulk of equipment appears to be in regular use, with only very tiny proportions reporting they own but do not use certain types of equipment (Figure 27). This again suggests that the major issue for the resourcing of practical work in chemistry – although somewhat more acute at post-16 level – is with securing sufficient quantities of the indicative items.

**Figure 27: Resourcing levels for post-16 chemistry**

As with pre-16 chemistry, further analysis was carried out to ascertain the distribution of schools able to access varying percentages of the indicative items in good order and in sufficient quantities (Figure 28 – please note this is scaled to 30% for ease of viewing).
This shows that approximately half of schools have sufficient access to less than 70% of the indicative items (compared to approximately 40% at pre-16 level); and less than 1 in 5 of schools have sufficient access to 90% or more of the indicative items (compared to around a quarter at pre-16 level). Approximately 1 in 6 schools report that less than half of the indicative items are accessible in good order and in sufficient quantities. Although these disparities are less marked than those in post-16 biology, this again conforms to a pattern of post-16 resourcing being somewhat more challenging than pre-16 resourcing.

At post-16 level, the responses for individual items of equipment show similarities to those at pre-16 level (Figures 29 and 30). Once again, the least problematic items appear to be staple glassware and plastic/ceramic items, such as flasks and measuring cylinders. Almost all other types of equipment seem to be considerably more challenging to provide in sufficient quantities.

The pH meter is frequently reported as being needed in greater quantities, with just over half of respondents stating they need more in order to be able to do pair work. High precision (±0.001g) balances, heating mantles, colorimeters, and ground glass syringes were also frequently reported as being needed in greater quantities, and were also the types of equipment most likely to be unavailable but needed. The cross-over with resourcing issues at pre-16 is striking, and can again presumably be attributed to the relatively high cost of these types of equipment. In addition, it is may be noted that another relatively high cost consumable, TLC plates, were most frequently reported (by 10% of schools) as being unavailable but needed.
In general, then, the resourcing of practical experiences in chemistry appears to exhibit a number of problems. The resourcing of higher cost equipment and consumables seems to be challenging, with substantial proportions of schools reporting that they lack sufficient quantities of many of the indicative items. In addition, there appears to be considerable variation between schools, with around one-sixth of schools reporting that more than half of the items are not accessible in sufficient quantities. In contrast to the situation in post-16 biology, the responses suggest that there is broad acceptance of the need for all the benchmark items in the suggested quantities, and by implication acceptance that the kinds of practical work envisaged by SCORE are appropriate. The key issue seems to be cost, as it is the higher-cost equipment and consumables that are most frequently reported as being insufficiently available, or even, in some cases, not available at all.
Figure 29: Resourcing levels for pre-16 chemistry – equipment and consumables

Base: 2196 responses
Figure 30: Resourcing levels for post-16 chemistry – equipment and consumables

<table>
<thead>
<tr>
<th>Type of equipment</th>
<th>% of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye protection - for every student</td>
<td>Have enough in working order</td>
</tr>
<tr>
<td>Conical flasks (100ml &amp; 250ml) - for every student</td>
<td>Have enough in working order</td>
</tr>
<tr>
<td>Measuring cylinders of various sizes - for every student</td>
<td>Have enough in working order</td>
</tr>
<tr>
<td>Thermometer (± 0.1 °C) – for every student</td>
<td>Have enough in working order</td>
</tr>
<tr>
<td>Volumetric flask (of appropriate size) - for every student</td>
<td>Have enough in working order</td>
</tr>
<tr>
<td>Titration equipment - for every student</td>
<td>Have enough in working order</td>
</tr>
<tr>
<td>Molecular modelling kit - pair work</td>
<td>Have enough but not all working</td>
</tr>
<tr>
<td>Quick Fit equipment (for distillation and reflux) - pair work</td>
<td>Don’t have enough</td>
</tr>
<tr>
<td>Büchner funnel + flask and method for generating suction - pair work</td>
<td>Don’t have but need</td>
</tr>
<tr>
<td>Balance ± 0.01 g - small group work</td>
<td>Don’t have but need</td>
</tr>
<tr>
<td>Ground glass gas syringe - pair work</td>
<td>Don’t have but need</td>
</tr>
<tr>
<td>Colorimeter - small group work</td>
<td>Don’t have but need</td>
</tr>
<tr>
<td>TLC plates - for every student</td>
<td>Don’t have but need</td>
</tr>
<tr>
<td>pH meter - pair work</td>
<td>Don’t have but need</td>
</tr>
<tr>
<td>Balance ± 0.001 g - small group work</td>
<td>Don’t have but need</td>
</tr>
<tr>
<td>Heating mantle - pair work</td>
<td>Don’t have but don’t need</td>
</tr>
<tr>
<td></td>
<td>Don’t know</td>
</tr>
</tbody>
</table>

Base: 1752 responses
5.2.3 Physics

An initial overview of the availability of equipment and consumables for physics practical science experiences can be given by pooling all the responses for all the indicative items from all the respondents, and considering their distribution among the response categories.

At pre-16 level, some 72% of responses state that the indicative items are available in sufficient quantities, and a further 15.6% of responses relate to items that are not available in sufficient quantities. As with chemistry, only relatively tiny numbers of responses are to be found in the remaining response categories, suggesting the main issue with pre-16 physics equipment and consumables relates to securing sufficient quantities of the indicative items (Figure 31). These figures further suggest that physics is, on average, the best resourced of the three sciences at pre-16 level: the availability of resources slightly exceeds that reported for chemistry and substantially exceeds that reported for biology; and the proportion of responses stating that items are not available in sufficient quantities is somewhat lower.

**Figure 31: Resourcing levels for pre-16 physics**

![Bar chart showing resourcing levels for pre-16 physics](image)
In order to understand the relative resourcing levels across schools, a distribution analysis was undertaken using identical methods to those employed for biology and chemistry. The percentage of the benchmark items available in sufficient quantities and in full working order was calculated for each school. The relative proportions of schools able to access varying percentages of the equipment and consumables were then calculated to form of a banded frequency distribution (Figure 32 – please note this is scaled to 35% for ease of viewing).

**Figure 32: Pre-16 physics - distribution of schools by percentage of equipment & consumables fully accessible**

![Graph showing frequency distribution](image)

The frequency distribution reinforces the impression that, at pre-16 level, physics is relatively the best resourced of the three sciences. Nearly 1 in 3 schools reported having 90% or more the indicative items, compared to around 1 in 4 for pre-16 chemistry and less than 1 in 7 for pre-16 biology. However this still means that more than two-thirds of schools are not in this relatively favourable position. In addition, there are high levels of disparity between schools, with nearly a third of schools reporting they have sufficient access to less than 70% of the indicative items, and more than 1 in 6 reporting they have sufficient access to less than half of the items.

A wider range of equipment is needed to deliver pre-16 physics provision than pre-16 biology or chemistry. However, in many cases these are not required in the same quantities, with nearly half of the listed indicative items needed for class demonstrations or large group work as opposed to pair or small group work. This may help account for the relatively better reported resourcing of physics, as demonstration items – even when costly – need only be purchased in relatively small quantities and are also likely to be easier to keep in good order than those used frequently in class. Indeed, it is notable that eight of the twelve indicative items needed for demonstrations or large
group work were reported as being available in sufficient quantities in more than 80% of schools; on the other hand, this was true of only one of the eleven items needed for pair work, and the other ten were available in fewer than 80% of schools. Of the equipment needed for pair work, there appear to be particular problems with magnets (available in sufficient quantities for pair work in only around half of schools), UV and infrared kits, and energy meters (Figure 35).

As with the other sciences, it again appears that the resourcing of practical work poses greater challenges at post-16 level. Comparing the pooled responses for all types of equipment from all respondents, around 62% of responses state that equipment is available in sufficient quantities and in working order, considerably fewer than the 72% reported at pre-16 level (Figure 33). Some qualitative feedback also indicated that resourcing post-16 physics provision is more problematic. Respondents frequently cited the high individual cost of post-16 physics resources, which can make it more difficult to fund sufficient quantities for a class. Furthermore, in a context of funding constraints and budget cuts, it can be more difficult to justify the expense of resourcing post-16 items that are not used as frequently as items for pre-16 science provision.

However, this conclusion is somewhat mitigated by the marginally fewer responses (14%) stating that the items were not available in sufficient quantities, tending to indicate that the discrepancy is less marked than in the other sciences. In addition, there were considerably more ‘don’t know’ responses for post-16 physics, and this may have had the effect of slightly distorting the results (Figure 33).

Figure 33: Resourcing levels for post-16 physics

The distribution of schools having sufficient access to varying proportions of the indicative items
shows that – as at pre-16 level – just under a third of schools report sufficient availability of 90% or more of the indicative items, and two-thirds reported less. However, just less than 4 in every 10 schools report having access to less than 70% of the items and more than 1 in 5 have access to less than half, rather higher than the corresponding figure at pre-16 level (Figure 34 – please note this is scaled to 35% for ease of viewing). The implication would appear to be that whilst there is better access to items at post-16 level compared with pre-16 level, there is greater inequality between schools at post-16 level due to a wider variation in the range of resourcing levels.

At post-16 level, it appears that items used for demonstrations and large group work are more widely available than equipment for pair work and small group work, although the pattern is less emphatic than at pre-16 level. Nevertheless, it is still noteworthy that the four most widely available pieces of equipment are all items for demonstration or large group work; and that the most widely available pieces of equipment for pair work – rheostats and capacitors – can be readily sourced for a few pounds each, and are therefore among the cheaper post-16 items. The hardest to resource items appear to be loud speakers, resistance substitution boxes and hall effect probes/search coil and solenoids (Figure 36).

Physics, then, emerges overall as a somewhat better resourced area than biology and chemistry at both pre-16 and post-16 levels. However, to some extent this reflects that greater preponderance of equipment used for demonstration and large group work. This means that there are still issues

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57 Based on prices given in the current catalogues of major suppliers of science equipment to schools as at January 2013
with supplying equipment in sufficient quantities to enable work in pairs and small groups.
Figure 35: Resourcing levels for pre-16 physics – equipment and consumables

- Slinky for wave demonstrations - demo/large group
- Van der Graaf generator - demo/large group
- Variety of springs - demo/large group
- Thermal expansion apparatus (e.g. ball & ring) - demo/large group
- Geiger counter - demo/large group
- Tuning forks - demo/large group
- Leads, wires (resistance and conducting) and switches - pair work
- Signal generator - demo/large group
- Strong horseshoe magnet (major magnet) - demo/large group
- Working bulbs and holders - pair work
- Force meters - pair work
- Ray boxes and accessories - pair work

Legend:
- Have enough in working order
- Have enough but not all working
- Don't have enough
- Have but don't use
- Don't have but need
- Don't have but don't need
- Don't know

% of responses
Under the Microscope: The State of Resourcing of Practical Science in Secondary Schools and Sixth-Form Colleges in England

April 2013

Base: 3430 responses

<table>
<thead>
<tr>
<th>Type of Equipment</th>
<th>% of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light gates and timer - demo/large group</td>
<td></td>
</tr>
<tr>
<td>Masses and hangers - pair work</td>
<td></td>
</tr>
<tr>
<td>Static electricity kit - pair work</td>
<td></td>
</tr>
<tr>
<td>Variety of magnets including alnico, magnadur and neodymium - pair work</td>
<td></td>
</tr>
<tr>
<td>Ammeters and voltmeters, or multimeters - pair work</td>
<td></td>
</tr>
<tr>
<td>Ripple tank - demo/large group</td>
<td></td>
</tr>
<tr>
<td>Galvanometer - demo/large group</td>
<td></td>
</tr>
<tr>
<td>Digital multimeter - pair work</td>
<td></td>
</tr>
<tr>
<td>LDRs - pair work</td>
<td></td>
</tr>
<tr>
<td>Thermistors - pair work</td>
<td></td>
</tr>
<tr>
<td>UV + infrared kit (sources and detectors) - small group work</td>
<td></td>
</tr>
<tr>
<td>Energy meter - small group work</td>
<td></td>
</tr>
</tbody>
</table>

Legend:
- Have enough in working order
- Have enough but not all working
- Don’t have enough
- Don’t have but don’t need
- Don’t have but don’t need
- Don’t know

Base: 3430 responses
Figure 36: Resourcing levels for post-16 physics – equipment and consumables

- Closed radioactive sources - demo/large group
- EHT power supply - demo/large group
- Vibration generator - demo/large group
- Air track + blower - demo/large group
- Rheostats of various sizes - pair work
- Capacitors of various sizes - pair work
- Stroboscope - demo/large group
- Pulley wheels - small group work
- Trolleys - pair work
- Electron beam tube - demo/large group
- Balance (2 decimal places) - small group work

Legend:
- Have enough in working order
- Have enough but not all working
- Don’t have enough
- Have but don’t use
- Don’t have but don’t need
- Don’t have but need
- Don’t know

% of responses

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Under the Microscope: The State of Resourcing of Practical Science in Secondary Schools and Sixth-Form Colleges in England

April 2013

Base: 2177 responses

% of responses

- Have enough in working order
- Have enough but not all working
- Don’t have enough
- Have but don’t use
- Don’t have but need
- Don’t have but don’t need
- Don’t know
5.2.4 General science equipment

Schools appear well-resourced in relation to general science equipment for ages 11-18, in comparison with individual science subjects. However variations between schools are still apparent - indicative items of general science equipment are not available in sufficient quantities to just over 15% of respondents (Figure 37).

Figure 37: Resourcing levels for general science equipment

![Diagram showing resourcing levels for general science equipment](image)

Base: 152

The most frequently cited resourcing issue during qualitative research in relation to general science equipment is insufficient quantities of data loggers (23.5% of respondents interviewed state that the items they do not have, but would want, are data loggers in sufficient quantities). Survey data shows data loggers are not available in the quantities required to just over 36% of respondents.

The majority of those interviewed for the qualitative phase of the research, that raised this as an issue, consider the main problem in resourcing data loggers is cost; a typical bottom end of the range cost is in the region of £80 and this does not include associated computer and software equipment to operate them or (where needed) teacher/technician training in their use.

Survey data shows that respondent schools can also find it difficult to maintain sufficient quantities of heated magnetic stirrers (not available in sufficient quantities to just over 40% of respondents) and bathroom scales (not available in sufficient quantities to nearly 35% of respondents) (Figure 38).
Figure 38: Equipment resourcing levels for general science equipment (for ages 11-18)

Type of equipment

- Crocodile clips - pair work
- Mirrors - pair work
- Metre rulers - pair work
- Clamps and stands - pair work
- Spirit or mercury thermometers, range -10 °C to 110 °C - pair work
- Working batteries - pair work
- Stop watch/stop clock - pair work
- LV power supply - pair work
- Heated magnetic stirrers - demo/large group
- Bathroom scales (in Newtons) - small group work
- Data logger + computer with range of sensors - small group work

% of responses

- Have enough in working order
- Have enough but not all working
- Don’t have enough
- Don’t know

Base: 1655 responses
5.2.5 Satisfaction with equipment and consumables

There appears to be an overall trend of tolerance where resourcing levels are concerned. Around 46% of respondents report that they are quite satisfied with the sufficiency of equipment and consumables for science (Figure 39), compared with 16.2% that state being quite dissatisfied – in spite of the relatively low resourcing levels in some cases as previously reported above in Sections 5.2.1 to 5.2.4.

**Figure 39: Satisfaction there is sufficient equipment and consumables**

<table>
<thead>
<tr>
<th>Level of satisfaction</th>
<th>% of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very satisfied</td>
<td>10%</td>
</tr>
<tr>
<td>Quite satisfied</td>
<td>30%</td>
</tr>
<tr>
<td>Neither satisfied nor dissatisfied</td>
<td>20%</td>
</tr>
<tr>
<td>Quite dissatisfied</td>
<td>10%</td>
</tr>
<tr>
<td>Very dissatisfied</td>
<td>5%</td>
</tr>
</tbody>
</table>

However only 10% of respondents in maintained schools and 17.2% of respondents in academies are very satisfied with the sufficiency of resources, compared with 60.9% of respondents in independent schools and just over 42% of respondents in sixth-form colleges (Figure 40)\(^{58}\).

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\(^{58}\) However this should be viewed with a degree of caution considering the relatively low base number of respondents from independent schools and sixth-form colleges
Figure 40: Satisfaction there is sufficient equipment and consumables (by school type)

![Graph showing satisfaction levels by school type](image)

Base: 470

5.2.6 Resources that respondents would want to have

Respondents were also asked about the types of equipment and consumables which are not currently available to them and that they would want to have for practical science provision. Qualitative feedback suggests a need for existing items in greater quantities and the ability to purchase additional items such as data loggers in particular (Figure 41).
Figure 41: Science resources that schools would like to have

5.3 Laboratory facilities

5.3.1 Mix of laboratories – general and specialist

There are slight differences in the laboratory facilities available by school type. Maintained schools and academies more typically have a higher proportion of general laboratories rather than specialist laboratories for each science (86.3% of maintained schools and 70.1% of academies have general laboratories only compared with just over a quarter of independent schools and just over 6% of sixth-form colleges) (Figure 42).

---

59 State-funded schools only
Figure 42: Mix of laboratory facilities – general or specialist (by school type)

<table>
<thead>
<tr>
<th>Type of institution</th>
<th>Specialist laboratories for each science</th>
<th>General laboratories i.e. can teach any science</th>
<th>A mix of specialist and general laboratories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintained school</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Academy</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Independent school</td>
<td>50%</td>
<td>50%</td>
<td>0%</td>
</tr>
<tr>
<td>Sixth-form college</td>
<td>50%</td>
<td>50%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Base: 167

5.3.2 Resourcing levels – laboratory facilities compared with indicative items

On average, each of the indicative laboratory facilities was not easily or not accessible to just over 23% of respondents (Figure 43).
Within state-funded schools, nearly a fifth of schools have adequate access to less than 70% of the indicative laboratory facilities needed and just over a fifth of schools have access to less than 80% of the indicative laboratory facilities needed (Figure 44 – please note this is scaled to 35% for ease of viewing).
All of the resourcing issues in relation to laboratory facilities relate in some way to their design and set up. Figure 45 shows that types of facilities that schools find most difficult to maintain as required include:

- Sufficient bench space;
- Access to blackout;
- Access to dim out;
- Sufficient space for easily visible class and group demonstrations;
- Sufficient space to leave long-term experiments; and
- Fume cupboards.
Figure 45: Resourcing levels - laboratory facilities

Type of facility

- First aid kit in prep room(s)
- Dishwasher in prep room(s)
- Chemical storeroom accessible to prep room
- Still-water purification in prep room(s)
- Dispensing jars + bottles in prep room(s)
- Equipment trolley in prep room(s)
- Access to water
- Security for chemical storeroom
- Computer, internet + telephone in prep room(s)
- Fridge/freezer in prep room(s)
- Access to gas
- Access to electricity
- Hazard labels, tapes + cards in prep room(s)

% of responses

- Easy access and use regularly
- Easy access and use sometimes
- Not easy to access
- No access but need
- No access but don’t need
- Don’t know
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Base: 3864 responses
5.3.3 Satisfaction with laboratory facilities

Just over 27% of respondents across all schools are either quite or very dissatisfied with laboratory facilities (Figure 46). There are clear differences by school type, with just over 26% of respondents in maintained schools and just over 32% of respondents in academies reporting they are quite or very dissatisfied with laboratory facilities, compared with 10.9% of independent schools that report some form of dissatisfaction (Figure 47). None of the sixth-form colleges that responded to this question expressed dissatisfaction with laboratory facilities⁶⁰ – and this should be considered in the context of Figure 42, which shows that nearly 60% of sixth-form college respondents have specialist laboratories for each science (compared with 1.7% of maintained schools and 3.8% of academies that do).

Figure 46: Satisfaction with sufficient laboratory facilities (all schools)

Although the relatively low base for sixth-form colleges means this should be treated with a degree of caution

⁶⁰ Base: 469
Qualitative feedback strongly emphasises design issues in relation to laboratory facilities, with problems relating to:

- inappropriate siting of the prep room and/or fume cupboard (cited by 18% of respondents);
- safe storage of chemicals (cited by 11% of respondents); and
- insufficient numbers of gas taps and sinks (cited by 9% of respondents).

Nearly a fifth of technicians report that prep rooms can be too small, which can impact negatively on health & safety; they may also be situated a long way from laboratories which poses logistical and sometimes safety challenges because of the time needed to transport items around the school.

Storage can also be an issue; even schools in modern buildings face challenges with storage space for resources and preparation space for technicians. In 11% of cases science preparation rooms are also caretaker’s cupboards and technicians in those schools report that they have to regularly move items around in order to pass health and safety inspections.

A particular concern appears to be the impact of the Building Schools for the Future programme (BSF). While only a small proportion of respondents (4%) had experience of BSF, all stated that the outcome of the programme was not what they wanted. In some cases the programme resulted in worse facilities due to poor design implemented without consultation with teachers and technicians.
“Recent BSF resulted in fewer overall rooms with laboratory facilities”

“Never design a new prep room, chemical store or class laboratory without consulting the technician. There are too many things that will be overlooked otherwise”

“BSF was our biggest problem. With 1200 pupils, 8 full time and 2 part time science teachers, we only have access to 5 laboratories now, as we lost 3 to BSF new build. This means all of us lab-share and have to do practicals in specific lessons which makes planning and teaching difficult at times”

This has meant that a higher proportion of science lessons are being taught in classrooms rather than in laboratories in some schools – therefore practical work cannot be undertaken. Furthermore older school laboratory buildings sometimes date back to the 1950s, and although in many cases the furnishings are considered to be of very high quality, modern day occupancy rates mean that they are overcrowded, impacting on the types of practical experiments that can be carried out.

“Whilst I have indicated that I am satisfied with laboratory facilities, it is a case of making do with what you are working with”

5.4 Technician support

5.4.1 Technician role

Qualitative feedback points to a great deal of variation reported in relation to the way in which the technician role is perceived within schools.

Technicians frequently have a career pattern of previous work as scientists in industry. Many can be extremely well-qualified but this is not always recognised, with around a fifth of state-funded schools appearing to perceive the technician role as administrative rather than as a science specialist. This is clearly evidenced within schools that seek cover for absent technicians via caretakers, kitchen or cleaning staff.

“The head teacher suggested that the only thing the technicians do when we come into work over the holidays is water the plants”

“I believe that the role of the technician is sorely misunderstood; many people think that their role is clerical or that of a teaching assistant when this isn’t the case...the technician is professional, they mix complex solutions, they look after specialist equipment, and they aren’t there to do my photocopying”

Even though other schools and colleges attach high value to their technicians and the role they play, the majority of technicians interviewed for the qualitative phase of this research (78%) report that they do not earn a ‘living wage’ and this can make it difficult to recruit as well as replace technicians that leave. Respondents state it is particularly hard to recruit physics specialist technicians with the salary and working conditions on offer.
“A major problem is often the standard of technician applicants - low pay structure for (undervalued) technicians puts off more able applicants. Lack of “standing” for technicians is a VERY sore point”

“A technician’s wage is not a living wage and you couldn’t afford to rely on it if you were the breadwinner of a household”

“[As technicians] my colleagues and I take on temporary work during the holidays because we need the money”

“We have a supply technician from an agency and want to make him permanent, but the school will offer him a term-time only contract, which he can’t afford”

“Technicians do a big job for appalling pay”

“[As a technician] I really resent being poorly paid and having to work in my own time to get through my workload...I have taken on increasing numbers of responsibilities and as a line manager I am responsible for managing the other technicians but my salary doesn’t reflect my qualifications, how long I have been doing the job or the responsibilities I have”

“If I could change just one thing about the teaching of science it would be that technicians should be better understood and better paid to reflect their skill level”

The dual issues of salary and working conditions can mean it is difficult to recruit and retain technicians, yet their absence or insufficient working hours clearly have a strong impact on practical science. Typically technicians do not have to give a term’s notice as teachers do and in the event of a technician leaving or absent due to illness, practical experiments may be changed or cancelled altogether.

“The technician team can make or break a department’s ability to carry out meaningful practical work”

“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”

“Many schools and colleges have the misguided belief that reducing the hours of science technicians, making some redundant or perhaps not replacing those that retire is a great way to save money. This management action actually impacts negatively on the safe and effective delivery of science education within the department”
5.4.2 Technician working hours

Just over a quarter of respondents (28%) within state-funded schools report that they need at least one additional technician.

Whilst around 30% of state-funded schools have full-time technicians employed all year round, the majority of around 70% employ them during term times only, or on ‘term time plus’ arrangements. The latter means they are employed during school terms and for a certain number of days outside of this, usually between 15 and 30 days.

Qualitative feedback indicates that the delivery of practical science can be substantially compromised because of insufficient technician time, including time in the laboratory or prep room to set up experiments. Concerns were expressed about a decrease in the number of working hours for technicians, particularly where respondents faced funding cuts, as this could make it unlikely that either working hours would increase, or technicians would be replaced if they leave.

“We number of technicians is decreasing – as they retire they’re not going to be replaced. We have four at the moment but it should be five. The chemistry technician is due to retire shortly – we’re not sure what we will do”

“We currently have a technician and a half (4 hours a day) – but could do with at least another hour a day”

“As technicians we work full-time and long hours, well above what the contract stipulates”

“In line with CLEAPSS guidance the department should currently have four technicians however the school can’t afford to pay for this”

Furthermore nearly a fifth of respondents report that the workload of technicians has increased in recent years due to the requirements of controlled assessments, which can require more work to organise and plan resourcing. The majority of technicians interviewed for the qualitative phase of this research (48%) state this means they have to put in extra hours in their own time to ensure practical work does not suffer.

5.4.3 Technician training

Just over a fifth of respondents (21%) interviewed for the qualitative phase of this research state that training provision and career pathways for technicians are not fit for purpose. This can impact upon schools’ capacity to attract people to the role, as well as upon the approach to resourcing of practical work – for example where technicians lack appropriate training, more experienced technicians may need to spend more time supporting them, which could be more usefully spent on planning and setting up practical experiments.
“There is no proper training system for technicians and it’s too much of a time burden for existing technicians to train up new inexperienced people”

“I am concerned that I am the only qualified technician in the school and my two colleagues are woefully badly equipped for dealing with the day-to-day of being a technician which in turn puts a terrible strain on me. I see that most of my technician friends are aged fifty or thereabouts and when they retire there will be nobody to replace them. We need some sort of system like an Apprenticeship where you can train up your replacement”

My two colleagues in the technician team are not scientists so I spend a great deal of time training them and helping them and fixing their mistakes. I often advise teachers on what to do because I have a wealth of experience and a science background but I am paid a pittance and I have no career prospects. When I started, there was a seven stage career framework from new starter to senior technician with pay scales to match and it was a proper career – that’s all gone”

“I would like to see increased opportunities for training for technicians and the creation of a national career structure for school science technicians”

5.4.4 Satisfaction with technician support

Heads of science and science teachers were asked whether they consider they have sufficient technician support. Nearly a quarter of all respondents (23.2%) are either quite or very dissatisfied with the amount of technician support available for practical science (Figure 48). Again there are clear differences between school type, with 28.2% of respondents from maintained schools and 23.4% of respondents from academies stating they are quite or very dissatisfied with the amount of technician support available – in stark contrast with independent schools and sixth-form colleges, where no respondents report any level of dissatisfaction⁶¹ (Figure 49).

Where respondents state they are very or quite satisfied that there is sufficient technician support qualitative feedback indicates that many of these individuals acknowledge that this is largely because of the goodwill of the highly trained individuals concerned, who regularly work outside their contracted hours for no additional pay, in order to provide teachers with the level of support they need.

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⁶¹ Although this should be treated with a degree of caution given the relatively low bases of respondents for independent schools and sixth-form colleges
Figure 48: Satisfaction there is sufficient technician support (all schools)

Figure 49: Satisfaction there is sufficient technician support (by school type)
5.5 Access to outside learning environments

5.5.1 Resourcing levels — access to outside learning environments compared with indicative items

On average, each of the outside learning environments is not accessible to nearly half of all respondents (47.8%) in relation to pre-16 science provision (Figure 50).

Figure 50: Resourcing levels for pre-16 access to outside space for practical science

For pre-16 provision, certain types of outside learning environment are used more frequently than others, for example trees and hedges, grassland and general open space for activities such as measuring speed. However less regular use is made of ponds or other water habitat (not accessible to just over 60% of respondents) and resources to demonstrate air quality and rock properties (not accessible to nearly three-quarters of respondents (Figure 51).
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Figure 51: Access to outside learning environments (pre-16 provision)

Type of outside learning environment

- Open space for a variety of activities e.g. model the solar system, measure speed, role plays etc.
- Trees/hedges
- Grassland; not just the school playing field, e.g. for use of quadrats, random sampling, use of keys (skills)
- A pond or other natural water habitat
- Functioning renewable energy source
- Outside resource to demonstrate properties of rocks + monitor air quality

% of responses

Base: 786 responses
Less than 7% of schools have full access to all the outside learning environments outlined in the survey, and 32.5% of schools have access to less than 40% of the outside learning environments needed (Figure 52 – please note this is scaled to 35% for ease of viewing).

**Figure 52: % access to adequate outside learning environments (pre-16 provision)**

![Figure 52: % access to adequate outside learning environments (pre-16 provision)](image)

*Base: 152*

The situation is noticeably different for post-16 outside space for learning, with the indicative outside learning environments inaccessible to just over three-quarters of respondents (Figure 53).

**Figure 53: Resourcing levels for post-16 access to outside space for practical science**

![Figure 53: Resourcing levels for post-16 access to outside space for practical science](image)

*Base: 152*

However, nearly a quarter of respondents also report that they do not need access to the
environments listed in the survey, suggesting that they consider some of the types of outside space are deemed unnecessary for effective delivery. This is more clearly demonstrated in Figure 54, with just under a third of respondents stating that they do not need access to resources such as a medical physics department and research facilities for gene technology or to study particle and/or nuclear physics.
Figure 54: Access to outside learning environments (post-16 provision)

Base: 548 responses
The summary of access to outside learning environments for post-16 provision highlights major issues, with no schools reporting that they have access to 50-100% of the outside learning environments, and nearly 60% that can access less than 10% of the outside learning environments needed (Figure 55 – please note this is scaled to 65% for ease of viewing).

Figure 55: % access to adequate outside learning environments (post-16 provision)

5.5.2 Satisfaction with access to outside learning environments

Despite the limitations noted in relation to access to outside learning environments, only 12.6% of respondents report they are quite or very dissatisfied with this level of access, suggesting that respondents may not have a clear perspective as to what ‘good’ levels of access to outside learning spaces should look like (Figure 56).

Differences by school type are less apparent (Figure 57), with 14.2% of respondents from maintained schools and 12% of respondents from academies stating they are quite or very dissatisfied with access to outside learning environments, compared with 6.5% of independent school respondents and 10.5% of sixth-form colleges.\(^2\)

\(^2\) Although the relatively low base number of respondents for independent schools and sixth-form colleges means this should be viewed with a degree of caution
Under the Microscope: The State of Resourcing of Practical Science in Secondary Schools and Sixth-Form Colleges in England
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Figure 56: Satisfaction with sufficient access to outside learning environments (all schools)

Base: 470

Figure 57: Satisfaction with sufficient access to outside space (by school type)

Base: 470
5.6 Approaches to resourcing in new builds

During the qualitative phase of the research approaches towards resourcing of science departments in new build schools and colleges was explored. There does not appear to be one particularly favoured approach to resourcing of new build science departments. In some cases resources have been planned and secured by the Head of the department in consultation with technicians – thereby ensuring that decisions on how to resource science is based upon their combined years of experience.

In other circumstances this process can be outside the control of the teachers and/or technicians. As previously stated, a major concern is that new facilities – and laboratories in particular – are designed and planned without consultation with those who will be using them. Respondents strongly emphasise concerns about a growing trend in new builds (or newly refurbished spaces) of insufficient space to meet the science needs as well as accommodate growing pupil numbers.

“Laboratory facilities are often poor in new PFI builds. For example the arrangement of gas and electric supplies makes access difficult, the fixed long benches are usually at the back and facing AWAY from the teacher who is therefore unable to see what the pupil is doing. Water is only supplied on the sides and back of the room instead of the arrangement in traditional laboratories, and there are many other problems”

“No-one seemed to remember that storage space is critical for science labs”

“Too many of the new schools have been built ‘architecturally pretty’ but have utterly useless lab spaces”

One school described having to divide one laboratory into two, so that two classes could proceed in parallel. The alternative was to teach the second class in an ordinary classroom. However this presents issues in ensuring there is enough equipment to go round.

Space is at a premium even in “new builds” where designers do not always take account of class sizes and the way in which equipment needs to be used. This relates to secure storage of equipment, chemicals and space for preparation, as well as overcrowding in laboratories. The latter can mean there is not enough time, when laboratories are unoccupied, for preparation of practical experiments for the next classes.

63 Private Finance Initiative – a school building programme announced by the Government in 2011 originally worth £2bn (this dropped to £1.75bn in December 2012)
Case study: laboratory design in a new build sixth-form college

After several years of planning, this college has been able to build state-of-the-art science facilities including new laboratories and prep rooms with sufficient storage space. Five new chemistry laboratories with accompanying prep and teaching rooms have been built in response to the growing student intake, which meant more space and resources were required.

Laboratory layout in terms of seating, location of equipment and types of resources in the laboratories is standardised to ensure consistency when teaching and to ensure all classes are able to use the same types of consumables/equipment. Laboratories, prep rooms and teaching rooms are spacious and well-organised with new equipment and electronic whiteboards with data projectors.

Prior to the extension project the laboratories were not laid out in a standard manner and layouts varied dramatically which meant that not all were suitable for versatile practical work. However this has now changed. Prep rooms have separate chemical stores and a vented funnel for flammables. There is ample storage as well as extra hidden storage in small locked rooms which can house bulk buys.

5.7 Anticipated future levels of resourcing for practical science

Over a third of respondents (36.4%) report that they are not very, or not at all confident that they will have sufficient resources for teaching practical science effectively over the forthcoming two academic years (Figure 58). It should be noted when considering these findings however, that against a backdrop of an uncertain economic climate, respondents were only able to speculate about future resourcing levels rather than provide exact forecasts.

There is greater confidence among independent schools compared with state-funded schools (Figure 59) – 71.6% of respondents in the former are very confident about future resourcing levels compared with 14.1% of respondents from maintained schools and 19.5% of respondents from academies.

Qualitative feedback has raised longer-term concerns about the sufficiency of resourcing in the context of funding cuts and the prospect of not being able to replace equipment once it wears out (also see Section 5.8).
Figure 58: Confidence there will be enough equipment and consumables over the next two academic years (all schools)

Figure 59: Confidence there will be enough equipment and consumables (by school type)
5.8 Impacts of resourcing levels on teaching and learning of practical science

5.8.1 Use of technologies and IT to provide practical science experiences in the classroom

There is some use of new technologies and IT to help deliver practical science within secondary schools and colleges, but this varies from school to school, with 47.5% of respondents making use of such a resource to some extent and only 2.8% of respondents making no use at all of technologies (Figure 60).

There is greater use of this type of resource (which must be funded from the science budget) among independent schools (Figure 61), with just over 41% of independent schools making use of technologies compared with 17% of respondents from maintained schools and 13.2% of respondents from academies.\(^6\)

Figure 60: Extent to which school science departments make use of new technologies/IT

<table>
<thead>
<tr>
<th>%</th>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>47.50%</td>
<td>140</td>
<td>To a significant extent</td>
</tr>
<tr>
<td>33.40%</td>
<td>98</td>
<td>To some extent</td>
</tr>
<tr>
<td>16.20%</td>
<td>48</td>
<td>To a small extent</td>
</tr>
<tr>
<td>2.80%</td>
<td>8</td>
<td>Not at all</td>
</tr>
</tbody>
</table>

Base: 294

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\(^6\) Although this must be viewed with a degree of caution given the relatively low base of independent school respondents.
Figure 61: Extent to which school science departments make use of new technologies/IT (by school type)

Base: 294

5.8.2 Respondent concerns about impacts of inadequate resourcing on practical science teaching and learning

Approaches to resourcing can have an immediate and in some cases long-term impact on science teaching and learning. Qualitative feedback suggests that under-resourcing can mean that certain types of experiment cannot be undertaken. If schools do not have sufficient equipment, if group sizes increase (for example one item shared between two pupils is now more likely, in some cases, to be shared between three or four pupils) or if technicians are not available or sufficiently skilled, the resource gap will have a direct impact on learning. Poor design – notably of laboratories and prep rooms – can (in rare cases) result in a reduction in the number of lessons timetabled to take place in a laboratory.

Respondents acknowledge there is a great deal of variance between the science learning experience between schools – notably by school type as well as region, as both factors can help influence the levels of resourcing that are available.
“I have now been teaching for 44 years and have never worked in such a poorly resourced environment”

“Due to a lack of storage space, we cannot purchase sufficient equipment to avoid topics being taught on a rota and sharing of equipment, even if there was the money”

“[We need] better ventilation in the laboratories as people are always ill with headaches”

“[There is a] huge variation in [the science] experience for different students in different secondary schools”

“We recognise that at this school we are lucky in respect of resourcing science, however when meeting other technicians from other school we realise that we are in a minority”

Examples of alternative approaches to resourcing (the ‘make do and mend’ culture) typically relate to networking and collaborative approaches, for example:

- Relationships established between a network of local schools to enable borrowing of equipment – this often necessitates schools agreeing to undertake controlled assessments at different times so that equipment can be passed from one school to the next;

- Borrowing of equipment from the Teacher Science Network (TSN);

- Overcoming timetabling clashes by arranging for some pupils to attend certain science classes at other schools (in close proximity, and for the whole academic year);

- ‘Shopping around’ for better prices rather than using recommended equipment suppliers to save money;

- Technician networks formed to share experiences, and in some cases, science equipment;

- Technician developed relationships with local suppliers to source resources at the best prices (this includes abattoirs and butchers for hearts and eyes for biology experiments).
6. Drivers influencing resourcing of practical science in secondary schools and sixth-form colleges

A number of drivers combine to influence the manner, and the extent to which, practical science is being resourced currently, and are likely to continue to sway approaches and attitudes over the next few years. This section is drawn solely from qualitative feedback.

6.1 Curriculum changes

On-going change to the curriculum is the most commonly cited factor (by 65% of respondents) that drives resourcing of practical science. Respondents note that instability within the curriculum can act as a major obstacle for resourcing, contributing to inability to plan ahead and wasted expenditure on textbooks and equipment that must be regularly replaced.

Respondents indicate that changes enforced by examination boards and central Government result in:

- Wasted expenditure on textbooks that have to be frequently replaced;
- Rising proportion of budget spent on reprographics as a result of regular curriculum change; and
- Lack of stability in the curriculum prevents planning ahead for resourcing, as the situation may change.

“Funding for the ever changing political changes to science curriculum does not match the amount of change currently being experienced”

“In my 10 years as a science teacher the one single issue that has prevented the development of more and better practical work in science has been the constant change in programmes of study and specifications for examined courses”

“The constant changes brought about because of Government initiatives means that any medium/long term developments are not worth spending money on as in 3 or 4 years’ time the Government will only change everything again”

6.2 Controlled assessments

Over two-thirds of respondents (68%) state that controlled assessments act as a major driver of the amount and type of equipment that is resourced for practical science. The need to run all assessments for the same year group on the same day frequently means schools do not have the equipment they need in sufficient quantities, compelling some to try to borrow from other local
institutions, and others to buy additional items that subsequently may not be used for the remainder of the academic year.

Respondents also note that organisations designing controlled assessments do not take account of equipment typically available for schools, meaning that those in poorly-funded regions can lose out.

Furthermore some schools object to some Awarding Organisations choosing to dictate which suppliers they should use to source equipment for controlled assessments. This is partly because they are perceived to be too expensive (having a ‘captive’ market meaning they can charge higher prices); and partly because suppliers tend to run out of equipment as stocks are then ordered by a large proportion of schools.

“New controlled assessment GCSE practicals sometimes requires large numbers of everyday items (graduated pipettes, measuring cylinders, stopwatches, balances, burettes, data loggers) that we do have, but not in sufficient quantities”

“We have found controlled assessments difficult because of the number of pupils doing the experiment at the same time (usually the majority of a year group all at the same time)”

“Demands of equipment for controlled assessment at Key Stage 4 are a significant burden, greatly increasing costs for consumables and sometimes requiring outlay on expensive additional equipment”

6.3 Economic factors

Inevitably the economic downturn has impacted upon schools’ capacity to resource science, with over 45% of respondents reporting funding cuts or budgets that have remained static. Where budgets have increased year-on-year, the majority of respondents (63.7%) argue that in practice, they do not see any uplift because pupil numbers and class sizes have also increased.

The impact of funding cuts can have a knock-on effect in a number of areas – for example the number of technicians and/or technician working hours that can be funded, investment in training and CPD (for teachers and technicians), and the type and volume of science equipment and consumables that can be purchased.

“With budgets decreasing each year for the last three years, the amount of practical [work] has decreased...and will continue to do so”

Respondents acknowledge that some schools in economically poor areas are at a major disadvantage. For example respondents in poorly funded Local Authorities report that they are unable to give students the freedom or support to design their own experiments, as they lack sufficient equipment and/or technician time.
“There is a huge range of budgets among local schools. A straw poll at a Subject Leaders Network indicated a range of £4,000 (us) to £40,000 in annual budget - even those of a comparable size (to us) being around a range of £12-20,000”

“It is particularly unjust that students who study in the worst funded local authorities...may suffer”
7. What would improve the resourcing of practical science?

Respondents were asked to consider what would improve the way in which practical science is resourced. The key issues relate to insufficient money to buy resources (reported by just over 33% of respondents); insufficient time to deliver practical work (cited by just over 14% of respondents) and insufficient technician support because of a lack of time in laboratories and limited technician working hours (reported by 13.5% of respondents). Only a tiny proportion of respondents (1.2%) report that they have not encountered any issues in resourcing practical science (Figure 62).

Figure 62: Summary of key issues respondents face in resourcing practical science

A small number of respondents interviewed for the qualitative phase of this research consider that policy-makers do not give sufficient priority to science which can be reflected in the amount of funding available for the subject. Rising class sizes are also becoming problematic in some schools.

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65 State-funded schools only
“Science is still being treated as the poorer relation to Maths & English......it needs to be treated as equal in its importance with support and given funding to match”

“Until science is treated as an important part of the curriculum, funding will always be below par”

“Class sizes are a concern (we have 34 in some classes). The Government should give a cap on class sizes for practical work in secondary science and fund extra science teachers and the laboratory space needed”

Over a quarter of respondents (27.6%) state that the situation would be improved if more money was available for resourcing practical science. Just over a fifth of respondents (22.7%) believe that stability in the curriculum is needed (Figure 63).

**Figure 63: What respondents consider would improve resourcing of practical science**

![Bar chart showing responses to improve resourcing of practical science](chart.png)

Base: 290

“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”

“The only solution is increased funding for science in proportion to other subjects, which probably needs to be specified and enforced by Government”

“Ring-fenced money (for science) and more of it”

“There should be a Government guide of percentage of budget to be given to science departments per pupil”

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*State-funded schools only*
8. Conclusions and recommendations

8.1 Conclusions

1. There is considerable variation between funding and resourcing levels for practical science between secondary schools and sixth-form colleges in England – with particular disparity noted between state-funded schools compared with independent schools. This variation contributes to considerable differences in the type of practical science teaching and learning experience that can be offered to pupils. For state-funded schools the average per capita spend on science is £8.81 compared with £27.29 within independent schools. The spread from the lowest per capita spend on science resourcing to the highest is also extensive: ranging from £0.75 to £31.25 within state-funded schools, and from £7.18 to £83.21 within independent schools.

2. Whilst a consistent science learning experience cannot be guaranteed in either the private sector or state-funded schools, it is clear independent schools have greater control over their science revenue and how they choose to spend it.

3. Over 80% of respondent state-funded schools do not formally allocate funding specifically to science practical work. The largest proportion of the science budget is spent on equipment and consumables (at an average of nearly 40% in state-funded schools). A significant proportion of budget is being increasingly spent on reprographics amounting to an average of 28% in state-funded schools. Those monies spent on reprographics are at the expense of purchasing new or updating existing equipment.

4. The levels of dissatisfaction with science resourcing vary considerably between school types: 44.4% of respondents from maintained schools, 30.3% of respondents from academies and 6.5% of respondents from independent schools. Respondents in state-funded schools that are very satisfied with the funding available for resourcing science have, on average, just over double the per capita spend on science (£16.95 – academic year 2011/12), compared with those that report being very dissatisfied (an average per capita of £7.86). Nearly a third of maintained schools and nearly a fifth of academies are either quite or very dissatisfied with resourcing of science equipment and consumables.

5. Science teachers and technicians are, in some cases, supplementing the core science budget with contributions from their own pocket – however it is not possible to quantify the typical amount spent, and the frequency with which this is occurring.

6. Respondents in state-funded schools report impacts on science teaching and learning as a result of limited funding – notably a need to adapt to a culture of ‘make do and mend’ – cited as an issue by over a third of respondents. Nearly a third of maintained schools expect to offer less science practical teaching and experiences in the next two academic years as a
result of anticipated future funding levels.

7. The average state-funded secondary school has just 70% of the equipment and consumables it needs to teach science subjects, but four in ten state-funded schools have less than 70% of the equipment and consumables they require, while a third of state-funded schools have 80% or more of the equipment and consumables they need.

8. As well as disparity between schools in England in relation to resourcing, there is noticeable variation in resourcing levels between individual science subjects. Biology appears to be the ‘poor relation’ (63.1% of responses indicate sufficient quantities in full working order at pre-16 level, compared with 70.7% for pre-16 chemistry and 72% for pre-16 physics). At post-16 levels, resourcing for biology presents a bigger cause for concern – less than 44% of responses indicate access to sufficient numbers of the indicative items (compared with 66% for post-16 chemistry and 62% for post-16 physics).

- Less than 12% of schools have access to more than 90% of the indicative items for post-16 biology. Less than 1 in 5 schools have access to more than 90% of the indicative items and 1 in 6 have access to less than 50% of the indicative items for post-16 chemistry;

- The most pressing issue for resourcing of pre-16 chemistry appears to be maintaining the indicative items in sufficient quantities, in full working order. Only a quarter of schools can access more than 90% of the indicative items for pre-16 chemistry.

- Although the best resourced of all three science subjects (with nearly 1 in 3 schools that have access to more than 90% of the indicative items for pre-16 physics), there are still issues, with nearly a third of schools with sufficient access to less than 70% of the items required. There is greater inequality at post-16 level, with around 4 in 10 schools having access to less than 70% of the indicative items.

- Compared with the individual science subjects, schools are relatively well-resourced in relation to general science equipment – however sufficient quantities of the indicative items are still not available to 15% of schools. The most frequently cited type of general equipment needed by schools is heated magnetic stirrers (not available to 40% of schools in sufficient quantities) and data loggers (not available to 36% of schools in sufficient quantities).

9. Laboratory facilities are not easily or simply not accessible to 23% of respondents. Nearly a fifth of schools have access to less than 70% of the indicative laboratory facilities. The research also found concerns about design issues with, and quality standards of, laboratory facilities in schools, even – and perhaps especially – in schools that had been recently rebuilt or refurbished. In the case of laboratories built through BSF and PFI programmes problems are attributable to insufficient consultation with teaching staff and technicians.

10. Access to outside learning environments presents a major cause for concern, with less than
7% of schools having access to indicative outside learning environments for pre-16 provision and nearly 60% of schools having access to less than 10% of the indicative items for post-16 provision. In spite of this, less than 15% of respondents report being either quite or very dissatisfied with access to outside learning environments, an potential indicator of a lack of awareness among schools about what ‘good’ access to outside space for learning actually looks like.

11. Around 70% of respondents employ technicians during term-time only. Nearly 30% of maintained schools and nearly a quarter of academies state they are quite or very dissatisfied with the amount of technician support available to them.

12. The qualitative research revealed extensive concerns over salaries, working conditions and career structure. In some schools, technicians were highly valued professionals, who were able to make a significant contribution to the delivery of high quality practical science; in others they seem to be perceived as a low-level role, and therefore expertise is not being fully harnessed.

13. In spite of some major issues in relation to resourcing, respondents appear somewhat tolerant of the situation, with the majority of state-funded schools (over 45% on average) reporting they are quite satisfied with resourcing levels. However it is clear that schools have adapted their approach to teaching and learning of practical science as a direct result of inadequate funding and resourcing — notably over a third of respondents cited a need to adapt to a culture of ‘make do and mend’. Other impacts include larger group sizes and fewer practical science experiences.

14. There are other drivers influencing the way in which practical science is resourced in secondary schools and sixth-form colleges. In particular, external policy developments appear to play an important role in determining the level and adequacy of resources — notably on-going instability within the science curriculum, with frequent changes acting as a barrier for long-term planning in relation to resourcing of science departments, as well as maintaining equipment in sufficient quantities. The latter issue also comes about because of the impact of controlled assessments requiring high volumes of equipment to be in use all at the same time; schools find it challenging to secure the necessary quantities — particularly if these items are then used only infrequently for the remainder of the year.

15. Respondents cite that actions most likely to improve resourcing of practical science are: more funding, stability in the curriculum, better laboratory design and more time for practical science (in relation to planning for science teachers and technicians as well as longer lessons and more time in the timetable generally for practical science).

8.2 Recommendations

Recommendations for SCORE – information for secondary schools and sixth-form colleges:

- Develop and disseminate among schools guidance on maximum class sizes for different
types of practical work;

- Develop and make available to schools (for example via SCORE and their partner websites) guidance on external sources of funding such as grants, competitions and awards, and keep this updated;

- Develop and disseminate among schools guidance on utilising outside learning environments for different types of practical work, and the value of this;

- Develop and disseminate among schools information about the value of technicians for science departments, and how to best utilise their expertise;

- Develop and disseminate among schools the benchmark lists of items required to effectively deliver science practical work, together with likely costs of sourcing these items.

**Recommendations for SCORE – influencing policy:**

- Consider undertaking additional research into the costs of resourcing science compared with the costs of resourcing other subjects such as English and Mathematics, which may provide an evidence base (depending on findings) with which to lobby Government to retain the 12% weighting for post-16 science;

- Use this evidence base to lobby Government in relation to securing on-going stability in the science curriculum;

- Consider seeking the development of a national funding formula which could be used to lobby for more equitable and consistent funding of science practical work across and within schools;

- Consider lobbying Government for the Technician Service Factor to become statutory, thus compelling schools to ensure science departments retain a full complement of technicians;

- Consider lobbying Government for statutory maximum class sizes and the amount of space needed for practical science lessons;

- Consider a need to lobby central and local Governments to provide one-off targeted funding to ensure that every school has key equipment in every classroom and that preparation and storage areas are fit-for-purpose;

- Encourage Awarding Organisations to audit their support materials and assessment processes to ensure that they are not inadvertently passing on costs to schools;

- Encourage that laboratory new builds or refurbishments be designed in full consultation with teachers and technicians, who should be regarded as the primary client for such work and when such works take place, the provision of appropriate, suitably located storage and
preparation facilities should be a priority.

Recommendations for SCORE – general:

- Repeat this research in approximately two years’ time, to maintain a clear understanding of the level and sufficiency of funding and resourcing for practical science and to understand the impact of any changes e.g. to policy that have taken place in the interim;

- Undertake specific research into the issue of reprographics costs in maintained schools, and in particular consider in more detail what the underlying causes of high and apparently increasing reprographics costs might be, and how they might be addressed;

- Consider whether there is a need for additional research to establish in more detail the nature of the obstacles to more extensive use of outside learning environments, and how they may be overcome;

- Seek to influence the development and implementation of a national training, qualification and progression structure specifically for science technicians.
Appendix 1: List of indicative items

Biology – pre-16

- Visking tubing
  *(pair work)*
- Ecological sampling equipment (e.g. 50m tape measures and quadrats)
  *(pair work)*
- Equipment to measure changes in the body e.g. temperature, blood pressure, heart rate
  *(pair work)*
- Plastic petri dishes (and inoculating loops)
  *(pair work)*
- Potometers
  *(small group work)*
- Gas exchange or breathing change equipment
  *(small group work)*
- Food tests (e.g. Biuret)
  *(small group work)*
- Appropriate dissection kits
  *(small group work)*
- Plants (e.g. Cabomba, geranium, cress)
  *(small group work)*
- Optical microscopes x400 max (and microscope lamps)
  *(small group work)*
- Water bath (and thermometers)
  *(small group work)*
- Working autoclave/pressure cooker
  *(demo/large group)*
- Models (of organs) (e.g. eye, ear, torso, heart, DNA)
  *(demo/large group)*
- Digital microscope with visualiser/flexi-camera
  *(demo/large group)*
- Klinostat
  *(demo/large group)*
Biology – post-16

- Eye piece graticular
  (pair work)
- Example slides
  (pair work)
- Top pan balance +/- 0.001g
  (pair work)
- Colorimeter
  (small group work)
- Genetic engineering kits
  (small group work)
- Haemocytometer
  (demo/large group)
- Spirometer
  (demo/large group)
- Gram Stains
  (demo/large group)
- Ninhydrin
  (demo/large group)
- Digital microscope with visualiser/flexi-camera/stage micrometers
  (demo/large group)
- Gel electrophoresis equipment and centrifuge
  (demo/large group)
Chemistry – pre-16

- Eye protection  
  (for every student)
- Conical flasks (100ml & 250ml)  
  (pair work)
- Measuring cylinders of various sizes  
  (pair work)
- Spotting/dimple tile  
  (pair work)
- Evaporating basin  
  (pair work)
- Titration equipment (including burette, pipette and pipette filler)  
  (pair work)
- Molecular modelling kit  
  (pair work)
- Ground glass gas syringe  
  (pair work)
- Balance ± 0.1 g (required for core and additional)  
  (small group work)
- Balance ± 0.01 g (required for triple chemistry)  
  (small group work)
- Quick Fit equipment for distillation  
  (demo/large group)
- Heating mantle  
  (demo/large group)
- Equipment for demonstrating the electrolysis products of dilute acid (e.g. a Hoffman voltammeter)  
  (demo/large group)
- Rock and mineral kit  
  (demo/large group)
- Variety of smart materials  
  (demo/large group)

Chemistry – post-16

- Titration equipment (including burette, pipette and pipette filler)  
  (for every student)
- Volumetric flask (of appropriate size)  
  (for every student)
• Thermometer (± 0.1 °C)  
  (for every student)
• Conical flasks (100ml & 250ml)  
  (for every student)
• Eye protection  
  (for every student)
• Measuring cylinders of various sizes  
  (for every student)
• TLC plates  
  (for every student)
• Quick Fit equipment (for distillation and reflux)  
  (pair work)
• Büchner funnel and flask and appropriate method for generating suction  
  (pair work)
• Ground glass gas syringe  
  (pair work)
• Heating mantle  
  (pair work)
• Molecular modelling kit  
  (pair work)
• pH meter  
  (pair work)
• Balance ± 0.01 g  
  (small group work)
• Balance ± 0.001 g  
  (small group work)
• Colorimeter  
  (small group work)

Physics – pre-16

• Working bulbs and holders  
  (pair work)
• Variety of magnets including alnico, magnadur and neodymium  
  (pair work)
• Masses and hangers  
  (pair work)
• Ammeters and voltmeters, or multimeters  
  (pair work)
• Static electricity kit  
  (pair work)
• Leads, wires (resistance and conducting) and switches  
  (pair work)
• Force meters  
  *(pair work)*
• Thermistors  
  *(pair work)*
• LDRs  
  *(pair work)*
• Ray boxes and accessories  
  *(pair work)*
• Digital multimeter  
  *(pair work)*
• Energy meter  
  *(small group work)*
• UV + infrared kit (sources and detectors)  
  *(small group work)*
• Tuning forks  
  *(demo/large group)*
• Variety of springs  
  *(demo/large group)*
• Slinky for wave demonstrations  
  *(demo/large group)*
• Light gates and timer  
  *(demo/large group)*
• Signal generator  
  *(demo/large group)*
• Van der Graaf generator  
  *(demo/large group)*
• Geiger counter  
  *(demo/large group)*
• Strong horseshoe magnet (major magnet)  
  *(demo/large group)*
• Galvanometer  
  *(demo/large group)*
• Ripple tank  
  *(demo/large group)*
• Thermal expansion apparatus (e.g. ball & ring)  
  *(demo/large group)*

**Physics – post-16**

• Micrometer  
  *(pair work)*
• Vernier callipers  
  *(pair work)*
• Rheostats of various sizes  
  *(pair work)*
• Capacitors of various sizes  
  *(pair work)*
• Trolleys  
  *(pair work)*
• Diffraction gratings  
  *(pair work)*
• Resistance substitution box  
  *(pair work)*
• Pulley wheels  
  *(small group work)*
• Balance (2 decimal places)  
  *(small group work)*
• Loud speakers  
  *(small group work)*
• Hall effect probe/search coil and solenoids (with iron cores)  
  *(small group work)*
• Stroboscope  
  *(demo/large group)*
• Air track + blower  
  *(demo/large group)*
• Vibration generator  
  *(demo/large group)*
• EHT power supply  
  *(demo/large group)*
• Large parallel plates (capacitor)  
  *(demo/large group)*
• Electron beam tube  
  *(demo/large group)*
• Microwave kit  
  *(demo/large group)*
• UV source (photoelectric effect)  
  *(demo/large group)*
• Millisecond timer  
  *(demo/large group)*
• Closed radioactive sources  
  *(demo/large group)*

**General science equipment**

• Spirit or mercury thermometers, range -10 °C to 110 °C  
  *(pair work)*
• Clamps and stands  
  *(pair work)*
• Metre rulers  
  *(pair work)*
• Stop watch/stop clock  
  *(pair work)*
• LV power supply  
  *(pair work)*
• Crocodile clips  
  *(pair work)*
• Mirrors  
  *(pair work)*
• Working batteries  
  *(pair work)*
• Bathroom scales (in Newtons)  
  *(small group work)*
• Data logger and computer with range of sensors (e.g. Temperature, pH, sound)  
  *(small group work)*
• Heated magnetic stirrers  
  *(demo/large group)*

**Laboratory facilities**

• Access to gas
• Access to water
• Access to electricity
• Access to dim out
• Access to blackout
• Sufficient areas for visible class demonstrations and for group work
• Working fume cupboard which has access to gas, electricity and water
• At post-16, space to leave long term investigations/experiments
• Close proximity to preparation room
• Good ventilation in chemical storeroom
• Security for chemical storeroom
• Chemical storeroom accessibility to preparation room
• Ducted fume cupboard in preparation room(s) with access to gas, electricity and water
• Sufficient storage for all equipment in preparation room(s)
• Radioactive storage facilities in preparation room(s)
• Sufficient bench space in preparation room(s)
• First aid kit in preparation room(s)
• Computer, internet connections and telephone in preparation room(s)
• Fridge/freezer in preparation room(s)
• Dishwasher in preparation room(s)
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- Equipment trolley in preparation room(s)
- Oven in preparation room(s)
- Still-water purification in preparation room(s)
- Dispensing jars and bottles in preparation room(s)
- Hazard labels, tapes and cards in preparation room(s)
- Safeguards in the School Laboratory 11th Edition

Access to outside learning opportunities – pre-16

- A pond or other natural water habitat
- Trees/hedges
- Grassland; not just the school playing field, e.g. for use of quadrats, random sampling, use of keys (skills).
- Outside resource to demonstrate the different properties of rocks (erosion etc.) and to monitor air quality
- Open space for a variety of activities e.g. model the solar system, measure speed, role plays etc.
- Functioning renewable energy source (e.g. photovoltaic or wind)

Access to learning opportunities outside the school – post-16

- Varied ecology and habitats which are different from those around the school
- Research facility for gene technology
- Research facility for spectroscopy
- Research facility (accelerator) to study particle and/or nuclear physics
- Medical physics department in a hospital