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# *Assessing the costs of benchmarks of good practice in practical science*

Gatsby Charitable  
Foundation

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May 2017

*Final report*

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# Contents

<i>Executive summary</i>	<b>1</b>
<b>1 Introduction</b>	<b>3</b>
<b>2 Delivering the benchmarks – The school delivery model</b>	<b>5</b>
<b>3 Approach</b>	<b>8</b>
<b>4 Benchmark 1: Planned practical science</b>	<b>14</b>
<b>5 Benchmark 2: Purposeful practical science</b>	<b>22</b>
<b>6 Benchmark 3: Expert teachers</b>	<b>28</b>
<b>7 Benchmark 4: Frequent and varied practical science</b>	<b>34</b>
<b>8 Benchmark 5: Laboratory facilities and equipment</b>	<b>40</b>
<b>9 Benchmark 6: Technical support</b>	<b>48</b>
<b>10 Benchmark 7: Real experiments, virtual enhancements</b>	<b>53</b>
<b>11 Benchmark 8: Investigative projects</b>	<b>54</b>
<b>12 Benchmark 9: A balanced approach to risk</b>	<b>59</b>
<b>13 Benchmark 10: Assessment fit for purpose</b>	<b>64</b>
<b>14 Summary of costs of the benchmarks</b>	<b>69</b>
<b>Appendices</b>	<b>73</b>
Appendix A: School characteristics by type	74
Appendix B: Employment costs by staff type	75
Appendix C: Recurring costs by Benchmark by school type	78
Appendix D: Expenses by Benchmark on recurring basis	81
Appendix E: One-off costs by Benchmark	82
Appendix F: Laboratory and equipment costs	83
Appendix G: Principal assumptions	89
Appendix H: Recruitment/retention of teachers and technicians	92

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# *Executive summary*

## *Background*

The Gatsby Charitable Foundation commissioned PricewaterhouseCoopers LLP (PwC) to assess the costs of ten benchmarks of good practice in the delivery of practical science in secondary schools in England<sup>1</sup>.

For the purposes of our work:

- ‘Science’ includes biology, chemistry, physics, combined science, earth science and other experimental sciences.
- ‘Practical science’ is defined as those activities in which pupils manipulate and observe real objects and materials in laboratories and field studies, including practical demonstrations by teachers, where they actively involve pupils.

Our study analyses secondary schools and sixth form colleges, whether maintained or independent<sup>2</sup>.

## *The benchmarks and their costs*

The ten benchmarks of good practice are illustrated in Figure 1. While Gatsby anticipates that schools will work towards all ten benchmarks simultaneously, we analyse the cost of the activities required to deliver each benchmark separately.

We consider three main types of costs that schools will incur if they achieve all the benchmarks:

- The staff costs related to achieving and maintaining the benchmarks;
- Capital costs associated with the provision of the appropriate facilities and equipment; and
- Any additional expenses incurred, (e.g. subscription fees, teaching cover, consumables etc.).

We distinguish the one-off costs as schools undertake activities for the first time from the recurring costs.

We also examine how far schools are already achieving the benchmarks, and thus incurring some or all of the costs. Our assessment draws on a parallel survey undertaken on behalf of Gatsby<sup>3</sup>. The difference between the expected costs and those currently being incurred is the costs of the additional activities that we expect schools would need to undertake to fulfil the benchmarks – we distinguish between the one-off costs as schools undertake activities for the first time and the recurring costs.

Finally, we consider whether these activities could be undertaken by schools reprioritising time spent on other activities rather than incurring additional expenditure.

## *Approach*

We start by developing a school delivery model for practical science as the basis of our cost analysis. This model comprises a core team within the school science department led by the Department Head, who is accountable to a member of the Senior Leadership Team (SLT) and, through them, the school’s Head Teacher, Board of Governors and other senior stakeholders. The core team includes all Subject Leaders, science teachers and technicians.

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<sup>1</sup> The full scope of this work is set out in our engagement letter dated 28<sup>th</sup> September, 2016.

<sup>2</sup> Further education colleges are outside the scope because the practical aspect of their vocational programmes are so different from general education and have been extensively studied elsewhere by Gatsby. Further education colleges are outside the scope because the practical aspect of their vocational programmes are so different from general education and have been extensively studied elsewhere by Gatsby.

<sup>3</sup> Pye Tait Consulting (2017) Good Practical Science Benchmark Survey.

We use the Standard Cost Model (SCM)<sup>4</sup> to estimate the costs of the benchmarks. This involves using activity based costing to breakdown each benchmark into its component activities and analysing cost information relating to a small cross-section of six ‘typical’ schools which we then extrapolate across all secondary schools in England.

Figure 1: The ten benchmarks



Our analysis considers the costs to schools of establishing and operating the benchmarks. We do not attach a cost to the time spent by pupils.

The first stage of our assessment is to estimate the potential costs of maintaining each benchmark for an individual school. We then estimate what proportion of the costs are currently being incurred by those schools which are fully or partly achieving the benchmarks and determine the additional costs that schools would need to incur so that they all fully achieve the benchmark, including any one-off costs as the schools achieve the benchmark for the first time.

<sup>4</sup> The SCM is based on extensive international experience and has been widely used by the UK Government and other governments to assess the costs (and benefits) of new and existing policy.

We draw on official statistics and research from the Office for National Statistics (ONS) and the Department for Education (DfE) and other research commissioned by Gatsby. We have also organised two workshops with teachers and technicians and consulted experts in the field, including Breckland Scientific Supplies Ltd, Philip Harris Ltd & Scientific Laboratory Supplies Ltd, CLEAPSS and Innova Design Solutions Ltd.

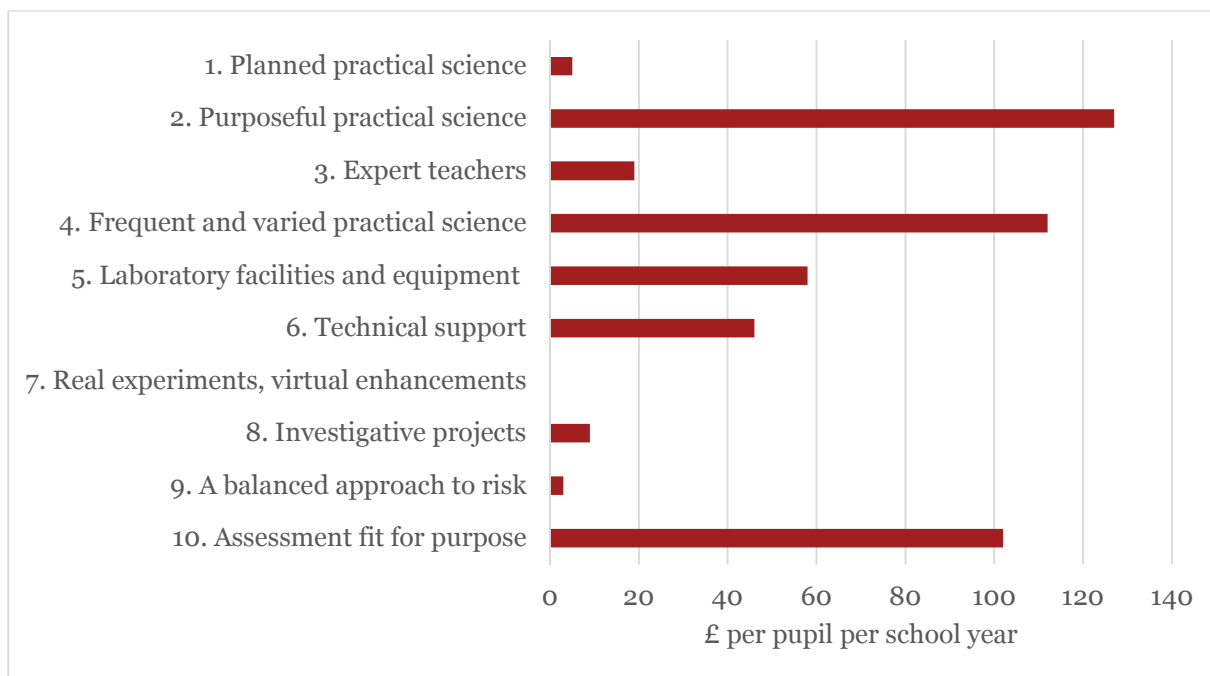
We have not undertaken any assurance or audit of the underlying data that have been used.

### Estimated costs

Figure 2 shows the average recurring costs per pupil per school year associated with delivery of each benchmark in a typical school. The key points to note are that:

- The most costly benchmarks are Benchmarks 2 (Purposeful practical science), 4 (Frequent and varied practical science) and 10 (Assessment fit for purpose): these are the benchmarks which capture the preparation for and delivery of practice science;
- The estimated costs of Benchmark 6 (Technical support) reflect the way in schools are typically organised to deliver practical science with teachers, rather than technicians taking on significant responsibilities: to the extent that more technicians could take on greater responsibility, this would reduce the costs associated with delivering the benchmark;
- The costs of providing laboratories and the other equipment and facilities needed for practical science (Benchmark 5) are just over £50 per pupil when considered on an annual basis;
- The costs of Benchmark 3 (Expert teachers) are limited to the costs of recruiting and developing the skills of the teaching workforce;
- The recurring costs of Benchmark 1 (Planned practical science) are £5, but this excludes the costs of developing a school policy for the first time, which is treated as a one-off cost; and
- If all the other benchmarks are being achieved, we do not expect schools to incur any additional costs in meeting Benchmark 7 (Real experiments, virtual enhancements).

Figure 2: Average recurring costs of each benchmark (£ per pupil per school year)



Source: PwC analysis

Table 1 shows a breakdown of the average costs per pupil per school year which are already being incurred by secondary schools or which would need to be incurred by them if they are to fully meet the respective benchmark. It distinguishes between those schools which have not achieved any part of the benchmark ('Not at all'), those which have achieved some parts of it ('Partly') and those which have achieved all of it ('Achieved'). The table also shows the proportions of schools which we estimate fall into each of the three categories.

First, for those schools which have not achieved any part of the benchmark, we distinguish between any additional one-off costs that a school might need to incur and the additional recurring costs that the average school in this category would face.

Second, for those schools which have only partly achieved the benchmark, we estimate the recurring costs which are currently being incurred as well as the further one-off costs and recurring costs that we expect that the average school in this category would face.

Finally, for those schools which have achieved all of the benchmark, we estimate the recurring costs that the average school is currently incurring.

The key points to note are that:

- No benchmark is currently being fully achieved by more than half of secondary schools;
- The strongest performance in terms of fully achieving the benchmark is for Benchmarks 6 (Technical support) and 9 (A balanced approach to risk);
- The biggest performance gap (where most schools are not achieving the benchmark at all) is in relation to Benchmarks 1 (Planned practical science) and 4 (Frequent and varied practical science);
- Schools are currently incurring the largest recurring costs for Benchmarks 2 (Purposeful practical science), 4 (Frequent and varied practical science) and 10 (Assessment fit for purpose); and
- The most significant one-off cost which schools face is associated with the development of a school policy for practical science (part of Benchmark 1 (Planned practical science)).

Care is needed in interpreting these cost estimates. In particular, where schools need to start undertaking activities to achieve a benchmark in full, this does not mean that they need to spend more, for example by recruiting more teachers or technicians to deliver science. In several cases, they can meet the benchmark by reallocating teaching time to delivering more practical science (at the expense of other forms of teaching). For example, they can substitute lessons involving well planned practical science for non-practical lessons. Our research and analysis suggest that the incremental expenditure for schools is primarily likely to be the limited additional expenses. These need to be weighed against the potential benefits associated with the delivery of more, better practical science in terms of improved academic achievement, enhanced skills and stronger commitment to STEM subjects.

Assessing the costs of benchmarks of good practice in practical science

Table 1: Annual recurring costs if maintaining benchmarks in a medium sized school with no sixth form and in a medium sized school with a sixth form (£ per pupil)

Benchmark	Not at all			Partly			Achieved		
	% of schools	Additional one-off costs (£ per school year)	Additional recurring costs (£ per school year)	% of schools	Recurring costs currently incurred (£ per school year)	Additional one-off costs (£ per school year)	Additional recurring costs (£ per school year)	% of schools	Recurring costs currently incurred (£ per school year)
1. Planned practical science	77%	£10	£5	10%	£1	£2	£4	13%	£5
2. Purposeful practical science	0%	n/a	n/a	72%	£47	n/a	£80	28%	£127
3. Expert teachers	0%	£3	n/a	85%	£8	£3	£11	15%	£18
4. Frequent and varied practical science									
• Lesson delivery	17%	n/a	£113	77%	£49		£64	6%	£113
• Biology field trip	40%	n/a	£1	40%	<£1	n/a	<£1	60%	£1
5. Laboratory facilities and equipment	0%	n/a	£60	92%	£23	n/a	£37	8%	£60
6. Technical support	0%	<£1	n/a	57%	£38	<£1	£8	43%	£46
7. Real experiments, virtual enhancements					Not applicable				
8. Investigative projects	9%	n/a	£57	76%	£9	n/a	£49	15%	£57
9. A balanced approach to risk	1%	n/a	£3	64%	£2	n/a	£1	35%	£3
10. Assessment fit for purpose	12%	n/a	£102	85%	£23	n/a	£79	3%	£102

Source: PwC analysis



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# 1 Introduction

## *Background*

The Gatsby Charitable Foundation commissioned PricewaterhouseCoopers LLP (PwC) to assess the costs of ten benchmarks of good practice in the delivery of practical science in secondary schools in England. The scope of this work is set out in our engagement letter dated 28<sup>th</sup> September, 2016.

## *Scope of analysis*

For the purposes of our work, ‘Practical science’ includes the wide variety of activities in which pupils manipulate and observe real objects and materials in laboratories and field studies. It includes practical demonstrations by teachers, where they actively involve pupils, but excludes the manipulation of data that have not been collected by pupils themselves and visits to places of scientific interest where no fieldwork or hands-on activity takes place<sup>5</sup>.

‘Science’ includes biology, chemistry, physics, combined science, earth science, and other experimental sciences but excludes mathematics, engineering, design and technology, computer science and social sciences.

Our study covers secondary schools and sixth form colleges, whether maintained or independent. Further education colleges are outside the scope because the practical aspect of their vocational programmes are typically quite different from general education and have been extensively studied elsewhere by Gatsby.

The focus of our analysis is the costs to individual schools and across the English secondary school population as a whole of each of the ten benchmarks:

- Benchmark 1: Planned practical science
- Benchmark 2 Purposeful practical science
- Benchmark 3 Expert teachers
- Benchmark 4 Frequent and varied practical science
- Benchmark 5 Laboratory facilities and equipment
- Benchmark 6: Technical support
- Benchmark 7: Laboratory facilities and equipment
- Benchmark 8: Investigative project
- Benchmark 9: A balanced approach to risk
- Benchmark 10: Assessment fit for purpose

We have not undertaken assurance or audit of any of the underlying data that have been used.

## *Report structure*

The rest of this report is structured in thirteen further Sections as follows:

- **Section 2** considers how schools might deliver the benchmarks;
- **Section 3** describes our approach to assessing the costs and benefits of the benchmarks;
- **Sections 4-13** assess the costs of achieving each of the benchmarks;
- **Section 14** summarises the costs of achieving all ten benchmarks.

A series of seven Appendices provide further details of the calculations and assumptions which underpin our analysis:

- Appendix A describes the characteristics of the schools we have used for our analysis;

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<sup>5</sup> This does not imply that there is no educational value to these activities, just that they are outside the scope of this report.

- Appendix B shows the basis of our estimates of staff costs by staff type;
- Appendix C summarises the recurring staff costs by benchmark by school type;
- Appendix D summarises the recurring expenses per activity;
- Appendix E details the one-off costs included in our analysis;
- Appendix F explains how we have assessed laboratory and equipment costs;
- Appendix G summarises the principal assumptions underpinning the analysis; and
- Appendix H explains our approach to assessing the costs of recruitment/retention of teachers and technicians.

## 2 *Delivering the benchmarks – The school delivery model*

### *Introduction*

This Section considers what schools might need to do to deliver each of the ten Benchmarks of good practice in practical science. Figure 3 describes the vision for each of the ten benchmarks. The remainder of the Section considers how schools might structure the delivery of the benchmarks. The delivery model is meant to be illustrative rather than prescriptive: schools will wish to consider how best to adapt this model to fit within their existing structures and staffing arrangements. This will imply some diversity as schools choose how they want to organise themselves. Nonetheless, the model is necessary to enable us to examine and assess the costs of achieving each of Gatsby’s benchmarks of good practice in practical science.

Figure 3: The vision for practical science



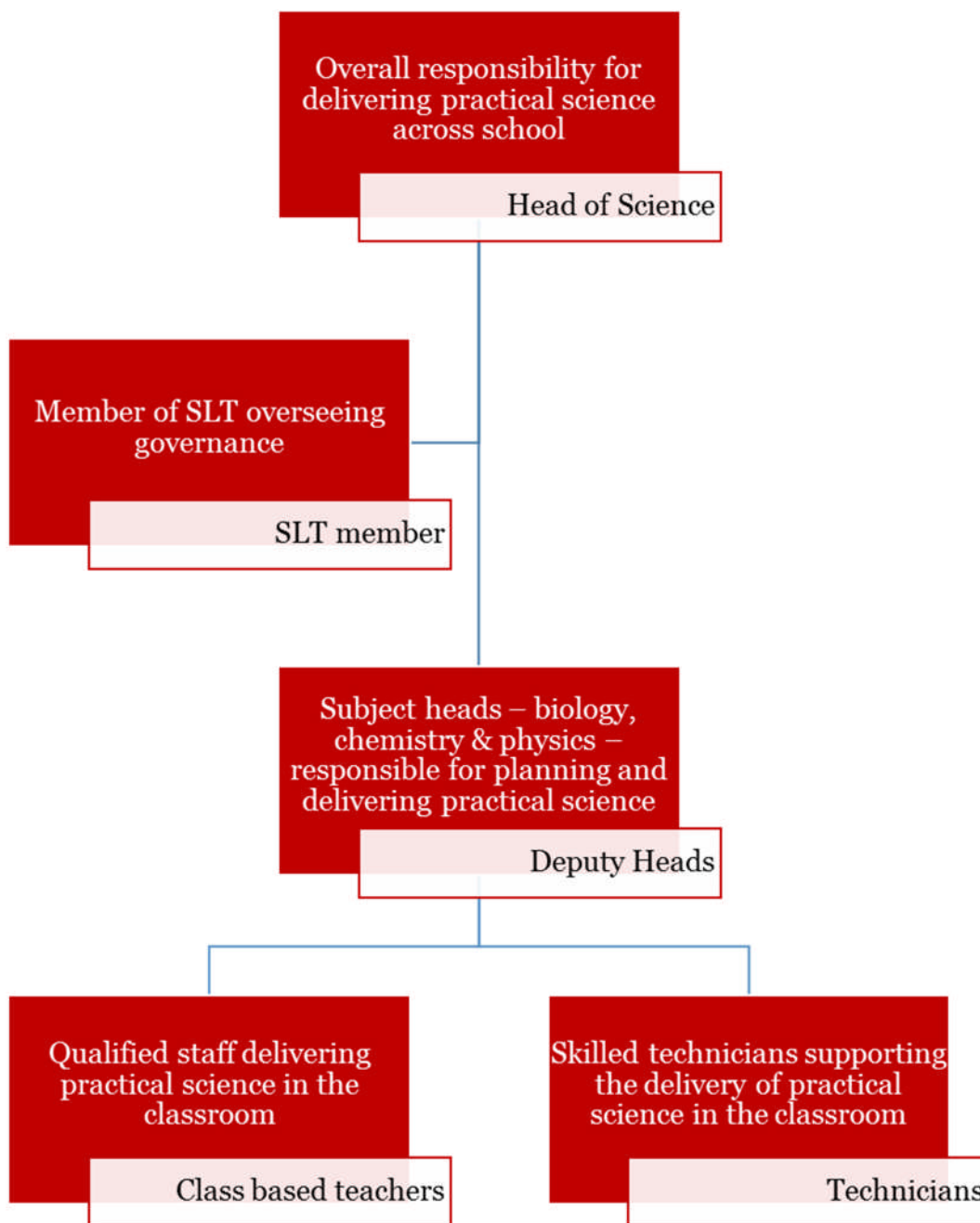
## Delivery model

Gatsby’s research and consultations to date have identified the following key principles of good practice in delivering practical science in a school environment:

- Leadership from the school’s Head of Science;
- Input from class based teachers with appropriate skills and experience;
- Adequate support from well qualified technicians; and
- Support from the school’s Senior Leadership Team (SLT);

We have used these principles to inform the development of our hypothetical school delivery model which we use as the basis of our cost analysis. It is illustrated in Figure 4 and described in more detail in the remainder of this Section.

Figure 4: Practical science – delivery model



## *Roles and responsibilities within schools*

The model depicted in Figure 6 envisages a core team that is responsible for delivering practical science.

The core team is led by a Head of Department who reports to a member of the SLT, who is ultimately accountable to the school’s Head Teacher, Board of Governors and other senior stakeholders for the delivery of practical science in the school.

It also comprises the Head of Department’s deputies or assistants who will typically be responsible for particular subjects together with the class based teachers of science and the school’s technicians.

Table 2 summarises the responsibilities of each members of the team in relation to delivering the ten benchmarks of good practice in practical science.

*Table 2: Responsibilities of the practical science delivery team*

<b>Benchmark</b>	<b>SLT member</b>	<b>Head of Department (and Subject Leaders)</b>	<b>Class based teachers</b>	<b>Technicians</b>
1. Planned practical science	✓	✓	✓	✓
2. Purposeful practical science		✓	✓	✓
3. Expert teachers	✓	✓	✓	
4. Frequent and varied practical science		✓	✓	✓
5. Laboratory facilities and equipment				
6. Technical support		✓	✓	✓
7. Real experiments, virtual enhancements				
8. Investigative project			✓	✓
9. A balanced approach to risk		✓	✓	✓
10. Assessment fit for purpose		✓	✓	

In the next Section, we explain the approach we have adopted to estimating the costs of delivering each of the benchmarks.

# 3 Approach

## Introduction

This Section explains our approach to the analysis.

## Costs

We use the Standard Cost Model (SCM) to frame our assessment of the costs of the benchmarks. We adapt the SCM in order to define the data needed to estimate the potential costs of each of the benchmarks. The SCM, which is based on extensive international experience, focuses on the activities required to fulfil the specific commitments implied by each of the Benchmarks of good practice in practical science. It has been widely used by the UK Government and other governments to assess the costs (and benefits) of new and existing policy. It has also been used previously by Gatsby<sup>6</sup>.

## Standard Cost Model

The SCM relies upon a consistent and simplified approach to assessing the cost of each activity (see Table 3). It assesses:

- The unit cost of each activity (for an individual within a school), including any externally procured goods and services; and
- The quantity (i.e. how many people within each school undertake each activity each year).

Table 3: Calculation of costs

Unit cost	x	Quantity
Internal costs + External costs	x	Population x Frequency
Internal costs = internal time (hours) x wage rate (£ per hour) (+ overhead) + External costs = External goods and services purchased	x	Population = number of affected individuals (or schools) Frequency = how often each individual (or school) undertakes the activity (e.g. annual, etc.)
(Activity level for internal costs, benchmark level for external costs)		(Benchmark level – Same for all activities)

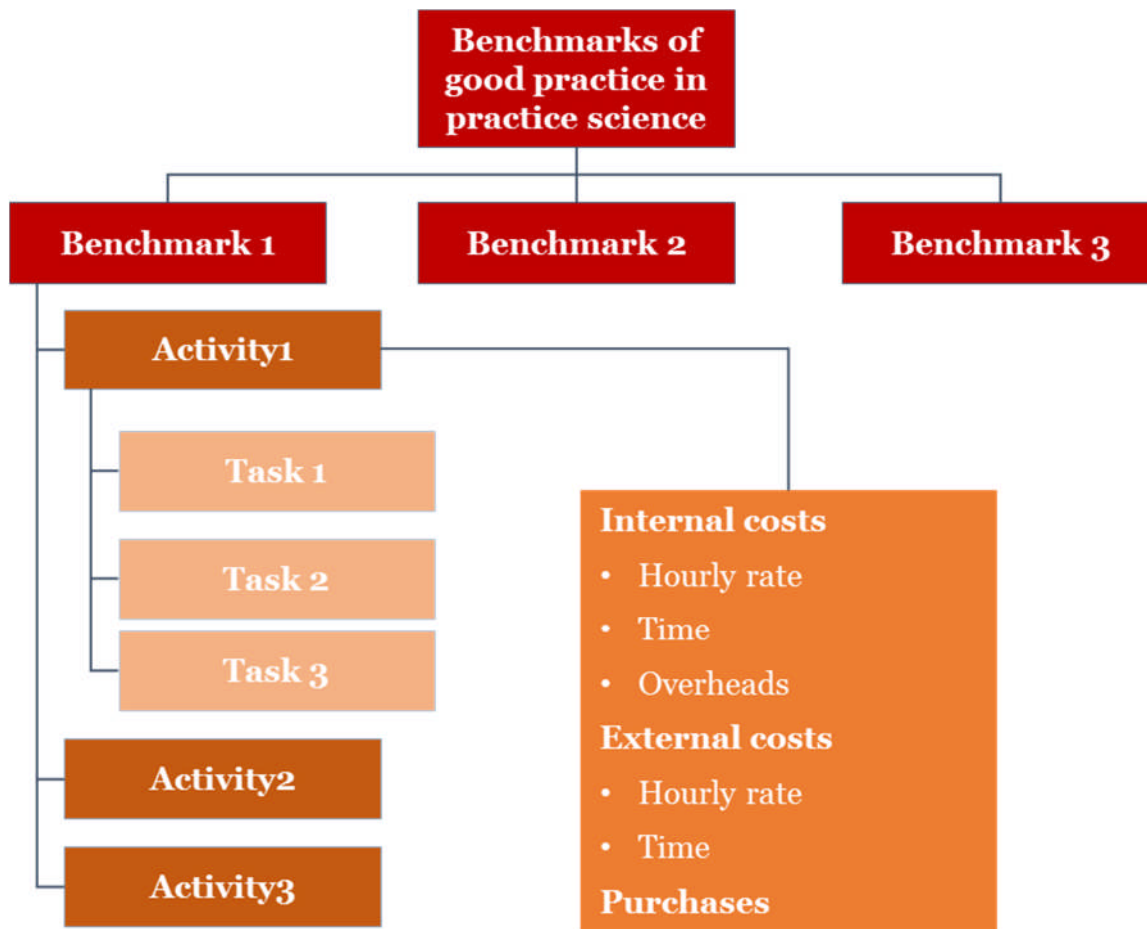
The SCM uses activity based costing to break down each benchmark into its component activities so that each can be assessed in a consistent (yet simplified) way. The analysis distinguishes between those activities that are one-off in nature (e.g. the establishment of a policy for practical science) and those which are undertaken on a regular basis. The latter give rise to recurring costs (e.g. the delivery of practical science in lessons).

Application of the SCM involves gathering cost information relating to a small cross-section of typical schools. The results can then be extrapolated across the wider population of schools to generate indicative estimates of the total costs for England as a whole.

Figure 5 summarises the key elements of cost within the SCM.

<sup>6</sup> PwC (2014) Assessing benchmarks of good practice in school career guidance.

Figure 5: Structure of costs in the SCM



## Scope

The scope of our analysis of costs is clear:

- We include all secondary schools in England only: this means we include both state funded and independent schools (including sixth form colleges and all through schools) but exclude further education colleges and pupil referral units.
- We consider the costs both of establishing and then operating each of the benchmarks.
- We focus on the costs incurred by schools (including teachers and other staff).
- We do not consider any costs for pupils or parents.
- All costs are expressed in 2016 prices.

## Application of the SCM

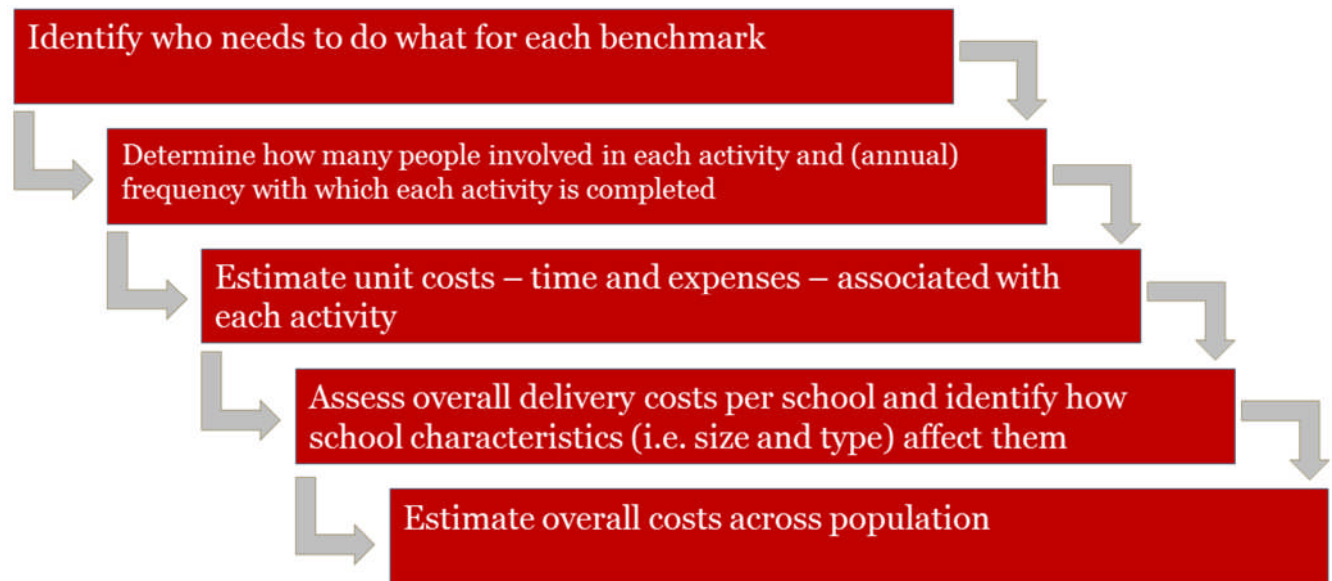
Our approach to assessing the potential costs of each benchmark involves two stages.

The first stage is a five step process to estimate the ‘baseline’ costs for six different types of typical school if they are fully undertaking all of the activities implied by a benchmark (see Figure 6):

- The first step involves defining precisely what activities each stakeholder (within scope) is expected to undertake to deliver each benchmark and how these activities link to each other (if at all).
- In the second step, we determine how many times each of the identified activities is expected to be undertaken in a ‘typical’ year: this is a product of what the cost drivers are (e.g. pupils, schools, subjects etc.) and how frequently the activity is needed. This means that the time needed to undertake some activities is estimated on a per teacher basis whilst in other cases it is estimated on a whole school basis. This approach was tested through two workshops with teachers and with representatives from the Gatsby Charitable Foundation.

- The third step involves assessing the time and expenses associated with each activity using the SCM to structure this analysis. Our approach to gathering information on costs has involved desk research, analysis of existing research commissioned for Gatsby and two workshops with teachers and technicians as well interviews with experts.
- The fourth step involves estimating the overall costs for a school as the product of the quantity (Step 2) and the unit cost (Steps 3 and 4).and assessing the effect of two key school characteristics, the number of pupils in the school and the year groups taught, on delivery costs at school level.
- The final step involves extrapolating the estimated costs at school level across the population of English secondary schools.

Figure 6: Application of the SCM



Our approach to the first stage is based on analysing the expected costs for six different schools which are used to represent the population of English secondary schools. In order to do this we have examined the structure of the population of secondary schools in England based on the Department for Education’s (DfE’s) SFR 20/2016<sup>7</sup>. We have selected six different schools: schools with and without a sixth form (Years 12 & 13) in three size categories (large, medium and small). The characteristics of each of these schools are summarised in Table 4.

Table 4: Overview of the key characteristics of the six typical schools (Schools A to F)

School	Number of pupils on role	Years 12-13 (Sixth form)	Number of science teachers	Number of Department Heads	Number of class based teachers	Number of technicians
A	212	N	4	2	2	0.8
B	621	N	8	4	4	2.2
C	1,053	N	13	5	8	3.5
D	359	Y	6	3	3	1.7
E	904	Y	12	4	8	3.5
F	1,401	Y	18	5	13	5.2

Source: PwC analysis

<sup>7</sup> <https://www.gov.uk/government/statistics/schools-pupils-and-their-characteristics-january-2016>



Table 5 provides an analysis of how many schools of each type (A – F) there are across the population of English secondary schools and how many pupils they cater for. We distinguish between state funded and independent schools.

In order to determine the aggregate costs of delivering each of the benchmarks across all English secondary schools we first calculate the number of pupils in each of our six types of school. We then multiply the number of pupils in each school type by the average cost per pupil for that school type.

Table 5: Number of secondary school pupils in England by school type (i.e. Key Stage 3, 4 and 5 pupils in state funded secondary schools and pupils aged 11-19+ in 'Other' independent schools)

Type of school	A 1-400 pupils, no sixth form	B 401-800 pupils, no sixth form	C 801 pupils or over, no sixth form	D 1-700 pupils, with sixth form	E 701-1,100 pupils, with sixth form	F 1,101 pupils or over, with sixth form	Total
State funded n	50,436	333,850	491,887	141,565	703,911	1,399,060	3,120,709
State funded %	2%	11%	16%	5%	23%	45%	100%
Independent n	21,583	5,889	855	132,764	95,990	53,852	310,933
Independent %	7%	2%	0%	43%	31%	17%	100%
All n	72,019	339,739	492,742	274,329	799,901	1,452,912	3,431,642
All %	2%	10%	14%	8%	23%	42%	100%

Source: PwC analysis of DfE SFR20/2016

The second stage of our assessment is designed to enable us to estimate the costs currently being incurred by secondary schools and the additional costs as schools move closer to achieve fully each of the benchmarks. This involves two steps:

- Estimating what proportion of the costs are currently being incurred by those schools which are fully or partly achieving each of the benchmarks; and
- Determining the additional costs that schools would need to incur if they are to undertake all of the activities implied by the benchmark: we distinguish between the one-off costs (as parts of the benchmark are achieved for the first time) and the recurring costs (as the benchmark is maintained). Within the one-off costs, we consider those related to facilities (i.e. building and equipment costs), staff (recruitment, induction and continuing professional development (CPD)) and policy set-up.

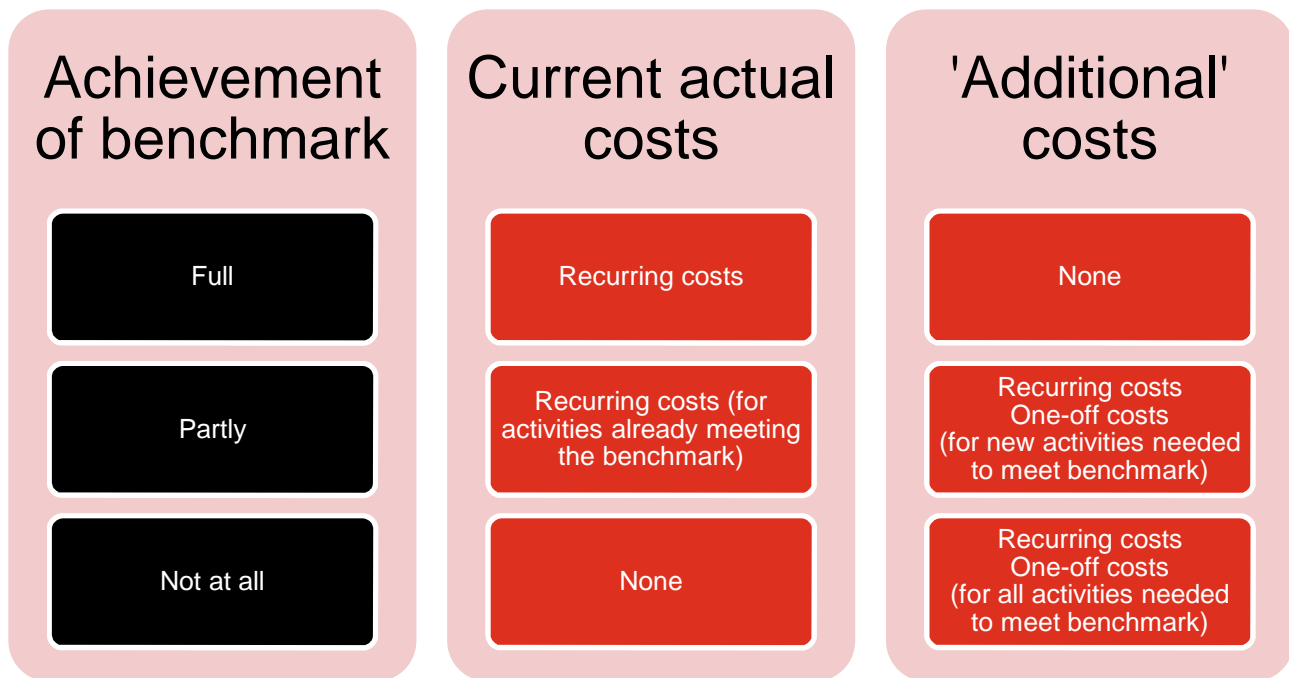
## Interpretation of the cost estimates

Our approach means that we are able to estimate three different costs for each of the benchmarks:

- The **'baseline' costs** which are the hypothetical recurring costs for schools if they undertake all the activities implied by each benchmark;
- The estimated **actual costs** currently being incurred by schools as a result of undertaking some or all of the activities implied by each benchmark which comprise two elements:
  - The recurring costs incurred by any schools which are undertaking **all** of the activities implied by each benchmark;
  - The recurring costs incurred by any schools which are undertaking **some** of the activities implied by each benchmark (i.e. they are partly achieving the benchmark); and
- The estimated **'additional' costs** that we would expect to be borne by those schools which either are not undertaking any of the activities implied by each benchmark or only undertaking some of them as they change their approach so that they undertake all of the activities implied by each benchmark: there are two elements to these costs:
  - The additional recurring costs incurred by schools as they change the way in which they deliver practical science so that they undertake **all** of the activities implied by each benchmark;
  - Any one-off costs as the schools ensure that they have in place the policy, people and laboratory facilities and equipment they need to deliver each benchmark.

Figure 7 summarises the difference between the current actual costs and the additional costs.

Figure 7: Summary of different cost estimates



Our different cost estimates need to be interpreted with some care:

- The **'baseline' costs** reflect how much we believe a school would need to spend on a recurring basis in order to continue to deliver each of the benchmarks of good practice in practical science. Hence, it is a notional measure, not a measure of actual spending. Furthermore, our focus is on the recurring costs rather than any initial (one-off) cost of achieving elements of the benchmark for the first time. In effect, it is an indication of how much a school should be setting aside for practical science if it wants to fulfil Gatsby's benchmarks of good practice. It includes the costs of maintaining a skilled workforce in schools and sustaining adequate laboratory facilities.
- The **actual costs** reflect how much we estimate schools are currently spending on the delivery of each of the benchmarks of good practice in practical science. It includes recurring spending where schools are undertaking all the activities implied by each benchmark as well as recurring spending where a school is only undertaking some of the required activities. In effect, it is a measure of how far schools are incurring the 'baseline' costs.
- The estimated **'additional' costs** reflect how much more schools would need to spend to enable them to fulfil all the obligations implied by the benchmarks. The estimate covers those schools which are not undertaking any of the activities implied by the benchmark as well as those which are already undertaking some (but not all) of them. It includes both the recurring costs and the one-off costs which schools would incur to enable them to meet the implied requirements of the benchmark for the first time, For example, the one-off costs could include:
  - The costs of establishing a policy for practical science teaching for the first time (Benchmark 1) but not the costs of reviewing and updating it which are part of the ongoing recurring costs;
  - The capital costs associated with providing additional laboratory and other project space that schools may need to enable them to meet the requirements (Benchmark 5): where this is the case, we present the cost estimate on both a capital basis and an annualised basis which takes account of the expected length of the life of the asset (so that it is comparable with our recurring cost estimates).
  - The costs of recruiting, inducting and retaining any skilled teaching and technician staff needed to deliver the benchmarks (especially Benchmark 3 and Benchmark 6). Where we identify a need for schools to employ more skilled staff, this does not always mean that the school requires additional

staff, rather it needs more staff with the qualifications and training needed to deliver practical science effectively.

The 'additional costs' do not necessarily mean that schools need to increase their overall expenditure, especially on staff, to undertake all the expected activities. In many cases, schools have the opportunity to reallocate staff time without detracting from pupils' educational experience and achievement, for example by switching time spent on non-practical teaching activities. This means that the underlying burden of fulfilling the Benchmarks is less than the 'additional costs'. Moreover, this burden needs to be compared to the benefits which Gatsby expects achievement of the Benchmarks to bring about.

## *Assumptions*

Our analysis of the cost of delivering the ten benchmarks is underpinned by several general as well as other benchmark specific assumptions. The following general assumptions apply to all ten benchmarks:

- Members of the School Leadership Team (SLT) work, on average, 6 paid hours per day<sup>8</sup>.
- Heads of Department (and Subject Leaders) work on average 6 paid hours per day.
- Technicians work, on average, 37 paid hours per week<sup>9</sup>.
- Class based teachers are contracted to work 1,265 hours over 195 days a year - 190 for pupil contact and five allocated for in-service training.

Our assumptions specific to individual benchmarks are discussed in the relevant Sections of this report below which deal with each of the benchmarks.

In the following Sections we analyse the time and expenses associated with delivery of each benchmark of good practice in practical science.

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<sup>8</sup> Office for National Statistics, Annual Survey of Hours and Earnings, Table 15.9a Paid hours worked – Total – For all employee jobs: United Kingdom, 2013, Provisional data for 'Senior professionals of educational establishments'

<sup>9</sup> Office for National Statistics, Annual Survey of Hours and Earnings, Table 15.9a Paid hours worked - Total - For all employee jobs: United Kingdom, 2013, Provisional data for 'Secretarial and related occupations -School secretaries'.

## 4 *Benchmark 1: Planned practical science*

### *Introduction*

In this Section we assess the potential costs of Benchmark 1. Our analysis is divided into four parts:

- First, we describe what the benchmark requires in terms of who needs to do what to deliver it: this builds on the delivery model discussed in Section 2.
- Second, for each typical school, we consider the unit costs of each of the activities that underpins Benchmark 1 and the number of times these costs can be expected to be incurred over the course of a year if the benchmark is being fully achieved by the school. In doing this, we assume that the school is well established in meeting the benchmark. We also examine how far our cost estimates vary depending on the type and location of the school and we test their sensitivity to our key assumptions.
- Third, we consider how far the benchmark is currently being achieved, largely based on the evidence from a survey of over 400 schools for Gatsby<sup>10</sup>. We use this as a basis for estimating the costs currently being incurred by schools in relation to Benchmark 1. We include those one-off costs which are being incurred as schools establish the benchmark.
- Finally, we consider the additional costs that schools would need to incur to achieve Benchmark 1. These includes the one-off costs as Benchmark 1 is established for the first time as well as the recurring costs.

### *Summary*

*The aim of Benchmark 1 is that every school should develop and maintain a written policy that explains why teachers use practical science, the outcomes they expect from it and how they achieve those outcomes.*

*The only costs associated with Benchmark 1 are staff costs; no expenses are associated with Benchmark 1. We estimate that the total recurring staff costs of implementing all parts of the benchmark would range from £4 per pupil per school year for a large school with a sixth form to £10 per pupil per school year for a small school with no sixth form. These costs, which assume that schools already have a policy for practical science in place, are equivalent to less than 1% of the school's revenue expenditure.*

*We estimate, based on a recent survey for Gatsby, that 13% of schools are currently fully achieving Benchmark 1. These schools would incur no additional costs.*

*Those schools that are only partly achieving Benchmark 1 or not achieving any part of it at all may face additional one-off costs, especially in the first year, primarily because they have to engage staff and develop a policy (if none is in place).*

*Over three quarters of schools (77%) are currently not achieving Benchmark 1 at all. We estimate that if these schools are to achieve Benchmark 1, on average, they would need to incur a one-off cost of £10 per pupil to engage staff and develop a policy and would then face recurring average annual costs of £5 per pupil per school year thereafter.*

*For the 10% of schools that are partly achieving Benchmark 1, we estimate that, on average, they would need to incur a one-off cost of £2 per pupil to engage staff fully on*

<sup>10</sup> Pye Tait consulting (2017), Good Practical Science Benchmark Survey

*their existing policy and then face further recurring costs of £4 per pupil per school year thereafter.*

*The costs associated with Benchmark 1 relate to staff time only. Whether or not they represent additional costs for schools depends upon whether or not staff time can be reallocated to enable staff to complete the activities required by the benchmark. Since the total amount of staff time required to undertake all of the activities associated with Benchmark 1 is relatively small (59 hours per school year or around 5% of the Full Time Equivalent (FTE) for a teacher), we believe this may be possible without significant opportunity cost (by reallocating staff time from other non-teaching activities rather than by recruiting additional members of staff). Thus, schools would not need to increase their overall expenditure.*

## *Delivering the benchmark*

### *What is the benchmark?*

#### ***Vision:***

*Every school and college should have a written policy that explains why teachers use practical science, the outcomes they expect from it and how they achieve those outcomes. The process of producing the policy is as important as the policy itself.*

#### ***Achieving the benchmark means that:***

*The policy should be produced as a collaborative effort by teachers and technicians across the science department.*

*The policy should explain the differences in the approach to practical science between different age groups.*

*The policy should say how special needs are accommodated.*

*The policy should include any use of opportunities for practical science outside the school, in universities, employers, science centres etc.*

*The policy should be annually reviewed against practice.*

*A member of the SLT should provide an overview of practical science.*

### *What activities will be needed to achieve the benchmark?*

We have identified four main groups of activities which we would expect a school delivery team to undertake to achieve Benchmark 1:

- Developing a practical science policy, covering the entire pupil body;
- Reviewing and updating the policy on an annual basis against practice, including identifying opportunities to introduce new or different science practicals;
- Communicating the practical science policy to all relevant stakeholders within the school; and
- Ensuring that practical science benefits from an overview (and support) by a member of the SLT.

We see the development of the practical science policy for the first time as a one-off rather than recurring cost. Once developed, Benchmark 1 envisages that the policy will be reviewed at least annually. This will be a recurring cost. Communication of the policy to staff and the provision of support and an overview of the policy by an SLT member will be recurring activities.

An important part of Gatsby's philosophy in developing the benchmarks is that technicians should be involved in all activities, including development and review of policy.

## Baseline costs

### What are the expected staff costs of achieving the benchmark?

Table 6 shows the estimated time and financial costs associated with delivering Benchmark 1 in a school which is appropriately resourced. Our cost estimate assumes that the school is undertaking all the activities envisaged by the benchmark on an established basis. In practice, this means that we assume it has already developed its policy for practical science for the first time and only needs to review it and then communicate the updated policy.

Our detailed assumptions for each activity are set out in Appendix G.

We estimate that each SLT member would spend three hours per school year at a cost to the school of £196. Each Department Head (and Subject Leader) would spend 17 hours per school year at a cost to the school of £926 and each class based teacher would spend one hour at a cost of £42. There is no estimated technician time in Benchmark 1.

Table 6: Time spent and staff cost of recurring activities needed to achieve Benchmark 1 (Hours per school year per person and £ per school year)

Activity	SLT member	Head of Department (and Subject Leaders)	Class based teachers	Technicians
Review the policy <sup>11</sup>	0	16	1	0
Communicate policy	0	1	0	0
Overview	3	0	0	0
<b>Total hours per role</b>	<b>3</b>	<b>17</b>	<b>1</b>	<b>0</b>
<b>Total employment cost per role (£)</b>	<b>£196</b>	<b>£926</b>	<b>£42</b>	<b>£0</b>

Source: PwC analysis

### What are the expected expenses of achieving the benchmark?

There are no additional expenses associated with the delivery of Benchmark 1 which means that the only relevant recurring costs relate to the cost of staff time described above.

### What is the total baseline costs per school of achieving the benchmark?

As explained above, we examine how school characteristics, notably the number of pupils and the number of year groups taught, influence the estimated cost of achieving Benchmark 1. To do this, we consider six schools with different combinations of these characteristics, which are outlined in Section 3.

Table 7 presents the results of our analysis of the recurring costs of delivering Benchmark 1. It shows how the costs vary between different types of school. For example, the total costs for a large school with pupils across Years 7-13 (School F) are more than double those of a small secondary school with pupils only in Years 7-11 (School A).

The costs per pupil also vary. The larger schools we assess, both with and without Years 12 and 13 (Schools C and F), are able to realise economies of scale as their costs are £5 and £4 per pupil respectively whereas the smallest schools (Schools A and D) incur costs of £10 and £9 respectively.

<sup>11</sup> We assume an annual review of the policy against practice, including identifying opportunities to introduce new or different practical activities.

Table 7: Recurring costs of achieving Benchmark 1 by school size and year groups taught (£ per school year)<sup>12</sup>

School	SLT member	Head of Department (and Subject Leaders)	Class based teachers	Technicians	Expenses	Total average cost	Average cost per pupil
A	£196	£1,851	£85	£0	£0	<b>£2,132</b>	<b>£10</b>
B	£196	£3,703	£169	£0	£0	<b>£4,068</b>	<b>£7</b>
C	£196	£4,629	£338	£0	£0	<b>£5,163</b>	<b>£5</b>
D	£196	£2,777	£127	£0	£0	<b>£3,100</b>	<b>£9</b>
E	£196	£3,703	£338	£0	£0	<b>£4,237</b>	<b>£5</b>
F	£196	£4,629	£549	£0	£0	<b>£5,374</b>	<b>£4</b>
<b>Weighted average cost per pupil</b>							<b>£5</b>

Source: PwC analysis

### How sensitive are the baseline costs to other key assumptions?

In addition to our general assumptions set out in Section 2, the estimated cost of delivering Benchmark 1 is based on the average cost of different teaching staff across England. In practice, we estimate that staff costs are 15% higher in inner London and in the Rest of England (excluding London area) they are 4% lower. The detailed assumptions and calculations which sit behind these figures are included in Appendix B.

### What costs are currently being incurred by schools in relation to the benchmark?

Table 8 summarises how far the different activities associated with delivery of Benchmark 1 are currently undertaken by secondary schools in England based on a recent survey for Gatsby.

Although almost one quarter of schools indicate that they have a written policy, the qualitative evidence suggests that the policy is not always consistent with the principles of Benchmark 1. Likewise, the headline results of the survey may also overstate the extent to which schools review their policy on a regular basis.

Table 8: Proportion of secondary schools currently undertaking activities which are part of Benchmark 1

	% of schools
Schools that have a written policy	23% <sup>13</sup>
Schools with a written policy where the Head(s) of Department, class based teachers and technicians were all involved in its development	31%
Schools that have discussions among the science department team, including all teachers and technicians, as and when required, of:	
• why teachers use practical science, the outcomes they expect from it and how they achieve those outcomes	61%
• the different approaches to practical science in different age groups	55%
• how special needs are accommodated	67%
• use of opportunities for practical science outside the school, in universities, industry, science centres etc.	57%
Schools with a written policy annually reviewing this against practice	68% <sup>14</sup>
Schools with a member of the SLT with an overview of practical science	40%

Source: Pye Tait Consulting (2017) Good Practical Science Benchmark Survey

<sup>12</sup> We exclude one-off costs of engaging staff and developing policy.

<sup>13</sup> This may not always correspond to the benchmark requirements, explained in more detail in report.

<sup>14</sup> We include respondents saying they will review the policy more than once a year.

Table 9 estimates the recurring costs of each activity currently being incurred across all types of secondary schools on a per pupil basis where the school already has a policy in place. It excludes the costs of developing the policy for the first time.

Table 9: Costs per pupil currently incurred by secondary schools in relation to Benchmark 1 (£ per pupil per school year)

Activity	A	B	C	D	E	F	Weighted average cost	% of schools undertaking each activity	Average cost currently incurred
Review the policy <sup>15</sup>	£9	£6	£4	£8	£4	£4	£5	16%	£1
Communicate policy <sup>16</sup>	£1	<£1	<£1	<£1	<£1	<£1	<£1	23%	<£1
Overview	£1	<£1	<£1	<£1	<£1	<£1	<£1	9%	<£1
<b>Total average cost</b>	<b>£11</b>	<b>£6</b>	<b>£4</b>	<b>£9</b>	<b>£4</b>	<b>£4</b>	<b>£5</b>		
<b>Total average costs currently incurred</b>	<b>£2</b>	<b>£1</b>	<b>£1</b>	<b>£1</b>	<b>£1</b>	<b>£1</b>	<b>£1</b>		

Source: PwC analysis

## What are the likely additional costs of all schools achieving the benchmark?

Finally, we consider the additional costs that secondary schools that are not achieving or only partly achieving the benchmark would need to incur to achieve Benchmark 1. These additional costs are split into two components: Firstly, additional one-off costs that a school will only incur once, when it is achieving Benchmark 1 for the first time. Secondly, additional recurring costs that a school will incur every year if they are to continue achieving the benchmark.

Table 10 summarises the time that we expect members of a school staff to need to spend in the first year if they are not achieving Benchmark 1 at all. We estimate this applies to about three quarters of schools (77%). This represents the time required to involve the Department Head, Subject Leaders, class based teachers and technicians in the development of a written policy for practical science. We estimate that each SLT member would spend two hours per school year at a cost to the school of £131. Each Department Head and Subject Leader would spend 32 hours per school year at a cost to the school of £1,744 and each class based teacher would spend two hours at a cost of £85. Each technician is also estimated to spend two hours per year at a cost of £28 to achieve Benchmark 1.

Table 10: Time spent and staff cost of schools that need to develop a practical science policy (Hours per school year per person and £)

Activity	SLT member	Head of Department (and Subject Leaders)	Class based teachers	Technicians
Engage staff and develop a policy <sup>17</sup>	2	32	2	2
<b>Total hours per role</b>	<b>2</b>	<b>32</b>	<b>2</b>	<b>2</b>
<b>Total employment cost per role (£)</b>	<b>£131</b>	<b>£1,744</b>	<b>£85</b>	<b>£28</b>

Source: PwC analysis

Table 11 summarises the average time each member of a school staff would need to spend in the first year if they have partly adopted Benchmark 1. This applies to the 16% of schools that have a written policy, but did not

<sup>15</sup> These are incurred by 68% of the 23% of schools who have a written policy.

<sup>16</sup> We assume that all schools with a written policy (i.e. 23%) communicate that policy to the rest of the department.

<sup>17</sup> We assume that schools will produce a written policy that explains why teachers use practical science, the outcomes they expect from it and how they achieve those outcomes.



involve Department Heads, Subject Leaders, class based teachers and technicians in its development. This represents the time spent engaging the whole science department on the existing written policy.

We estimate that each SLT member would spend two hours per school year at a cost of £131. Each Department Head and Subject Leader would also spend two hours per school year (at a cost of £108) as would each class based teacher (at a cost of £85). Each technician is also estimated to spend two hours per year at a cost of £28 to achieve Benchmark 1.

Table 11: Time spent on activities needed to achieve Benchmark 1 and associated employment cost (Hours per school year per person and £ per school year)

Activity	SLT member	Head of Department (and Subject Leaders)	Class based teachers	Technicians
Engage staff on policy	2	2	2	2
<b>Total hours per role</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>2</b>
<b>Total employment cost per role (£)</b>	<b>£131</b>	<b>£108</b>	<b>£85</b>	<b>£28</b>

Source: PwC analysis

Table 12 presents the results of our analysis for the 77% of schools that are not achieving Benchmark 1 at all. It shows how the cost of delivering Benchmark 1 for the first time varies between different types of school. For example, the total cost for a large school with pupils across Years 7-13 (School F) is more than double that of a small secondary school with pupils only in Years 7-11 (School A).

The costs per pupil also vary. The larger schools, both with and without Years 12 and 13 (Schools C and F), are able to realise economies of scale as their costs are £9 and £7 per pupil respectively whereas the smallest schools (Schools A and D) incur costs of £18 and £16 respectively.

Table 12: One-off costs of achieving Benchmark 1 for schools not achieving the benchmark at all by school size and year groups taught (£ per school)

School	SLT member	Head of Department (and Subject Leaders)	Class based teachers	Technicians	Expenses	Total average cost	Average cost per pupil
A	£131	£3,488	£169	£23	£0	<b>£3,811</b>	<b>£18</b>
B	£131	£6,976	£338	£60	£0	<b>£7,505</b>	<b>£12</b>
C	£131	£8,720	£676	£98	£0	<b>£9,624</b>	<b>£9</b>
D	£131	£5,232	£254	£47	£0	<b>£5,663</b>	<b>£16</b>
E	£131	£6,976	£676	£98	£0	<b>£7,880</b>	<b>£9</b>
F	£131	£8,720	£1,099	£144	£0	<b>£10,093</b>	<b>£7</b>
<b>Weighted average cost per pupil</b>							<b>£10</b>

Source: PwC analysis

Table 13 shows how the cost of delivering Benchmark 1 for the first time, in the 10% of schools that are partly achieving the benchmark varies between different types of school. For example, the total costs for a large school with pupils across Years 7-13 (School F) are more than triple those of a small secondary school with pupils only in Years 7-11 (School A).

The costs per pupil also vary. The larger schools, both with and without Years 12 and 13 (Schools C and F), are able to realise economies of scale as their costs are £1 per pupil whereas the smallest schools (Schools A and D) incur costs of £3 and £2 respectively.

Table 13: One-off costs of achieving Benchmark 1 for schools partly achieving the benchmark by school size and year groups taught (£ per school)

School	SLT member	Head of Department (and Subject Leaders)	Class based teachers	Technicians	Expenses	Total average cost	Average cost per pupil
A	£131	£215	£169	£23	£0	<b>£538</b>	<b>£3</b>
B	£131	£430	£338	£60	£0	<b>£959</b>	<b>£2</b>
C	£131	£538	£676	£98	£0	<b>£1,442</b>	<b>£1</b>
D	£131	£323	£254	£47	£0	<b>£753</b>	<b>£2</b>
E	£131	£430	£676	£93	£0	<b>£1,335</b>	<b>£1</b>
F	£131	£538	£1,099	£144	£0	<b>£1,991</b>	<b>£1</b>
<b>Weighted average cost per pupil</b>							<b>£2</b>

Source: PwC analysis

Table 14 shows the additional recurring and one-off costs associated with achieving Benchmark 1 for schools achieving, partly achieving and not achieving the benchmark.

We estimate, based on the recent survey for Gatsby, that 13% of schools are currently fully achieving Benchmark 1. These schools would not incur any additional costs.

Those schools that are only partly achieving Benchmark 1 or not achieving any part of it at all may face additional one-off costs, especially in the first year, primarily because they have no policy in place.

Over three quarters of schools (77%) are currently not achieving Benchmark 1 at all. We estimate that if these schools are to achieve Benchmark 1, they would need to incur an average one-off cost of £10 per pupil in the first year and would face recurring annual costs of £5 per pupil thereafter.

For the 10% of schools that are partly achieving Benchmark 1, we estimate that, on average, they would need to incur an average one-off cost of £2 per pupil in the first year and then face recurring annual costs of £4 per pupil thereafter.

These costs relate to staff time only. Whether or not they represent additional costs for schools depends upon whether or not staff time can be reallocated to enable the activities to be undertaken in line with the benchmark. Since the amount of time required is relatively small (around 5% of a FTE), we believe this may be possible without significant opportunity cost (rather than by recruiting additional members of staff).

Table 14: Additional costs which would be incurred by secondary schools in relation to Benchmark 1

Achievement of benchmark	% of schools	Achievement of activity	% of schools	Recurring costs currently incurred (£ per pupil per school year)	Additional one-off costs by activity (£ per pupil per school)	Additional recurring costs by activity (£ per pupil per school year)
Not at all	77%	Engage staff and develop a policy	77%	n/a	£10	-
		Communicate policy	77%	n/a	-	<£1
		Oversight	77%	n/a	-	<£1
		Review the policy	77%	n/a	-	£5
Partly	10%	Engage staff on policy (assuming policy already in place)	10%	-	£2	-
		Communicate policy	23%	<£1	-	<£1
		Oversight	10%	<£1	-	<£1

<b>Achievement of benchmark</b>	<b>% of schools</b>	<b>Achievement of activity</b>	<b>% of schools</b>	<b>Recurring costs currently incurred (£ per pupil per school year)</b>	<b>Additional one-off costs by activity (£ per pupil per school)</b>	<b>Additional recurring costs by activity (£ per pupil per school year)</b>
		Review the policy	16%	£1	-	£4
Achieved	13%	Benchmark 1	13%	£5	-	n/a

*Source: PwC analysis*

## 5 *Benchmark 2: Purposeful practical science*

### *Introduction*

In this Section we assess the potential costs of Benchmark 2. We follow a similar structure to the one we use for the other Benchmarks.

### **Summary**

*The aim of Benchmark 2 is that teachers should know the purpose of any practical science activity and it should be planned and executed so it is effective and integrated with other science learning.*

*We estimate that the total recurring costs - staff and expenses - of implementing all parts of the benchmark would range from £117 per pupil per school year in a large school with no sixth form to £182 per pupil per school year in a small school with no sixth form. This is equivalent to 1-2% of the school's revenue expenditure. The vast majority of costs associated with implementing Benchmark 2 (99%) are staff costs; only 1% is expenses, mainly subscription fees for scientific teaching resources.*

*Based on a recent survey for Gatsby, we estimate that all schools are currently either fully achieving (28%) or partly achieving (72%) Benchmark 2. The schools that are fully achieving the benchmark would incur no additional costs.*

*We estimate that, on average, the 72% of schools that are partly achieving Benchmark 2 would incur further recurring costs of £82 per pupil per school year to achieve the benchmark.*

*The further costs associated with implementing Benchmark 2 primarily relate to staff time. How far they represent additional costs for schools depends upon whether or not staff time can be reallocated to enable staff to complete fully all of the activities associated with Benchmark 2.*

*Since the total amount of staff time required to implement the benchmark is limited (461 hours per school year or around one third of an FTE), we believe this may be possible without significant opportunity cost (for example, by reducing the time spent planning non-practical science lessons rather than by recruiting additional members of staff). Thus, schools would not need to incur staff costs which are higher than they currently are.*

### *Delivering the benchmark*

#### *What is the benchmark?*

##### **Vision:**

*Teachers should know the purpose of any practical science activity, and it should be planned and executed so it is effective and integrated with other science learning.*

##### **Benchmark:**

*Teachers should have a clear purpose for every practical activity and know how it relates to the rest of what they are teaching.*

*Teachers should plan how to introduce each practical and how to follow it up.*

*Teachers should take account of pupils' special needs in their planning, so all pupils can participate equally.*

## *What activities will be needed to achieve the benchmark?*

We have identified six main groups of activities which we would expect a school delivery team to undertake if it is to achieve Benchmark 2:

- Planning the practical activities to be covered by each class throughout the school year;
- Using research into effective science education to identify new and/or different practical activities to incorporate into the curriculum;
- Trialling and practicing any new practical activities;
- Explaining the purpose for every practical activity and how it relates to the rest of what they are teaching as part of the science curriculum;
- Planning how to introduce each practical lesson and follow up each lesson, including taking account of any pupils' special needs; and
- Reviewing practical lessons post-delivery to assess whether learning outcomes were achieved and any changes are required.

## *Baseline costs*

### *What are the expected staff costs of achieving the benchmark?*

Table 15 shows the estimated time and financial costs associated with delivering Benchmark 2 in a school which is appropriately resourced. Our cost estimate assumes that the school is undertaking all the activities envisaged by the benchmark on an established basis. We have identified no one-off costs associated with adopting Benchmark 2 for the first time.

Our detailed assumptions for each activity are set out in Appendix G.

We estimate that each Department Head (and Subject Leader) would spend 185 hours per school year at a cost to the school of £9,926 and each class based teacher would spend 206 hours at a cost of £8,707 per teacher. Each technician is estimated to spend 70 hours per year supporting teaching staff at a cost of £986. We do not expect the SLT member to spend any time on delivering this benchmark.

*Table 15: Time spent on recurring activities needed to achieve Benchmark 2 (Hours per school year per person and £ per school year)*

<b>Activity</b>	<b>SLT member</b>	<b>Head of Department (and Subject Leaders)</b>	<b>Class based teachers</b>	<b>Technicians</b>
Plan the practical activities to be covered by each class throughout the year <sup>18</sup>	0	6	6	7
Use research into effective science education to identify new/different practical activities <sup>19</sup>	0	6	1	1
Trial and practice new practical activities <sup>20</sup>	0	9	12	24
Explain the purpose for every practical activity and how it relates to the rest of what they are teaching <sup>21</sup>	0	22	29	0
Lesson planning including how to introduce each practical <sup>22</sup>	0	136	154	38

<sup>18</sup> We assume 1 day per year.

<sup>19</sup> We assume 10 minutes per week for 38 weeks for Subject Leaders.

<sup>20</sup> We assume 1 hour per activity for Subject Leaders and class based teachers and 2 hours per activity for technicians. We also assume 12 new activities per year. We assume that Subject Leaders have 85% of the teaching time of class based teachers.

<sup>21</sup> We assume 5 minutes per practical lesson and 10 practical lessons per week over 38 weeks. We also assume that Subject Leaders have 85% of the teaching time of classroom teachers.

<sup>22</sup> We assume 4 hrs per week (plus 1%) for subject leaders, 4 hrs per week (plus 1%) for classroom teachers over 38 weeks and 1 hour per week for technicians.

Activity	SLT member	Head of Department (and Subject Leaders)	Class based teachers	Technicians
Lesson planning on how to follow up each practical <sup>23</sup>	0	1	2	0
Lesson planning to take account of pupils' special needs <sup>24</sup>	0	1	2	0
Review lesson plan post-delivery <sup>25</sup>	0	1	2	0
<b>Total hours per role</b>	<b>0</b>	<b>185</b>	<b>206</b>	<b>70</b>
<b>Total employment cost per role (£)</b>	<b>£0</b>	<b>£9,926</b>	<b>£8,707</b>	<b>£986</b>

Source: PwC analysis

### What are the expected expenses of achieving the benchmark?

The expenses associated with the delivery of Benchmark 2 include subscription fees for scientific teaching resources to inform research into effective science education to identify new/different practical activities. While there are a range of free resources available to schools we assume these expenses to be £500 per school year on average. This is based on the current annual subscription costs of the Royal Society of Biology's *Journal of Biology Education*, the Royal Society of Chemistry's *Education in Chemistry* and the Institute of Physics' *Physics Education* (i.e. £187, £336 and £390 respectively). As these journals are likely to inform the overall teaching of science, rather than just practical science, we attribute half of their total cost to this benchmark.

### What is the total baseline costs per school of achieving the benchmark?

As explained above, we consider how school characteristics, notably size and the year groups taught, influence the estimated cost of achieving Benchmark 2. To do this, we examine six schools with different combinations of these characteristics.

Table 16 presents the results of our analysis. It shows how the cost of delivering Benchmark 2 varies between different types of school. For example, the total costs for a large school with pupils across Years 7-13 (School F) are more than four times those of a small secondary school with pupils only in Years 7-11 (School A).

The costs per pupil also vary. The larger schools we assess, both with and without Years 12 and 13 (Schools C and F), are able to realise economies of scale as their costs are £117 and £120 per pupil respectively whereas the smallest schools (School A and D) incur costs of £180 and £162 respectively.

Table 16: Recurring costs of achieving Benchmark 2 by school size and year groups taught (£ per school year)

School	SLT member	Head of Department (and Subject Leaders)	Class based teachers	Technicians	Expenses	Total average cost	Average cost per pupil
A	£0	£19,852	£17,414	£822	£500	<b>£38,588</b>	<b>£182</b>
B	£0	£39,704	£34,827	£2,129	£500	<b>£77,160</b>	<b>£124</b>
C	£0	£49,630	£69,655	£3,436	£500	<b>£123,220</b>	<b>£117</b>
D	£0	£29,778	£26,120	£1,643	£500	<b>£58,042</b>	<b>£162</b>
E	£0	£39,704	£69,655	£3,442	£500	<b>£113,301</b>	<b>£125</b>
F	£0	£49,630	£113,189	£5,077	£500	<b>£168,395</b>	<b>£120</b>
<b>Weighted average cost per pupil</b>							<b>£127</b>

Source: PwC analysis

<sup>23</sup> We assume an extra 1% of practical lesson planning time.

<sup>24</sup> We assume an extra 1% of practical lesson planning time.

<sup>25</sup> We assume an extra 1% of practical lesson planning time.

## How sensitive are the baseline costs to other key assumptions?

In addition to our general assumptions set out in Section 2, the estimated cost of delivering Benchmark 1 is based on our estimate of the average cost of different teaching staff across England. In practice, we estimate that staff costs are 15% higher in inner London and in the Rest of England (excluding London area) they are 4% lower. The detailed assumptions and calculations which sit behind these figures are included in Appendix B.

## What costs are currently being incurred by schools in relation to the benchmark?

Table 17 summarises how far the different activities associated with delivery of Benchmark 2 are currently being undertaken by secondary schools in England based on a recent survey for Gatsby<sup>26</sup>.

Table 17: Secondary schools currently achieving Benchmark 2

	% of schools
Schools where all teachers have a clear purpose for every practical activity and know how it relates to the rest of what they are teaching	40%
Teachers plan how to introduce each practical	36%
Teachers plan how to follow up each practical	30%
Teachers take account of pupils' special needs in their planning, so all pupils can participate equally	35%

Source: Pye Tait Consulting (2017) Good Practical Science Benchmark Survey

All schools are undertaking at least some of the activities required by Benchmark 2. We estimate that 28% are undertaking all of Benchmark 2. Table 18 estimates the cost of each activity currently being incurred across all types of secondary schools on a per pupil basis.

Table 18: Costs per pupil currently incurred by secondary schools in relation to Benchmark 2 (£ per pupil per school year)

Activity	A	B	C	D	E	F	Weighted average cost	% of schools undertaking each activity	Average cost currently incurred
Plan the practical activities to be covered by each class throughout the year	£6	£4	£4	£6	£4	£4	£4	40%	£2
Use research into effective science education to identify new/ different practical activities	£4	£3	£2	£3	£2	£2	£2	40%	£1
Trial and practice new practical activities	£11	£8	£7	£10	£8	£8	£8	40%	£3
Explain the purpose for every practical activity and how it relates to the rest of what they are teaching	£23	£15	£15	£20	£16	£15	£16	40%	£6
Lesson planning including how to introduce each practical	£132	£91	£86	£118	£92	£88	£93	36%	£34
Lesson planning on how to follow up each practical	£1	£1	£1	£1	£1	£1	£1	30%	<£1

<sup>26</sup> Pye Tait Consulting (2017) Good Practical Science Benchmark Survey

Activity	A	B	C	D	E	F	Weighted average cost	% of schools undertaking each activity	Average cost currently incurred
Lesson planning to take account of pupils' special needs	£1	£1	£1	£1	£1	£1	£1	35%	<£1
Review lesson plan post-delivery	£1	£1	£1	£1	£1	£1	£1	40%	<£1
<b>Total average cost</b>	<b>£180</b>	<b>£123</b>	<b>£117</b>	<b>£160</b>	<b>£125</b>	<b>£120</b>	<b>£127</b>		
Total average incurred cost	£66	£46	£43	£59	£46	£44	£47		

Source: PwC analysis

## What are the likely additional costs of all schools achieving the benchmark?

Finally, we consider the additional costs that school would need to incur to achieve Benchmark 2.

Table 19 shows the additional recurring costs associated with achieving Benchmark 2 for schools which are not achieving any of the benchmark and those which are partly achieving the benchmark.

No school is not achieving at least some part of the benchmark.

Nearly three quarters of schools (72%) are partly achieving Benchmark 2. We estimate that, on average, these schools would incur further recurring costs of £82 per pupil per school year to achieve the benchmark.

As these costs primarily relate to staff time, whether or not they represent additional costs for schools depends upon whether or not staff time can be reallocated to enable the activities associated with Benchmark 2 to be undertaken in full. Since the amount of time required is small (around one third of an FTE), we believe this may be possible without significant opportunity cost (rather than by recruiting additional members of staff).

Over one quarter of schools (28%) are fully achieving Benchmark 2 and these schools will incur no additional costs.

Table 19: Additional costs which would be incurred by secondary schools in relation to Benchmark 2 (£ per pupil per school year)

Achievement of benchmark	% of schools	Achievement of activity	% of schools	Recurring costs currently incurred (£ per pupil per school year)	Additional one-off costs by activity (£ per pupil per school)
Not at all	0%	Plan the practical activities to be covered by each class throughout the year	60%	n/a	£4
		Use research into effective science education to identify new/ different practical activities	60%	n/a	£2
		Trial and practice new practical activities	60%	n/a	£8
		Explain the purpose for every practical activity and how it relates to the rest of what they are teaching	60%	n/a	£16
		Lesson planning including how to introduce each practical	64%	n/a	£93
		Lesson planning on how to follow up each practical	70%	n/a	£1
		Lesson planning to take account of pupils' special needs	65%	n/a	£1



<b>Achievement of benchmark</b>	<b>% of schools</b>	<b>Achievement of activity</b>	<b>% of schools</b>	<b>Recurring costs currently incurred (£ per pupil per school year)</b>	<b>Additional one-off costs by activity (£ per pupil per school)</b>
Partly	72%	Review lesson plan post-delivery	60%	n/a	£1
		Plan the practical activities to be covered by each class throughout the year	12%	£2	£3
		Use research into effective science education to identify new/ different practical activities	12%	£1	£1
		Trial and practice new practical activities	12%	£3	£5
		Explain the purpose for every practical activity and how it relates to the rest of what they are teaching	12%	£6	£10
		Lesson planning including how to introduce each practical	8%	£34	£60
		Lesson planning on how to follow up each practical	2%	<£1	£1
		Lesson planning to take account of pupils' special needs	7%	<£1	£1
		Review lesson plan post-delivery	12%	<£1	£1
Achieved	28%	Benchmark 2	28%	£127	n/a

Source: PwC analysis

## 6 Benchmark 3: Expert teachers

### Introduction

In this Section we assess the potential costs of Benchmark 3 following the same structure as that used in the other Sections which analyse the estimated costs of other Benchmarks.

### Summary

*The aim of Benchmark 3 is to ensure that teachers have subject specialist training (both initial and continuing) appropriate to the subject (biology, chemistry, physics etc.) and age range they teach, so they can carry out practical science with confidence and knowledge of the underlying principles.*

*We estimate that the total recurring staff costs and expenses associated with implementing all parts of Benchmark 3 would range from £18 per pupil per school year in a large school with a sixth form to £29 per pupil per school year in a small school with no sixth form (or less than 1% of the school's revenue expenditure). These costs are largely staff costs (about 88%) rather than expenses (about 12%). The expenses associated with Benchmark 3 are the cost of advertising vacant posts in local newspapers and fees for continuing professional development (CPD).*

*Based on a recent survey for Gatsby, we estimate that 15% of schools are currently fully achieving Benchmark 3. These schools would incur no additional costs.*

*The vast majority of schools (85%) are partly achieving Benchmark 3. We estimate that, on average, these schools would incur recurring costs of £11 per pupil per school year. They would also incur one-off costs of £3 per pupil as they recruit teachers with the skills and qualifications expected.*

*Almost 90% of the total costs associated with achieving Benchmark 3 are staff time. Whether or not they represent additional costs for schools depends upon whether or not staff time can be reallocated to enable staff to complete the activities required to achieve the benchmark. Since the total amount of staff time required to undertake all of the activities associated with Benchmark 3 is relatively small (82 hours per school year or 6% of an FTE), we believe that this may be possible without significant opportunity cost (by reallocating staff time from non-practical CPD activities rather than by recruiting additional members of staff). Thus, schools would not need to incur staff costs which are higher than they currently are.*

*We see the external costs in a slightly different way: we believe that schools are more likely to need to spend more on CPD and recruitment than they currently do.*

### Delivering the benchmark

#### What is the benchmark?

##### **Vision:**

*Teachers should have had subject specialist training (both initial and continuing) appropriate to the subject (biology, chemistry, physics etc.) and age range they teach, so they can carry out practical science with confidence and knowledge of the underlying principles.*

##### **Benchmark:**

*At post-16 level, teachers should have a post-A level science qualification related to the science subject they teach (biology, chemistry, physics), together with relevant pedagogical training.*

*At pre-16 level, if teachers do not have a post-A level science qualification related to the subject they teach, they should have had sufficient additional training to give them the confidence and subject knowledge to conduct effective practical work at that level.*

*School science departments should review their teacher expertise annually, and ensure that individual needs for continuing professional development, including time for professional reflection, are being met. This should include specific training in practical science.*

## ***What activities will be needed to achieve the benchmark?***

We have identified three main groups of activities which we would expect a school delivery team to undertake if it is to achieve Benchmark 3:

- Review of the level of expertise across the science department teaching staff on at least an annual basis;
- Recruitment and retention of the 'right' school workforce: this includes ongoing activities to deal with natural wastage, for example as teachers change career or retire, as well as specific activities to align the delivery team with the Benchmark, for example by recruiting sufficient teachers with the right qualifications and experience and filling existing vacancies; and
- Provision of appropriate Continuing Professional Development for teaching staff, especially newly qualified teachers (NQTs).

## ***Baseline costs***

### ***What are the expected staff costs of achieving the benchmark?***

Table 20 shows the estimated time and financial costs associated with delivering Benchmark 3 in a school which is appropriately resourced. Our cost estimate assumes that the school is undertaking all the activities envisaged by the benchmark on an established basis. We have identified no one-off costs associated with adopting Benchmark 3 for the first time.

We estimate that each SLT member would spend six hours per school year reviewing teacher expertise at a cost to the school of £423. Each Head of Department and Subject leader would spend 16 hours per school year doing CPD at a cost to the school of £872. Class based teachers would each spend 13 hours per school year on CPD at a cost of £548. There is no technician time associated with Benchmark 3; the costs of the equivalent activities are captured as part of Benchmark 6 (Technical support).

The principal costs to schools of providing CPD are the cost of time that teachers are away from teaching whilst they are doing CPD and any expenses that they may incur whilst doing so. We are aware that some providers offer CPD at no cash cost to schools:

- The National STEM Centre provides an estimated 25% of all science CPD. Its costs are underwritten by central government and other sponsors. In some cases, teachers receive bursaries which cover their expenses but not the cost of the supply teachers if they are needed to substitute for them.
- Some of the awarding bodies have also offered CPD historically at no expense to the school.

In both cases, there are questions about whether such arrangements are likely to be sustainable. Even if they are, schools will continue to face the opportunity cost of teachers' time and/or the need to pay for a replacement supply teacher. Furthermore, some doubts have been raised about whether the CPD gives teachers all the skills they need to deliver practical science in line with the benchmarks.

Table 20: Time spent on recurring activities needed to achieve Benchmark 3 (Hours per school year per person and £ per school year)

Activity	SLT member	Head of Department (and Subject Leaders)	Class based teachers	Technicians
Annual review of teacher expertise <sup>27</sup>	6	0	0	0
Continuing professional development (CPD) <sup>28</sup>	0	16	13	0
<b>Total hours per role</b>	<b>6</b>	<b>16</b>	<b>13</b>	<b>0</b>
<b>Total employment cost per role (£)</b>	<b>£423</b>	<b>£872</b>	<b>£548</b>	<b>£0</b>

Source: PwC analysis

Schools will need to continue to replace those science teachers who leave teaching, for example if they change careers or retire. Table 21 summarises our estimates of the cost of recruiting a specialist science teacher. We assume that schools will face the cost of replacing teachers who leave through natural wastage on a recurring basis every year.

In addition, where schools have existing vacancies or where their teachers do not have the qualifications and experience implied by Benchmark 3, they will need to either recruit additional teachers or provide additional subject specific CPD to the non-specialist teachers. Either way we treat the associated staff costs as one-off.

Appendix H provides further details of how we assess these costs.

Table 21: Estimated cost of recruiting and inducting each science teacher across all secondary schools (Hours per school year per person and £ per school year)

	SLT member	Subject leaders	Class based teachers	Technicians	Total average cost
Hours required for each recruitment & induction	6	6	6	1	
<b>Cost of each recruitment &amp; induction (£)</b>	<b>£423</b>	<b>£349</b>	<b>£274</b>	<b>£14</b>	<b>£1,060</b>

Source: PwC analysis

Where schools recruit Newly Qualified Teachers (NQTs) rather than experienced teachers, we expect them to provide additional initial support for these teachers. We assume that each NQT would spend 26 hours per school year at a cost to the school of £1,096 on CPD (see Table 22).

Table 22: Time spent on recurring activities needed to achieve Benchmark 3 (Hours per school year per Newly Qualified Teacher and £ per school year)

Activity	SLT member	Head of Department (and Subject Leaders)	Class based teachers	Technicians
CPD for NQTs <sup>29</sup>	0	0	26	0
<b>Total hours per NQT</b>	<b>0</b>	<b>0</b>	<b>26</b>	<b>0</b>
<b>Total employment cost per NQT (£)</b>	<b>£0</b>	<b>£0</b>	<b>£1,096</b>	<b>£0</b>

Source: PwC analysis

<sup>27</sup> We assume 1 day.

<sup>28</sup> We assume 2.5 days for subject leaders and 2 days for class based teachers.

<sup>29</sup> We assume 4 days per NQT.

### *What are the expected expenses of achieving the benchmark?*

The expenses associated with the delivery of Benchmark 3 are the cost of advertising for a teaching vacancy and providing health and safety inductions/checks once a vacancy is filled. We estimate that the cost of advertising one vacancy in the TES would be £975. With the cost of staff time associated with providing health and safety checks and induction at £1,060 per vacancy, the total cost to a school is £2,035 per vacancy.

### *What is the total baseline costs of achieving the benchmark?*

As explained above, we consider how school characteristics, notably the number of pupils and the number of year groups taught, influence the estimated cost of achieving Benchmark 3. To do this, we examine six schools with different combinations of these characteristics.

Table 23 presents the results of our analysis. It shows how the average cost of delivering Benchmark 3 varies between different types of school. For example, the total costs for a large school with pupils across Years 7-13 (School F) are more than three times those of a small secondary school with pupils only in Years 7-11 (School A).

The costs per pupil also vary. The larger schools we assess, both with and without Years 12 and 13 (Schools C and F), are able to realise economies of scale as their costs are both £18 per pupil whereas the smallest schools (School A and D) incur costs of £29 and £25 respectively.

Table 23: Recurring costs of achieving Benchmark 3 by school size and year groups taught (£ per school year)

School	SLT member	Head of Department (and Subject Leaders)	Class based teachers	Technicians	Total - annual review and CPD	Recruitment and NQT training cost	Total average cost	Average cost per pupil
A	£423	£2,494	£1,696	£0	£4,614	£1,567	£6,180	£29
B	£423	£4,988	£3,393	£0	£8,804	£3,133	£11,938	£19
C	£423	£6,235	£6,786	£0	£13,444	£5,092	£18,536	£18
D	£423	£3,741	£2,545	£0	£6,709	£2,350	£9,059	£25
E	£423	£4,988	£6,786	£0	£12,197	£4,700	£16,897	£19
F	£423	£6,235	£11,027	£0	£17,685	£7,050	£24,735	£18
<b>Weighted average cost per pupil</b>								<b>£19</b>

Source: PwC analysis

### *How sensitive are the baseline costs to the key assumptions?*

In addition to our general assumptions set out in Section 2, the estimated cost of delivering Benchmark 3 is based on our estimate of the average cost of different teaching staff across England. In practice, we estimate that staff costs are 15% higher in inner London and in the Rest of England (excluding London area) they are 4% lower. The detailed assumptions and calculations which sit behind these figures are included in Appendix B.

### *What costs are currently being incurred by schools in relation to the benchmark?*

Table 25 summarises how far the different activities associated with delivering Benchmark 3 are currently undertaken by secondary schools in England based on a recent survey for Gatsby<sup>30</sup>. It shows that just over one third of schools undertake an annual review of all teachers' training and development needs. Furthermore, less than one quarter of schools (22%) offer all teachers regular training specific to practical science.

Evidence on the skills and qualification of teachers comes from both the survey and from official statistics published by the Department for Education. Our interpretation of these data is explained in Appendix H. Both

<sup>30</sup> Pye Tait Consulting (2016) Good Practical Science Benchmark Survey.

sources suggest that the majority of schools, if not all, of them need more science teachers with the right qualifications and experience than they currently have.

Table 24: Secondary schools currently achieving Benchmark 3

	% of schools
Schools where all science teachers have annual reviews of training and development needs in relation to practical science	35%
Schools where all science teachers have regular training specific to practical science	22%
Schools where all teachers at post-16 level have a post-A level science qualification related to the science subject they teach (biology, chemistry, physics)	75%
Schools where all teachers at post-16 level have relevant pedagogical training relevant to their specialist subject	57%
Schools where all teachers at pre-16 level, if they do not have a post-A level science qualification related to the subject they teach, have had sufficient additional training to give them the confidence and subject knowledge to conduct effective practical work at that level	39%
Schools where all science teachers have time for professional reflection with colleagues where so required	39%

Source: Pye Tait Consulting (2016) Good Practical Science Benchmark Survey

Table 26 estimates the average cost per school year of each activity currently being incurred across all six types of secondary schools on a per pupil basis.

Table 25: Costs currently incurred by secondary schools in relation to Benchmark 3 (£ per pupil per school year)

Activity	A	B	C	D	E	F	Weighted average cost	% of schools undertaking currently each activity	Average cost currently incurred
Annual review of teacher expertise	£2	£1	£0	£1	£0	£0	£1	35%	£0
Continuing professional development (CPD) for existing teachers	£20	£13	£12	£18	£13	£12	£13	22%	£3
Recruitment (including health and safety induction/checks for new teachers)	£4	£3	£3	£4	£3	£3	£3	100%	£3
CPD for NQTs	£3	£2	£2	£3	£2	£2	£2	100%	£2
<b>Total average cost</b>	<b>£29</b>	<b>£19</b>	<b>£18</b>	<b>£25</b>	<b>£19</b>	<b>£18</b>	<b>£19</b>		
<b>Total average cost currently incurred</b>	<b>£12</b>	<b>£8</b>	<b>£8</b>	<b>£11</b>	<b>£8</b>	<b>£8</b>	<b>£9</b>		

Source: PwC analysis

## What are the likely additional costs of all schools achieving the benchmark?

Finally, we consider the additional costs that schools would need to incur to achieve Benchmark 3.

We estimate that 15% of schools are currently fully achieving Benchmark 3. These schools would incur no additional costs.

The vast majority of schools (85%) are partly achieving Benchmark 3. We estimate that, on average, these schools would incur recurring annual costs of £11 per pupil.

All schools, therefore, are achieving at least some part of the benchmark.

Although approximately three quarters of these costs are staff time, they represent a small proportion of staff time for an average school (6% of an FTE). For this reason, we believe that schools may be able to reallocate

staff time from other non-practical activities rather than recruiting additional members of staff. Thus, schools would not need to incur additional staff costs.

We see the external costs in a slightly different way: we believe they are more likely to need additional expenditure on CPD and recruitment.

Table 26: Additional costs which would be incurred by secondary schools in relation to Benchmark 3

Achievement of benchmark	% of schools	Achievement of activity	% of schools	Recurring costs currently incurred (£ per pupil per school year)	Additional one-off costs by activity (£ per pupil per school)	Additional recurring costs by activity (£ per pupil per school year)
Not at all	0%	Annual review of teacher expertise	22%	n/a	-	£1
		Continuing professional development (CPD) for existing teachers	18%	n/a	-	£13
		Recruitment (including health and safety induction/checks for new teachers)	0%	n/a	£3	<£1
		CPD for NQTs	0%	n/a		£2
Partly	85%	Annual review of teacher expertise	63%	<£1	-	<£1
		Continuing professional development (CPD) for existing teachers	67%	£3	-	£10
		Recruitment (including health and safety induction/checks for new teachers)	85%	£3	£3	<£1
		CPD for NQTs	85%	£2		<£1
Achieved	15%	Benchmark 3	15%	£19	n/a	n/a

Source: PwC analysis

## 7 *Benchmark 4: Frequent and varied practical science*

### *Introduction*

In this Section we assess the potential costs of Benchmark 4. We follow a similar same structure to the one used in the other Sections which analyse the estimated costs of other Benchmarks.

### *Summary*

*The aim of Benchmark 4 is for pupils to experience a practical activity in at least half of their science lessons: the activities can be short and may not last the whole lesson, but should be varied in type.*

*There are two activities as part of this benchmark: lesson delivery and, for schools with a sixth form, provision of a field trip for Key Stage 5 (KS5) pupils studying biology.*

*The only recurring costs of delivering practical science in at least half of all science lessons are staff costs; the cost of laboratories, equipment and consumable resources are captured in Benchmark 5 and the cost of technical support is covered by Benchmark 6. We estimate that the recurring costs of delivering this part of the benchmark would range from £105 per pupil per school year in a large school with a sixth form to £164 per pupil per school year in a small school with no sixth form (or about 2% of the school's revenue expenditure).*

*Using a recent survey for Gatsby, we estimate that 6% of schools are currently delivering practical science in at least half of their science lessons. These schools would incur no additional costs for implementing this element of the benchmark.*

*Over three quarters of schools are partly achieving Benchmark 4 (77%). We estimate that, on average, these schools would face further recurring costs of £64 per pupil per school year to deliver practical science in at least half of their science lessons.*

*The remaining 17% of schools are not meeting the benchmark at all. We estimate that, on average, these schools would face recurring costs of £113 per pupil per school year.*

*The costs of delivering practical science in at least half of all science lessons relate to staff time only. Whether or not they represent additional costs for schools depends upon whether or not staff time can be reallocated to enable staff to complete the activities required to achieve the benchmark. In the case of Benchmark 4, we would expect that if a teacher is not delivering a practical science lesson then they would be spending the majority (if not all) of their time delivering non-practical science lessons. This implies that schools would not need to incur additional recruit additional science teaching staff.*

*Furthermore, since the total amount of staff time required to undertake all of the activities associated with Benchmark 4 is relatively small (395 hours per school year or about one third of an FTE), we believe that schools may be able to reallocate this time in such a way that there is no significant opportunity cost (by replacing some of the time spent on non-practical science with more time for practical science activities rather than by recruiting additional members of staff). Thus, schools would not need to increase their spending on staff.*

*Schools with sixth forms offering KS5 biology would also face the recurring costs of providing a field trip. We estimate that these costs would range from £1 per pupil per*



*school year in a large school with a sixth form to £2 per pupil per school year in a small school with a sixth form. Around 40% of these costs are staff costs and the remainder (60%) is expenses. The expenses are largely transport costs associated with facilitating biology field trips.*

*The preliminary findings from BES research suggest that about 60% of schools are providing biology field trips at KS5. These schools would incur no additional costs associated with providing biology field trips at KS5. The remaining 40% are not providing biology field trips at KS5. On average, these schools would face additional recurring costs of £1 per pupil per school year.*

## *Delivering the benchmark*

### *What is the benchmark?*

#### ***Vision:***

*Pupils should experience a practical activity in at least half of their science lessons. These activities can be short, but should be varied in type.*

#### ***Benchmark:***

*On average, across the year and across all the sciences, at least half of lessons should involve direct practical activities, whether hands-on or teacher demonstration.*

*Practical activities can be short or long. There should be enough long science lessons (of at least 50 minutes) in the timetable to give teachers flexibility about when they do experiments.*

*Practical activities should be varied and balanced in type, including investigations, projects, collaborative research, experiments to confirm theory, experiments to show phenomena, and practising techniques.*

### *What activities will be needed to achieve the benchmark?*

The key activity associated with Benchmark 4 is the delivery of frequent and varied practical science lessons on the scale envisaged by the Benchmark.

In practice, it is difficult to distinguish from some of the activities needed to achieve Benchmark 9 (A balanced approach to risk) and Benchmark 10 (Assessment fit for purpose), especially the formative assessment element. This means that the costs associated with each of these benchmarks are best considered together.

## *Baseline costs*

### *What are the expected staff costs of achieving the benchmark?*

Table 27 shows the estimated time and financial costs associated with delivering Benchmark 4 in a school which is appropriately resourced. Our cost estimate assumes that the school is undertaking all the activities envisaged by the benchmark on an established basis. We have identified no one-off costs associated with adopting Benchmark 4 for the first time.

Our detailed assumptions for each activity are set out in Appendix G.

Overall, we estimate that each Head of Department and Subject Leader would spend 182 hours per school year at a cost to the school of £9,807 and each class based teacher would spend 181 hours per school year at a cost of £7,660. Each technician would each spend 45 hours per year at a cost to the school of £636. We do not expect the SLT member to spend any time on delivering this benchmark.

Schools with a sixth form teaching KS5 biology will also incur staff costs associated with providing a one day field trip for pupils. These costs will be equivalent to one day of staff time for every 20 pupils studying KS5 biology in Year 12. We estimate that each class based teacher would spend six hours per school year at a cost of £274 and that each technician would spend seven hours per school year for larger groups (i.e. 20-40 pupils) at a cost of £104.

Table 27: Time spent on recurring activities needed to achieve Benchmark 4 (Hours per school year per person and £)

Activity	SLT member	Head of Department (and Subject Leaders)	Class based teachers	Technicians
Lesson delivery <sup>31</sup>	0	182	175	38
KS5 biology field trip	0	0	6	7
<b>Total hours per role</b>	<b>0</b>	<b>182</b>	<b>181</b>	<b>45</b>
<b>Total employment cost per role (£)</b>	<b>£0</b>	<b>£9,807</b>	<b>£7,660</b>	<b>£636</b>

Source: PwC analysis

### What are the expected expenses of achieving the benchmark?

The primary expenses associated with the delivery of Benchmark 4 are coach hire to transport the staff and KS5 pupils to the field trip location. We estimate that these costs would be £450 for a 25 seater coach or £550 for a 45 seater coach.<sup>32</sup>

### What is the total baseline costs of achieving the benchmark?

As explained above, we consider how school characteristics, notably the number of pupils and the number of year groups taught, influence the estimated cost of achieving Benchmark 4. To do this, we examine six schools with different combinations of these characteristics.

Table 28 presents the results of our analysis. It shows how the cost of delivering Benchmark 4 varies between different types of school. For example, the total costs for a large school with pupils across Years 7-13 (School F) are more than four times those of a small secondary school with pupils only in Years 7-11 (School A).

The annual costs per pupil also vary. The larger schools we assess, both with and without Years 12 and 13 (Schools C and F), are able to realise economies of scale as their costs are £104 and £106 per pupil respectively whereas the smallest schools (School A and D) incur costs of £164 and £148 respectively.

Table 28: Recurring costs of achieving Benchmark 4 by school size and year groups taught (£ per school year)

School	SLT member	Head of Department (and Subject Leaders)	Class based teachers	Technicians	Expenses	Total average cost	Average cost per pupil
A	£0	£19,614	£14,771	£444	£0	<b>£34,829</b>	<b>£164</b>
B	£0	£39,227	£29,543	£1,149	£0	<b>£69,919</b>	<b>£113</b>
C	£0	£49,034	£59,086	£1,854	£0	<b>£109,974</b>	<b>£104</b>
D	£0	£29,420	£22,431	£887	£450	<b>£53,189</b>	<b>£148</b>
E	£0	£39,227	£59,360	£1,961	£450	<b>£100,999</b>	<b>£112</b>
F	£0	£49,034	£96,288	£2,844	£550	<b>£148,716</b>	<b>£106</b>
<b>Weighted average recurring cost per pupil</b>							<b>£112</b>

Source: PwC analysis

### How sensitive are the baseline costs to the key assumptions?

In addition to our general assumptions set out in Section 2, the estimated cost of delivering Benchmark 4 is based on our estimate of the average cost of different teaching staff across England. In practice, we estimate that staff costs are 15% higher in inner London and in the Rest of England (excluding London area) they are 4% lower. The detailed assumptions and calculations which sit behind these figures are included in Appendix B.

<sup>31</sup> This includes risk management by teachers and explanation of risks to pupils, but excludes time spent on formative assessment.

<sup>32</sup> This is based on quotes received for a 40 mile round trip (Source: Richmond's Coaches and Kings Ferry).

## What costs are currently being incurred by schools in relation to the benchmark?

Table 29 summarises how far the different activities associated with delivery of Benchmark 4 are currently undertaken by secondary schools in England based on a recent survey for Gatsby<sup>33</sup>. It shows the proportion of secondary schools where over half of the lessons involve practical activities. The variation by subject and Key Stage is evident.

In addition, preliminary findings from BES research show that 60% of secondary schools provide a one day field trip during KS5 for pupils studying biology.

Table 29: Secondary schools currently achieving Benchmark 4

	% of schools
Schools where all science lessons are at least 50 minutes long	88%
Schools where on average, across the year and across all the sciences, at least half of lessons involve direct practical activities, whether hands-on or teacher demonstration	
<ul style="list-style-type: none"> <li>• Key Stage 3 science</li> <li>• Key Stage 4 biology</li> <li>• Key Stage 4 chemistry</li> <li>• Key Stage 4 physics</li> <li>• Key Stage 4 applied science</li> <li>• Post-16 biology</li> <li>• Post-16 chemistry</li> <li>• Post-16 physics</li> <li>• Post-16 applied science</li> </ul>	68% 33% 55% 47% 24% 17% 33% 29% 39%
Schools where practical activities include investigations, projects, collaborative research, experiments to confirm theory, experiments to show phenomena, and practising techniques	
<ul style="list-style-type: none"> <li>• Pre-16 sciences</li> <li>• Post-16 sciences</li> </ul>	33% 35%

Source: Pye Tait Consulting (2016) Good Practical Science Benchmark Survey

Table 30 estimates the cost of each activity currently being incurred across all types of secondary schools on a per pupil basis.

Table 30: Costs currently incurred by secondary schools in relation to Benchmark 4 (£ per pupil per school year)

Activity	A	B	C	D	E	F	Weighted average cost	% of schools undertaking each activity	Average cost currently incurred
KS3 science	£62	£49	£47	£42	£35	£36	£42	68%	£28
KS4 biology	£11	£6	£5	£5	£4	£3	£5	33%	£2
KS4 chemistry	£11	£6	£5	£5	£4	£3	£5	55%	£3
KS4 physics	£11	£6	£5	£5	£4	£3	£5	47%	£2
KS4 combined	£69	£46	£42	£46	£33	£32	£39	24%	£9
KS5 biology	n/a	n/a	n/a	£15	£11	£10	£6	17%	£1
KS5 chemistry	n/a	n/a	n/a	£15	£11	£10	£6	33%	£2
KS5 physics	n/a	n/a	n/a	£15	£11	£7	£5	29%	£2
KS5 combined <sup>34</sup>	n/a	n/a	n/a	n/a	n/a	n/a	n/a	39%	n/a

<sup>33</sup> Pye Tait Consulting (2016) Good Practical Science Benchmark Survey.

<sup>34</sup> This costs is captured within the single subjects (i.e. biology, chemistry and physics).

Activity	A	B	C	D	E	F	Weighted average cost	% of schools undertaking each activity	Average cost currently incurred
Biology field trip (schools with sixth form only)	n/a	n/a	n/a	£2	£1	£1	£1	60%	£0
<b>Total average costs</b>	<b>£164</b>	<b>£113</b>	<b>£104</b>	<b>£148</b>	<b>£112</b>	<b>£106</b>	<b>£114</b>	<b>43%</b>	<b>£49</b>

Source: PwC analysis

## What are the likely additional costs of all schools achieving the benchmark?

Finally, we consider the additional costs that schools would need to incur to achieve Benchmark 4. We consider the costs of lesson delivery separately from those of biology field trips.

Table 31 shows the additional recurring costs associated with achieving Benchmark 4 for schools not achieving and partly achieving the benchmark. Also shown are the costs already being incurred by the 6% of schools already fully achieving the lesson delivery element of the benchmark; these schools face no additional costs as do the 60% of schools offering biology field trips.

Over three quarters of schools are partly achieving Benchmark 4 (77%). We estimate that, on average, these schools would face recurring annual costs of £64 per pupil.

The remaining 17% of schools are not meeting the benchmark at all. We estimate that, on average, these schools would face recurring annual costs of £113 per pupil. These costs primarily relate to staff time, and are the equivalent of about one third of an FTE. We believe, therefore, that schools may be able to reallocate time in such a way that there is no significant opportunity cost. This would avoid the expense of recruiting additional members of staff.

Schools with sixth forms offering KS5 biology would also face the recurring costs of providing a field trip. The preliminary findings from the BES research suggest that about 60% of schools are currently providing biology field trips at KS5. The other 40% that are not would face recurring annual costs of £1 per pupil. Around 40% of these costs are staff costs and the remainder (60%) is expenses. We would expect the expenses to be additional.

Table 31: Additional costs which would be incurred by secondary schools in relation to Benchmark 4

Achievement of benchmark	% of schools	Achievement of activity	% of schools	Recurring costs currently incurred (£ per pupil per school year)	Additional recurring costs by activity (£ per pupil per school year)
Not at all	17%	KS3 science	32%	n/a-	£42
		KS4 biology	77%	n/a	£5
		KS4 chemistry	45%	n/a	£5
		KS4 physics	53%	n/a	£5
		KS4 combined	76%	n/a	£39
		KS5 biology	83%	n/a	£6
		KS5 chemistry	77%	n/a	£6
		KS5 physics	71%	n/a	£5
		KS5 combined	61%	n/a	£0
				Biology field trip (schools with sixth form only)	40%
Partly	77%	KS3 science	62%	£28	£13
		KS4 biology	27%	£2	£3
		KS4 chemistry	49%	£3	£2
		KS4 physics	41%	£2	£2

<b>Achievement of benchmark</b>	<b>% of schools</b>	<b>Achievement of activity</b>	<b>% of schools</b>	<b>Recurring costs currently incurred (£ per pupil per school year)</b>	<b>Additional recurring costs by activity (£ per pupil per school year)</b>
		KS4 combined	18%	£9	£30
		KS5 biology	11%	£1	£5
		KS5 chemistry	27%	£2	£4
		KS5 physics	23%	£2	£4
		KS5 combined	33%	<£1	<£1
	40%	Biology field trip (schools with sixth form only)	40%	<£1	<£1
Achieved	6%	Lesson delivery	6%	£113	n/a
	60%	Biology field trip (schools with sixth form only)	60%	£1	n/a

Source: PwC analysis

# 8 Benchmark 5: Laboratory facilities and equipment

## Introduction

In this Section we assess the potential costs of Benchmark 5. We follow a structure which is consistent with that used in the other Sections which analyse the estimated costs of other Benchmarks.

### Summary

*The aim of Benchmark 5 is that every school should have enough laboratories to make it possible for every teacher to do frequent practical science safely with sufficient equipment for pupils to work in small groups. This includes having an accessible outdoor space which can be used.*

*The primary costs associated with Benchmark 5 are expenses which cover the development and maintenance of laboratories, the equipment used in the laboratories and the consumables used during practical lessons. We estimate that the total recurring costs associated with Benchmark 5 and expressed on an annualised basis would range from £53 per pupil per school year in a large school with a sixth form to £77 per pupil per school year in a small school with no sixth form (or 1-2% of the school's revenue expenditure).*

*Based on a recent survey for Gatsby, we estimate that all schools are currently either fully achieving (8%) or partly achieving (92%) Benchmark 5. The schools that are fully achieving the benchmark would incur no additional costs.*

*The vast majority of schools (92%) are partly achieving Benchmark 5. We estimate that for these schools to fully achieve the benchmark they would incur further recurring costs – expressed on an annualised basis - of £37 per pupil per school year. These costs primarily relate to the costs of developing facilities and purchasing equipment, however, a small proportion (£2 per pupil per school year or c.5%) would be related to purchasing consumable resources for use in practical activities (e.g. chemicals). We believe that the cost of more consumables would be additional for schools that are partly achieving Benchmark 5.*

*The position with respect to accessible outdoor space is slightly different. Those schools without such access would incur the cost of the additional staff time needed to accompany pupils to a suitable space outside the school. We estimate this additional staff cost would be approximately £1 per pupil per annum, but could potentially be accommodated without the need to recruit additional staff and, hence, incur extra cost.*

## Delivering the benchmark

### What is the benchmark?

#### **Vision:**

*All schools should have enough laboratories to make it possible for every teacher to do frequent practical science safely and each laboratory should have sufficient equipment for pupils to work in small groups.*

#### **Benchmark:**

*There should be enough laboratories so that the availability of laboratories is never a barrier to carrying out practical activities in the science subjects taught.*

*Laboratories should be large enough to safely accommodate the size of classes that will occupy them.*

*The spaces should be flexible enough to allow pupils to work individually, in pairs and in small groups.*

*There should be sufficient equipment to make it possible for teachers to do standard practical activities expected in their specialist subject at that level.*

*Teachers should have ready access to the technology required to enable collection and analysis of digital data.*

*There should be a preparation space or spaces with well-organised, safe storage with easy access to laboratories.*

*The school should have laboratory facilities such that pupils can carry out extended practical science investigations (see Benchmark 8).*

*Laboratories should be accessible to pupils with any Special Educational Needs and Disabilities (SEND) encountered in the school.*

*There should be an accessible outdoor space where practical activities can take place.*

## ***What activities will be needed to achieve the benchmark?***

Benchmark 5 primarily relates to the costs associated with providing laboratory facilities and equipment for practical science in secondary schools in England. We have identified five main types of cost that we would expect a school to incur to achieve Benchmark 5:

- The costs of developing new laboratory facilities, including suitable preparation and storage space;
- The costs of laboratory equipment (e.g. microscopes, Bunsen burners and power packs);
- The costs of maintaining the laboratory facilities and equipment (e.g. servicing microscopes and balances);
- The costs of the consumable resources associated with practical science (e.g. chemicals, batteries and glassware); and
- Any costs associated with providing access to an outdoor space (if one is not available at the school).

## ***Baseline costs***

### ***What are the expected capital costs of achieving the benchmark?***

We consulted advisers with experience of developing and operating school laboratories to identify the capital costs associated with achieving Benchmark 5. These consultations identified four main elements that contribute to the cost of developing new laboratory facilities:

- The cost of developing the laboratories, including installing workbenches, storage, ventilation and gas, water and electricity points;
- The cost of developing a preparation room including installing workspace, storage, ventilation and gas, water and electricity points;
- The cost of installing a fume cupboard(s) and ducting; and
- The cost of developing additional laboratories to accommodate smaller class sizes/ extended practical science investigations for schools with a sixth form.

Table 32 estimates the capital costs of providing the required laboratory facilities in each of the six representative school types. The table shows how many facilities of each type are needed in each school and the estimated unit cost of each facility. The cost of developing facilities is largely driven by school size, with the cost of developing facilities in a large school with pupils across Years 7-13 (School F) more than double that of a small school with pupils across Years 7-13 (School D). Larger schools are, however, able to realise significant economies of scale as their costs per pupil are £448 compared to £703 for the smallest school.

We assume that the lifetime of the facilities is 20 years.

Table 32: Capital costs of developing laboratory facilities for achieving Benchmark 5 by school size and year groups taught

Facility	Laboratory	Preparation room	Fume cupboard	Sixth form/project laboratory	Development costs (£ per school year)	Average cost per pupil (£ per school year)
<b>Unit cost (£)</b>	£37,500	£30,000	£4,125	£37,500		
<b>Units per school</b>						
A	2	3	1	0	<b>£169,125</b>	<b>£798</b>
B	7	3	1	0	<b>£356,625</b>	<b>£574</b>
C	12	3	1	0	<b>£544,125</b>	<b>£517</b>
D	3	3	3	1	<b>£252,375</b>	<b>£703</b>
E	8	3	3	1	<b>£439,875</b>	<b>£487</b>
F	13	3	3	1	<b>£627,375</b>	<b>£448</b>

Source: PwC analysis based on consultations with CLEAPSS and Innova

We consulted equipment suppliers to determine the costs associated with purchasing laboratory equipment. On this basis, we estimated the average cost and expected lifespan of each individual item of equipment. We then estimated an annualised cost per item by dividing the cost of each item by its expected lifespan. Next we grouped the individual items into different categories of laboratory equipment:

- Class sets of standard items (e.g. goggles, clamps, Bunsen burners, tripods);
- Subject specific equipment for use by pupils in Key Stage 3 and 4 (e.g. microscopes, balances and power packs) and Key Stage 5 (e.g. micrometer eye pieces, burette flasks and light gates); and
- Shared items required to deliver practical science in Key Stage 3 and 4 (e.g. autoclave, hot plate stirrer, vacuum pump and data loggers) and Key Stage 5 (e.g. electrophoresis, jointed glassware, radioactive sources).

Table 33 shows the estimated annualised unit cost of each category. The cost of purchasing equipment is largely driven by school size, with the total costs of equipment in a large school with pupils across Years 7-13 (School F) more than three times those of a small school with pupils across Years 7-13 (School D). It also shows that medium and large schools are able to realise economies of scale.

Further details of how the cost estimate are derived can be found in Appendix F.

Table 33: Annualised capital costs of purchasing laboratory equipment to achieve Benchmark 5 by school size and year groups taught (£ per school year)

Category	Class set of standard items	Subject specific equipment for KS3&4	Subject specific equipment for KS5	Shared items for KS3&4	Shared items for KS5	Total average cost per school	Average cost per pupil
<b>Unit cost per year (£)</b>	£1,750	£1,300	£1,050	£1,750	£1,750		
<b>Cost per school per year (£)</b>							
A	£3,500	£1,300	£0	£1,750	£0	<b>£6,550</b>	<b>£31</b>
B	£12,250	£3,033	£0	£1,750	£0	<b>£17,033</b>	<b>£27</b>
C	£21,000	£5,200	£0	£1,750	£0	<b>£27,950</b>	<b>£27</b>
D	£5,250	£1,300	£1,050	£1,750	£1,750	<b>£11,100</b>	<b>£31</b>
E	£14,000	£3,467	£2,800	£1,750	£1,750	<b>£23,767</b>	<b>£26</b>
F	£22,750	£5,633	£4,550	£1,750	£1,750	<b>£36,433</b>	<b>£26</b>

Source: PwC analysis based on consultations with Breckland, Philip Harris, SLS

Our consultations indicated that the maintenance costs associated with the laboratory facilities are negligible, within the 20 year lifespan of these facilities. The costs associated with maintaining the equipment are shown in



Table 34. These have been annualised (i.e. we divide the estimated maintenance cost by the frequency with which it is maintained). Class sets are not expected to incur any maintenance costs.

Table 34 shows that maintenance costs are largely driven by school size. The total cost per year of maintaining equipment in a large school with pupils across Years 7-13 (School F) is more than three times that of a small school with pupils across Years 7-13 (School D). The costs per pupil per school year are, however, similar across the six schools.

Table 34: Annualised costs of maintaining equipment for achieving Benchmark 5 by school size and year groups taught (£ per school year)

Category	Subject specific equipment for KS3&4 (per school)	Subject specific equipment for KS5 (per school)	Shared items for KS3&4 (per school)	Shared items for KS5 (per school)	Total average costs per school	Average cost per pupil
<b>Unit cost per year/School</b>	£700	£60	£100	£250		
A	£700	n/a	£100	n/a	<b>£800</b>	<b>£4</b>
B	£1,633	n/a	£100	n/a	<b>£1,733</b>	<b>£3</b>
C	£2,800	n/a	£100	n/a	<b>£2,910</b>	<b>£3</b>
D	£700	£60	£100	£250	<b>£1,110</b>	<b>£3</b>
E	£1,867	£160	£100	£250	<b>£2,377</b>	<b>£3</b>
F	£3,033	£260	£100	£250	<b>£3,643</b>	<b>£3</b>

Source: PwC analysis based on consultations with Breckland, Philip Harris, SLS

Our consultations indicated that schools purchase more consumables in their first year than in subsequent years. Specifically, in the first year of operation we assume that they purchase all of the consumable materials required to deliver Benchmark 5, while in subsequent years they only need to replenish depleted stocks and/or replace broken equipment such as glassware. Based on our consultations, we estimate that the total cost of consumables is £4 per pupil in the first year and £2.40 per pupil per school year thereafter. Table 35 shows the costs of consumable resources by school size and year groups taught. The total costs are driven entirely by the size of the school (i.e. the more pupils on role the greater the total cost per year will be) and results in an average annual cost per pupil of £2.

Table 35: Costs of purchasing consumable resources for achieving Benchmark 5 by school size and year groups taught (£)

School	Costs per school in Year 1	Costs per school per school year from Year 2 onwards	Total average costs over 20 years	Average total costs per school per school year	Average cost per pupil per school year
A	£848	£509	£10,515	<b>£526</b>	<b>£2</b>
B	£2,484	£1,490	£30,802	<b>£1,540</b>	<b>£2</b>
C	£4,212	£2,527	£52,229	<b>£2,611</b>	<b>£2</b>
D	£1,436	£862	£17,806	<b>£890</b>	<b>£2</b>
E	£3,616	£2,170	£44,838	<b>£2,242</b>	<b>£2</b>
F	£5,604	£3,362	£69,490	<b>£3,474</b>	<b>£2</b>

Source: PwC analysis

### What is the total baseline costs of achieving the benchmark?

Table 36 shows the overall costs of achieving Benchmark 5 in the first year and the recurring annual costs per pupil in subsequent years. It presents these combined overall costs over a 20 year period, to provide a long term analysis of the costs associated with Benchmark 5 and shows the costs per school and per pupil on an annualised basis so that they can be compared with those for other benchmarks.

We estimate that the total recurring costs of achieving Benchmark 5 in a medium sized school will be £38,138 per year in a school with pupils across Years 7-11 (School B) and £50,379 in a school with pupils across Years 7-13 (School E). These costs are largely driven by the size of the school, ranging from £16,332 in a small school with pupils across Years 7-11 (School A) to £74,920 in a large school with pupils across Years 7-13 (School F). The costs per pupil per year for these schools are £77 and £52 respectively, which shows that schools are able to realise economies of scale.

Table 36: Recurring costs of achieving Benchmark 5 by school size and year groups taught (£)

School	Total average costs per school in Year 1	Total average costs from Year 2 onwards	Total average costs per school over 20 years	Total average costs per school per year	Average cost per pupil per school year
A	£177,323	£7,859	£326,640	<b>£16,332</b>	<b>£77</b>
B	£377,876	£20,257	£762,760	<b>£38,138</b>	<b>£61</b>
C	£579,187	£33,387	£1,213,354	<b>£60,668</b>	<b>£58</b>
D	£266,021	£13,072	£514,381	<b>£25,719</b>	<b>£72</b>
E	£469,634	£28,313	£1,007,580	<b>£50,379</b>	<b>£56</b>
F	£673,056	£43,439	£1,498,398	<b>£74,920</b>	<b>£53</b>
<b>Weighted average cost per pupil</b>					<b>£58</b>

Source: PwC analysis based on consultations with Breckland, CLEAPSS, Innova, Philip Harris, SLS

We assume that schools that do not have an accessible outdoor space where practical activities can take place will make use of a local space within walking distance of the school. Taking pupils outside the school grounds will require the presence of an additional member of staff. These schools will, therefore, incur the staff costs associated with this staff time. This activity is discussed in more detail in relation to the likely additional costs of achieving Benchmark 5.

### How sensitive are the baseline costs to the key assumptions?

In addition to our general assumptions set out in Section 2, the estimated cost of delivering Benchmark 1 is based on our estimate of the average cost of different teaching staff across England. In practice, we estimate that staff costs are 15% higher in inner London and in the Rest of England (excluding London area) they are 4% lower. The detailed assumptions and calculations which sit behind these figures are included in Appendix B.

### What costs are currently being incurred by schools in relation to the benchmark?

Table 37 summarises how far the different activities associated with the delivery of Benchmark 5 are currently undertaken by secondary schools in England based on a recent survey for Gatsby<sup>35</sup>.

Table 37: Secondary schools currently achieving Benchmark 5

	% of schools
Schools where the availability of laboratories is never a barrier to carrying out practical activities in the science subjects taught	32%
Schools where all laboratories have sufficient equipment to make it possible for teachers to do standard practical activities expected in their specialist subject at that level	43%
Schools that have an accessible outdoor space where practical activities can take place	82%

Source: Pye Tait Consulting (2017) Good Practical Science Benchmark Survey

We use the survey results to estimate the costs currently being incurred by secondary schools in relation to Benchmark 5. Table 38 shows our estimates of the per pupil costs currently incurred by school size and year group taught. Initial analysis of the survey data did not identify any pattern of adoption by school size or year

<sup>35</sup> Pye Tait Consulting (2016) Good Practical Science Benchmark Survey.

group taught. We assume, therefore, that the proportion of schools undertaking each activity is consistent across all schools.

Table 38: Costs currently incurred by secondary schools in relation to Benchmark 5 (£ per pupil per school year)

Activity	A	B	C	D	E	F	Weighted average cost	% of schools undertaking each activity	Average cost currently incurred
Development of facilities	£40	£29	£26	£35	£24	£22	£26	32%	£8
Purchase of capital equipment	£31	£27	£27	£31	£26	£26	£27	43%	£12
Ongoing maintenance of facilities and equipment	£4	£3	£3	£3	£3	£3	£3	32%	£1
Consumable resources	£2	£2	£2	£2	£2	£2	£2	32%	£1
<b>Total average cost</b>	<b>£77</b>	<b>£61</b>	<b>£58</b>	<b>£72</b>	<b>£56</b>	<b>£53</b>	<b>£58</b>		
<b>Total average cost currently incurred</b>	<b>£28</b>	<b>£23</b>	<b>£21</b>	<b>£26</b>	<b>£21</b>	<b>£20</b>	<b>£22</b>		

Source: PwC analysis

## What are the likely additional costs of all schools achieving the benchmark?

Finally, we consider the additional costs that schools would need to incur to achieve Benchmark 5.

There are no additional one-off costs associated with achieving Benchmark 5.

Table 40 presents the additional recurring costs which would need to be incurred by secondary schools to achieve Benchmark 5. This shows that all schools are at least partly achieving the benchmark. Partly achieving, in relation to Benchmark 5, means that the availability of laboratories is not often a barrier to carrying out practical science activities, at least a few of the laboratories have sufficient equipment for students to conduct standard practical activities at any level and the school has an accessible outdoor space where practical science activities can take place. The additional costs incurred by the schools that are partly achieving the Benchmark 5 will depend on which activities they have already undertaken. We estimate, on average, schools will spend an additional £37 per pupil on a recurring basis to fully achieve the benchmark.

At present, 18% of secondary schools do not have an accessible outdoor space where practical activities can take place (Source: Pye Tait Consulting, 2017). We assume that these schools will make use of a local space within walking distance of the school. Taking pupils outside the school grounds will require the presence of an additional member of staff. We assume that:

- Each activity, including travel time, will take approximately one hour;
- Each activity will require one teacher and one technician; and
- The teacher's time is not additional (i.e. they would have been delivering the same lesson in the school grounds if accessible outdoor space was available).

Table 39 shows the additional costs that would be incurred by school size and year groups taught for schools with no accessible outdoor space. The total costs range from £392 in a small school with pupils across Years 7-11 (School A) to £1,820 in a large school with pupils across Years 7-13 (School F). The costs per pupil per year show that schools are able to realise economies of scale, with costs per pupil of £2 and £1 respectively for these schools.

Table 39: Cost of activities to achieve Benchmark 5 and associated costs for schools with no accessible outdoor space

School	Total number of science classes in KS3 & 4	Total number of KS5 biology classes	Hours per class (hours)	Total technician time (hours per year)	Total average cost per school (£ per school year)	Average cost per pupil (£ per school year)
A	28	0	1	28	£392	£2
B	76	0	1	76	£1,064	£2
C	113	0	1	113	£1,582	£2
D	37	2	1	39	£546	£2
E	85	4	1	89	£1,246	£1
F	124	6	1	130	£1,820	£1

Source: PwC analysis

Table 40 summarises our estimate of the additional recurring costs for Benchmark 5. We consider the costs of laboratories, equipment, consumables and access to an open space separately.

Only 8% of schools are fully achieving Benchmark 5. These schools will incur no additional costs.

The majority of schools (92%) are partly achieving Benchmark 5. We estimate that for these schools to fully achieve the benchmark they would incur further recurring costs – expressed on an annualised basis - of £37 per pupil. These costs primarily relate to the costs of developing facilities and purchasing equipment, however, a small proportion (£2 per pupil or c.5%) would be related to purchasing consumable resources for use in practical activities (e.g. chemicals). We believe it is reasonable to assume that these costs would be additional for these schools.

All schools are achieving at least some part of the benchmark; specifically, while 18% of schools do not have an accessible outdoor space where practical science activities can take place, no school indicated that their laboratories and equipment were totally insufficient.

The position with respect to accessible outdoor space is slightly different. Those schools without such access would incur the cost of the additional staff time needed to accompany pupils to a suitable space outside the school. We estimate this cost would be approximately £1 per pupil per year.

Table 40: Additional costs which would be incurred by secondary schools in relation to Benchmark 5

Achievement of benchmark	% of schools	Achievement of activity	% of schools	Recurring costs currently incurred (£ per school year)	Additional recurring costs by activity (£ per school year)
Not at all	0%	Development of facilities	0%	n/a	£26
		Purchase of capital equipment	0%	n/a	£27
		Ongoing maintenance of facilities and equipment	0%	n/a	£3
		Consumable resources	0%	n/a	£2
Partly	92%	Development of facilities	92%	£8	£18
		Purchase of capital equipment	92%	£12	£15
		Ongoing maintenance of facilities and equipment	92%	£1	£2
		Consumable resources	92%	£1	£2

<b>Achievement of benchmark</b>	<b>% of schools</b>	<b>Achievement of activity</b>	<b>% of schools</b>	<b>Recurring costs currently incurred (£ per school year)</b>	<b>Additional recurring costs by activity (£ per school year)</b>
		Outdoor space	92% <sup>36</sup>	£1	£1-
Achieved	8%	Benchmark 5	8%	£58	n/a

*Source: PwC analysis*

<sup>36</sup> This includes 18% of schools with no access to outdoor space

## 9 *Benchmark 6: Technical support*

### *Introduction*

In this Section we assess the potential costs of Benchmark 6. We follow a structure which is consistent with that we use in the other Sections which analyse the estimated costs of other Benchmarks.

### **Summary**

*The aim of Benchmark 6 is to ensure that science departments in all schools have enough technical support to enable teachers to carry out frequent and effective practical science.*

*We estimate that the total recurring costs - staff and expenses - of implementing all parts of Benchmark 6 would range from £42 per pupil per school year in a large school with no sixth form to £58 per pupil per school year in a small school with a sixth form. This is about 1% of the school's revenue expenditure. These costs are mainly staff costs; expenses account for less than 1% and include local newspaper advertising costs for vacant technician positions and CPD fees.*

*Drawing on a recent survey for Gatsby, we estimate that 43% of schools are currently fully achieving Benchmark 6. These schools would incur no additional costs.*

*Around one quarter of schools (26%) are partly achieving Benchmark 6 at present. We estimate that, on average, these schools would face recurring costs of £16 per pupil per school year to fully achieve Benchmark 6. They would also incur very small one-off costs (less than £1 per pupil) as they recruit technicians to fill vacancies.*

*For the remaining one third of schools (31%) who are not achieving any part of Benchmark 6, we estimate that these schools would face average recurring costs of £46 per pupil per school year to achieve Benchmark 6 in full.*

*Almost all of these costs - more than 99% - relate to staff time. Whether or not they represent additional costs for schools depends upon whether or not staff time can be reallocated to enable staff to complete the activities required to achieve the benchmark. Since the total amount of staff time required to undertake all of the activities associated with Benchmark 6 is modest (592 hours or less than half an FTE), we believe schools may be able to reallocate time from non-practical activities rather than recruiting additional members of staff with only limited opportunity cost. Thus, schools would not need to incur additional staff costs. The external costs are more likely to be additional as they require further expenditure on CPD and recruitment.*

*Our sensitivity analysis shows, however, that for every 50 hours of technical support reallocated from a teacher to a technician the school would save £1,400, on average.*

### *Delivering the benchmark*

#### *What is the benchmark?*

##### **Vision:**

*Science departments in all schools should have enough technical support to enable teachers to carry out frequent and effective practical science.*

**Benchmark:**

*For an average-size secondary school, there should be specialist technical expertise to support practical work in each of biology, chemistry and physics.*

*Technicians should be given regular opportunities to have professional development.*

**What activities will be needed to achieve the benchmark?**

The activities associated with Benchmark 6 are similar in many ways to those associated with Benchmark 3 (Expert teachers) and Benchmark 4 (Frequent and varied practical science). We have identified three main groups of activities which we would expect a school delivery team to undertake if it is to achieve Benchmark 6:

- Setting up before and tidying up after practical science lessons;
- Recruitment and retention of the appropriate workforce needed to provide technical support; and
- Provision of appropriate CPD for staff providing technical support (over and above the covered by other benchmarks).

A key issue is the level of skill and experience needed to provide technical support. Evidence from our data gathering and other sources suggests that teaching staff are often called upon to provide technical support because insufficient support is available from technicians with the required skills and experience. Equally, we heard about instances where experienced technicians were asked to step in and deliver practical science because inexperienced (and, in some cases, unqualified) teachers were not able to do so.

Benchmark 6 is careful to reference the need for **technical** support rather than **technician** support. Our analysis, therefore, does not presume in favour of one model of delivery over another. Instead, we build from existing practice and assess the extent to which the level of technical support is sufficient to meet the needs of the benchmark. We then analyse what cost implications (savings) might result if technicians could take on more of the responsibilities currently taken by teachers. In both cases, this means that we need to consider the potential costs of recruiting and retaining the appropriate workforce schools need to provide technical support. This includes the costs of any initial induction, especially for a new and/or inexperienced staff.

**Baseline costs**

**What are the expected staff costs of achieving the benchmark?**

Table 41 shows the estimated time and financial costs associated with delivering Benchmark 6 in a school which is appropriately resourced. Our cost estimate assumes that the school is undertaking all the activities envisaged by the benchmark on an established basis. It excludes the costs associated with recruiting technicians to fill existing vacancies.

We estimate that each Head of Department and Subject Leader would spend 24 hours per school year at a cost to the school of £1,302 and each class based teacher would spend 29 hours per school year at a cost of £1,204. Each technician would spend 528 hours per school year at a cost to the school of £7,389; this includes 15 hours for CPD. We do not expect the SLT member to spend any time on delivering this benchmark.

*Table 41: Time spent on recurring activities needed to achieve Benchmark 6 (Hours per school year per person and £ per school year)*

Activity	SLT member	Head of Department (and Subject Leaders)	Class based teachers	Technicians
Set up and tidy up of practical activities <sup>37</sup>	0	24	29	513

<sup>37</sup> We assume 15 minutes per technician and 5 minutes per subject leader and class based teacher to set up each practical activity and 15 minutes per technician to tidy up. We assume 10 practical activities per week for 38 weeks with an average of 1 technician for every 3 teachers.

Activity	SLT member	Head of Department (and Subject Leaders)	Class based teachers	Technicians
CPD for technicians <sup>38</sup>	0	0	0	15
<b>Total hours per role</b>	<b>0</b>	<b>24</b>	<b>29</b>	<b>528</b>
<b>Total employment cost per role (£)</b>	<b>£0</b>	<b>£1,302</b>	<b>£1,204</b>	<b>£7,389</b>

Source: PwC analysis

There are also recurring costs associated with staff recruitment in Benchmark 6 as schools replace staff lost through natural wastage. We estimate that each Head of Department or Subject Leader would spend six hours per vacancy at a cost to the school of £349 and each class based teacher would spend one hour per vacancy at a cost of £42. Each technicians would spend four hours per vacancy at a cost to the school of £52.

Further details of our approach are provided in Appendix H.

Table 42: Estimated recurring costs of recruitment activities needed to achieve Benchmark 6 (including induction) (Hours per school year per vacancy per person and £ per school year)

Activity	SLT member	Head of Department (and Subject Leaders)	Class based teachers	Technicians
<b>Total hours per role per vacancy</b>	<b>0</b>	<b>6</b>	<b>1</b>	<b>4</b>
<b>Total employment cost per role per vacancy (£)</b>	<b>£0</b>	<b>£349</b>	<b>£42</b>	<b>£52</b>

Source: PwC analysis

### *What are the expected expenses of achieving the benchmark?*

The expenses associated with the delivery of Benchmark 6 are the cost of advertising for any technician vacancies. We use the cost of advertising one vacancy in a local newspaper for 30 days which we estimate to be £440.

### *What is the total baseline costs of achieving the benchmark?*

As explained above, we consider how school characteristics, notably size and the year groups taught, influence the estimated cost of achieving Benchmark 6. To do this, we examine six schools with different combinations of these characteristics.

Table 43 presents the results of our analysis. It shows how the recurring costs of delivering Benchmark 6 varies between different types of school. For example, the total costs for a large school with pupils across Years 7-13 (School F) are more than five times those of a small secondary school with pupils only in Years 7-11 (School A).

The costs per pupil also vary. The larger schools we assess, both with and without Years 12 and 13 (Schools C and F), are able to realise economies of scale as their costs are £42 and £45 per pupil respectively whereas the smallest schools (School A and D) incur costs of £55 and £58 respectively.

Table 43: Recurring costs of achieving Benchmark 6 by school size and year groups taught (£ per school year)

School	Support for practical lessons and CPD per school	Recruitment cost per school	Total average cost per school	Average cost per pupil
A	£11,593	£49	£11,642	£55
B	£27,066	£143	£27,210	£44
C	£43,646	£243	£43,889	£42

<sup>38</sup> We assume 2 days per year.



School	Support for practical lessons and CPD per school	Recruitment cost per school	Total average cost per school	Average cost per pupil
D	£20,672	£89	£20,760	£58
E	£42,394	£223	£42,617	£47
F	£62,804	£345	£63,149	£45
<b>Weighted average cost per pupil</b>				<b>£46</b>

Source: PwC analysis

### How sensitive are the baseline costs to the key assumptions?

In addition to our general assumptions set out in Section 2, the estimated cost of delivering Benchmark 1 is based on our estimate of the average cost of different teaching staff across England. In practice, we estimate that staff costs are 15% higher in inner London and in the Rest of England (excluding London area) they are 4% lower. The detailed assumptions and calculations which sit behind these figures are included in Appendix B.

### What costs are currently being incurred by schools in relation to the benchmark?

Table 44 summarises how far the different activities associated with delivery of Benchmark 6 are currently undertaken by secondary schools in England based on a recent survey for Gatsby<sup>39</sup>. About two thirds of schools (67%) say that they have sufficient specialist technical expertise to support practical science and 33% do not. We believe that some of the 33% who do not have ‘sufficient’ specialist technical expertise do have some form of technical support and are, therefore, already incurring recurring costs associated with the provision of support for practical science. In the absence of further evidence from the survey, we assume that, on average, these schools incur half the costs of those schools with ‘sufficient’ specialist technical expertise. This means that we assume that the percentage of schools meeting this part of the benchmark is 84% (i.e. the mid-point between 67% and 100%).

Table 44: Secondary schools currently achieving Benchmark 6

	% of schools
Schools with technical expertise to support practical work in each of biology, chemistry and physics	67%
Schools where all science technicians are given regular opportunities to have professional development	56%

Source: Pye Tait Consulting (2016) Good Practical Science Benchmark Survey

Table 46 estimates the cost of each activity currently being incurred across each type of secondary schools on a per pupil basis.

Table 45: Costs currently incurred by secondary schools in relation to Benchmark 6 (£ per pupil per school year)

Activity	A	B	C	D	E	F	Weighted average cost	% of schools undertaking each activity	Average cost currently incurred
Set up and tidy up of practical activities	£52	£41	£39	£54	£44	£42	£43	84%	£36
Provide professional development opportunities for technicians	£3	£2	£2	£3	£3	£3	£3	56%	£1
Recruitment & induction	£0	£0	£0	£0	£0	£0	£0	100%	<£1
<b>Total average cost</b>	<b>£55</b>	<b>£44</b>	<b>£42</b>	<b>£58</b>	<b>£47</b>	<b>£45</b>	<b>£46</b>		

<sup>39</sup> Pye Tait Consulting (2016) Good Practical Science Benchmark Survey.

Activity	A	B	C	D	E	F	Weighted average cost	% of schools undertaking each activity	Average cost currently incurred
<b>Total average cost currently incurred</b>	<b>£45</b>	<b>£36</b>	<b>£34</b>	<b>£48</b>	<b>£39</b>	<b>£37</b>	<b>£38</b>		

Source: PwC analysis

## What are the likely additional costs of all schools achieving the benchmark?

Finally, we consider what additional costs schools would need to incur to achieve Benchmark 6 in full.

Table 46 shows the additional recurring costs associated with achieving Benchmark 6 for schools achieving, not achieving and partly achieving the benchmark.

We estimate that 43% of schools are currently fully achieving Benchmark 6. These schools would incur no additional costs.

The remainder of schools (57%) are partly achieving Benchmark 6 at present. We estimate that, on average, these schools would face recurring costs of £16 per pupil per school year to fully achieve Benchmark 6. For the remaining one third of schools (31%) who are not achieving any part of Benchmark 6, we estimate that these schools would face average recurring costs of £46 per pupil per school year to achieve Benchmark 6 in full.

Almost all of these costs - more than 99% - relate to staff time. Whether or not they represent additional costs for schools depends upon whether or not staff time can be reallocated to enable the activities to be undertaken in line with the benchmark. Since the amount of time required is modest – less than half an FTE - schools may be able to reallocate time from non-practical activities rather than recruiting additional members of staff. The external costs are more likely to be additional as they require further expenditure on CPD and recruitment.

Our sensitivity analysis shows, however, that for every 50 hours of technical support reallocated from a teacher to a technician the school would save £1,400, on average.

Table 46: Additional costs which would be incurred by secondary schools in relation to Benchmark 6

Achievement of benchmark	% of schools	Achievement of activity	% of schools	Recurring costs currently incurred (£ per pupil per school year)	Additional one-off costs by activity (£ per pupil per school)	Additional recurring costs by activity (£ per pupil per school year)
Not at all	0%	Set up and tidy up of practical activities	0%	n/a	-	£43
		Provide professional development opportunities for technicians	9%	n/a	-	£3
		Recruitment & induction	0%	n/a	<£1	<£1
Partly	57%	Set up and tidy up of practical activities	57%	<£1 to <£43	-	<£1 to <£43
		Provide professional development opportunities for technicians	48%	£1	-	£1
		Recruitment & induction	57%	<£1	<£1	<£1
Achieved	43%	Benchmark 6	43%	£46	n/a	n/a

Source: PwC analysis

# 10 Benchmark 7: Real experiments, virtual enhancements

## Introduction

In this Section we assess the potential costs of Benchmark 7.

### Summary

*The aim of Benchmark 7 is to encourage teachers to use digital technologies to support and enhance practical experience, but not to replace it.*

*We believe that if schools are fulfilling all the other nine benchmarks then they would have no need to undertake specific activities directly related to Benchmark 7. As a result, there are no costs directly associated with Benchmark 7.*

## Delivering the benchmark

### What is the benchmark?

#### **Vision:**

*Teachers should use digital technologies to support and enhance practical experience, but not to replace it.*

#### **Benchmark:**

*Virtual environments and simulated experiments have a positive role to play in science education but should not be used to replace a good quality hands-on practical.*

*Digital technologies are rapidly evolving and teachers should have access to evidence about what works, and training in their use, before implementing them in their science lessons.*

### What activities will be needed to achieve the benchmark?

How far schools need to undertake specific activities to achieve Benchmark 7 depends largely on whether or not they are achieving elements of the other nine benchmarks. The aim of Benchmark 7 is to discourage schools from substituting the use of digital technologies for practical science. So, if the other benchmarks are being achieved, there should be no costs for Benchmark 7 since the costs will be fully reflected in the other benchmarks (especially Benchmark 3 (Expert teachers) and Benchmark 4 (Frequent and varied practical science)). To the extent that these benchmarks are not being achieved, and schools are substituting other activities for practical science, teachers may need to undertake additional CPD to enable them to deliver practical science.

# 11 Benchmark 8: Investigative projects

## Introduction

In this Section we assess the potential costs of Benchmark 8. We follow a similar structure to the one used in the other Sections which analyse the estimated costs of other Benchmarks.

### Summary

*The aim of Benchmark 8 is that pupils should have opportunities to do open-ended and extended investigative projects at least once in their time at school.*

*We estimate that the total recurring costs - staff and expenses - of implementing all parts of Benchmark 8 would range from £8 per pupil per school year in a medium sized school with no sixth form to £12 per pupil per school year in a large school with a sixth form (considerably less than 1% of the school's revenue expenditure). Around 30% of these costs are staff costs and the remainder are expenses, mainly the materials required for each pupil's investigative project.*

*Using the results of a recent survey for Gatsby, we estimate that 15% of schools are fully achieving Benchmark 8 at present. These schools would incur no additional costs.*

*Over three quarters of schools (76%) are currently partly achieving Benchmark 8. We estimate that, on average, these schools would incur recurring costs of £6 per pupil per school year.*

*The remaining 9% of schools are not achieving any part of the benchmark. We estimate that, on average, these schools would incur recurring costs £10 per pupil per school year to deliver Benchmark 8.*

*Since the total amount of staff time required to undertake all of the activities associated with Benchmark 8 is relatively small (less than 20 hours per school year or just over 1% of an FTE), we believe this may be possible without significant opportunity cost (by reallocating staff time from other 'out of school hours' activities rather than by recruiting additional members of staff). Thus, schools would not need to increase their expenditure on staff.*

*We believe that the expenses associated with achieving Benchmark 8 (70% of total recurring costs) would be an additional cost for schools that are partly achieving or not achieving any part of the benchmark.*

## Delivering the benchmark

### What is the benchmark?

#### **Vision:**

*Pupils should have opportunities to do open-ended and extended investigative projects.*

#### **Benchmark:**

*There should be opportunities for pupils to do open-ended extended investigative projects in science.*

*The school should have laboratory facilities such that all pupils who want to can carry out extended practical science investigations, particularly among post-16 year olds.*

## *What activities will be needed to achieve the benchmark?*

The key activity associated with Benchmark 8 is to facilitate opportunities for pupils to undertake open-ended and extended investigative projects and to support them.

The costs we focus on are the time and expense directly associated with providing the support; we consider the possible costs of providing and maintaining the project space as part of our analysis of Benchmark 5 (Laboratory equipment and facilities). In adopting this approach, we are aware that some have suggested that Benchmark 8 would require schools to have facilities exclusively available for the projects, for example so that pupils can leave their work out without risk (because no other classes use the space). The consensus, however, is that school should be able to make use of existing space (provided it is sufficient).

## *Baseline costs*

### *What are the expected staff costs of achieving the benchmark?*

Table 47 shows the estimated time and financial costs associated with delivering Benchmark 8 in a school which is appropriately resourced. Our cost estimate assumes that the school is undertaking all the activities envisaged by the benchmark on an established basis. We have identified no one-off costs associated with adopting Benchmark 8 for the first time.

Our detailed assumptions for each activity are set out in Appendix G.

We estimate that, on average, each class based teacher would spend 38 hours per school year at a cost to the school of £1,606 and each technician would spend 76 hours at a cost of £1,064. This would result in sufficient provision to give every pupil in each year group the opportunity to complete at least five one hour sessions per school year. We do not expect either the SLT member or the Head of Department (or Subject Leader) to spend any time on delivering this benchmark.

*Table 47: Time spent on recurring activities needed to achieve Benchmark 8 (Hours per school year per person and £ per school year)*

<b>Activity</b>	<b>SLT member</b>	<b>Head of Department (and Subject leaders)</b>	<b>Class based teachers</b>	<b>Technicians</b>
Provide opportunities for pupils to do open-ended extended investigative projects in science <sup>40</sup>	0	0	38	76
<b>Total hours per role</b>	<b>0</b>	<b>0</b>	<b>38</b>	<b>76</b>
<b>Total employment cost per role (£)</b>	<b>£0</b>	<b>£0</b>	<b>£1,606</b>	<b>£1,064</b>

*Source: PwC analysis*

In practice, Benchmark 10 envisages that each pupil will undertake a project once in their time at school. This implies that for schools without a sixth form about one fifth of this time will be required and for schools which have a sixth form around one seventh of this time will be needed.

### *What are the expected expenses of achieving the benchmark?*

The expenses associated with Benchmark 8 are the costs of the materials for each pupil's investigative project. We estimate them to cost an average of £40 per pupil per project.

<sup>40</sup> We assume 1 hour per week for class based teachers and 2 hours per week for technicians.

## What is the total baseline costs of achieving the benchmark?

As explained above, we consider how school characteristics, notably the number of pupils and the number of year groups taught, influence the estimated cost of achieving Benchmark 8. To do this, we examine six schools with different combinations of these characteristics.

Table 48 presents the results of our analysis. It shows how the cost of delivering Benchmark 8 varies between different types of school. For example, the total costs for a large school with pupils across Years 7-13 (School F) are more than six times those of a small secondary school with pupils only in Years 7-11 (School A).

The costs per pupil in Benchmark 8 vary less across school size and type than in other benchmarks. This is because the expense of the materials is the main element of cost and is assumed to be the same for all pupils. This means that economies of scale are not as significant in Benchmark 8.

Table 48: Recurring costs of achieving Benchmark 8 by school size and year groups taught (£ per school year)

School	SLT member	Head of Department (and Subject Leaders)	Class based teachers	Technicians	Expenses	Total average cost per school	Average cost per pupil
A	£0	£0	£642	£177	£1,696	<b>£2,516</b>	<b>£12</b>
B	£0	£0	£1,284	£460	£4,968	<b>£6,712</b>	<b>£11</b>
C	£0	£0	£2,569	£742	£8,424	<b>£11,735</b>	<b>£11</b>
D	£0	£0	£688	£253	£2,051	<b>£2,993</b>	<b>£8</b>
E	£0	£0	£1,835	£531	£5,166	<b>£7,531</b>	<b>£8</b>
F	£0	£0	£2,982	£783	£8,006	<b>£11,770</b>	<b>£8</b>
<b>Weighted average cost per pupil</b>							<b>£9</b>

Source: PwC analysis

## How sensitive are the baseline costs to the key assumptions?

In addition to our general assumptions set out in Section 2, the estimated cost of delivering Benchmark 1 is based on our estimate of the average cost of different teaching staff across England. In practice, we estimate that staff costs are 15% higher in inner London and in the Rest of England (excluding London area) they are 4% lower. The detailed assumptions and calculations which sit behind these figures are included in Appendix B.

## What costs are currently being incurred by schools in relation to the benchmark?

Table 49 summarises how far the different activities associated with delivery of Benchmark 8 are currently undertaken by secondary schools in England based on a recent survey for Gatsby<sup>41</sup>.

Based on a recent survey for Gatsby, we estimate that 15% of schools offer all pupils the opportunity to do at least one open-ended extended investigative project over the course of their time at the school and that 9% do not offer any opportunity at all. The remaining 76% offer opportunities to some pupils. We assume that the 76% of schools that are partly achieving Benchmark 8 will incur a proportion of the costs associated with it. Based on the responses to the survey, we estimate that 45% of pupils in the schools partly achieving Benchmark 8 are currently undertaking a project. We assume, therefore, that the schools are currently incurring this proportion of the recurring costs needed to fully achieve Benchmark 8.

Table 49: Secondary schools currently achieving Benchmark 8

	% of schools
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<sup>41</sup> Pye Tait Consulting (2016) Good Practical Science Benchmark Survey.

Schools where all pupils have opportunities to do open-ended extended investigative projects in science over the course of their school career	15%
Schools where all laboratory facilities are such that pupils can carry out extended practical science investigations	28%

Source: Pye Tait Consulting (2016) Good Practical Science Benchmark Survey

Table 50 estimates the cost currently being incurred across all types of secondary schools on a per pupil basis for those schools fully and partly achieving Benchmark 8.

Table 50: Costs currently incurred by secondary schools in relation to Benchmark 8 (£ per pupil per school year)

Activity	A	B	C	D	E	F	Weighted average cost	% of schools undertaking each activity	Average cost currently incurred
<b>Total cost</b>	<b>£12</b>	<b>£11</b>	<b>£11</b>	<b>£8</b>	<b>£8</b>	<b>£8</b>	<b>£10</b>	<b>60%</b>	<b>£6</b>
<b>Total average cost currently incurred</b>	<b>£7</b>	<b>£6</b>	<b>£7</b>	<b>£5</b>	<b>£5</b>	<b>£5</b>	<b>£6</b>		

Source: PwC analysis

## What are the likely additional costs of all schools achieving the benchmark?

Finally, we consider the additional costs that schools would need to incur to achieve Benchmark 8.

Table 51 shows the additional recurring costs associated with achieving Benchmark 4 for schools achieving, not achieving and partly achieving the benchmark.

The 15% of schools fully achieving Benchmark 8 already will incur no additional costs.

Over three quarters of schools (76%) are currently partly achieving Benchmark 8. We estimate that, on average, these schools would incur recurring annual costs of up to £57 per pupil. The extent to which these costs are additional will depend on their existing provision and the costs they are currently incurring, for example, where a school is providing opportunities for less than half of its pupils to do open-ended extended investigative projects we estimate they are currently incurring a recurring cost of less than £29 per pupil per school year. Where a school is providing opportunities for at least half of its pupils to do open-ended extended investigative projects we estimate they are currently incurring a recurring cost of between £29 per pupil per school year and £56 per pupil per school year.

The remaining 9% of schools are not achieving any part of the benchmark. We estimate that, on average, these schools would incur recurring costs £57 per pupil per school year to deliver Benchmark 8.

We believe that the expense element of these would be an additional cost for schools.

Table 51: Additional costs which would be incurred by secondary schools in relation to Benchmark 8

Achievement of benchmark	% of schools	Achievement of activity	% of schools	Recurring costs currently incurred (£ per school year)	Additional recurring costs by activity (£ per school year)
Not at all	9%	Provide opportunities for pupils to do open-ended extended investigative projects	9%	£0	£10
Partly	76%	Provide opportunities for some pupils to do open-ended extended investigative projects	76%	£6	£4
Achieved	15%	Benchmark 8	15%	£10	n/a

Source: PwC analysis





# 12 Benchmark 9: A balanced approach to risk

## Introduction

In this Section we assess the potential costs of Benchmark 9. Again, we follow a similar structure as that used in the other Sections which analyse the estimated costs of other Benchmarks.

### Summary

*The aim of Benchmark 9 is to avoid pupils' experience of practical science being restricted by unnecessary risk aversion. This is closely linked to Benchmarks 1, 2 and 4.*

*The costs associated with Benchmark 9 relate to staff costs only; there are no expenses. We estimate that the total recurring staff costs would range from £3 per pupil per school year in a large school with a sixth form to £4 per pupil per school year in a small school with no sixth form (or less than 1% of the school's revenue expenditure).*

*Based on a recent survey for Gatsby, we estimate that over one third of schools (35%) are currently fully achieving Benchmark 9. These schools would incur no additional costs.*

*Nearly two thirds of schools (64%) are partly achieving Benchmark 9. On average, these schools would incur recurring costs of £2 per pupil per school year to achieve the benchmark fully.*

*Only 1% of schools are not currently achieving any part of Benchmark 9. We estimate that, on average, these schools would incur recurring costs of £3 per pupil per school year.*

*As these costs relate to staff time only, whether or not they represent additional costs for schools depends upon whether or not staff time can be reallocated to enable the activities associated with Benchmark 9 to be undertaken in full. Since the total amount of staff time required is very small (13 hours or less than 1% of an FTE), we believe this may be possible without significant opportunity cost (by reallocating staff time from other health and safety activities rather than by recruiting additional members of staff). Thus, schools would not need to incur staff costs which are higher than they currently are.*

## Delivering the benchmark

### What is the benchmark?

#### **Vision:**

*Pupils' experience of practical science should not be restricted by unnecessary risk aversion.*

#### **Benchmark:**

*Responsibility for safety is shared between the school as the employer, the teacher and the technician. This should be clearly understood by all members of science staff.*

*The school should ensure that teachers and technicians have access to authoritative and up-to-date guidance including model risk assessments.*

*Teachers should assess the risks and benefits for every practical activity, and act accordingly.*

*Teachers and technicians should adopt a balanced and proportionate approach to managing risks, and be supported by senior management in doing so.*

## *What activities will be needed to achieve the benchmark?*

We have identified two main activities which we would expect a school delivery team to undertake if it is to achieve Benchmark 9:

- An annual review of practical science risk guidance policy – which will complement the activities in Benchmark 1 (Planned practical science); and
- Assessment of the risks and benefits of every practical activity by teachers and technicians as part of their lesson plan – which will complement activities that are part of Benchmark 2 (Purposeful practical science) and Benchmark 4 (Frequent and varied practical science).

## *Baseline costs*

### *What are the expected staff costs of achieving the benchmark?*

Table 52 shows the estimated time and financial costs associated with delivering Benchmark 9 in a school which is appropriately resourced. Our cost estimate assumes that the school is undertaking all the activities envisaged by the benchmark on an established basis. As with some other benchmarks, we have identified no one-off costs associated with adopting Benchmark 9 for the first time.

Our detailed assumptions for each activity are set out in Appendix G.

We estimate that each Head of Department (and each Subject Leader) would spend four hours per school year at a cost to the school of £231 and each class based teacher would spend four hours per school year at a cost to the school of £170. Technicians would each spend five hours per school year at a cost to the school of £71 to achieve Benchmark 9. We do not expect the SLT member to spend any time on delivering this benchmark.

This time needs to be considered alongside the time included within Benchmark 2 (Purposeful practical science) and Benchmark 4 (Frequent and varied practical science).

*Table 52: Time spent on recurring activities needed to achieve Benchmark 9 (Hours per school year per person and £)*

<b>Activity</b>	<b>SLT member</b>	<b>Head of Department (and Subject Leaders)</b>	<b>Class based teachers</b>	<b>Technicians</b>
Annual review risk guidance policy	0	3	3	1
Assess risks and benefits of every practical science activity <sup>42</sup>	0	1	2	5
<b>Total hours per role</b>	<b>0</b>	<b>4</b>	<b>4</b>	<b>5</b>
<b>Total employment cost per role (£)</b>	<b>£0</b>	<b>£231</b>	<b>£170</b>	<b>£71</b>

*Source: PwC analysis*

### *What are the expected expenses of achieving the benchmark?*

We do not expect there to be any expenses associated with the delivery of Benchmark 9 which means that the only costs of achieving Benchmark 9 are those of the staff time described above.

### *What is the total baseline costs of achieving the benchmark?*

As explained above, we consider how school characteristics, notably the number of pupils and the number of year groups taught, influence the estimated costs of achieving Benchmark 9. To do this, we examine six schools with different combinations of these characteristics.

<sup>42</sup> We assume an extra 1% of lesson planning time.

Table 53 presents the results of our analysis. It shows how the cost of delivering Benchmark 9 varies between different types of school. For example, the total annual costs for a large school with pupils across Years 7-13 (School F) are more than four times those of a small secondary school with pupils only in Years 7-11 (School A).

The annual costs per pupil remain similar across a range of school types and sizes. The larger schools we assess, both with and without Years 12 and 13 (Schools C and F), and the smaller schools (School A and D) incur costs in the range of £3-£4 per pupil per school year.

Table 53: Recurring costs of achieving Benchmark 9 by school size and year groups taught (£ per school year)

School	SLT member	Head of Department (and Subject Leaders)	Class based teachers	Technicians	Expenses	Total average cost per school	Average cost per pupil
A	£0	£462	£340	£59	£0	<b>£860</b>	<b>£4</b>
B	£0	£923	£679	£153	£0	<b>£1,755</b>	<b>£3</b>
C	£0	£1,154	£1,359	£247	£0	<b>£2,760</b>	<b>£3</b>
D	£0	£692	£510	£118	£0	<b>£1,320</b>	<b>£4</b>
E	£0	£923	£1,359	£247	£0	<b>£2,529</b>	<b>£3</b>
F	£0	£1,154	£2,208	£365	£0	<b>£3,727</b>	<b>£3</b>
<b>Weighted average cost per pupil</b>							<b>£3</b>

Source: PwC analysis

### How sensitive are the baseline costs to the key assumptions?

In addition to our general assumptions set out in Section 2, the estimated cost of delivering Benchmark 9 is based on our estimate of the average cost of different teaching staff across England. In practice, we estimate that staff costs are 15% higher in inner London and in the Rest of England (excluding London area) they are 4% lower. The detailed assumptions and calculations which sit behind these figures are included in Appendix B.

### What costs are currently being incurred by schools in relation to the benchmark?

Table 54 summarises how far the different activities associated with delivery of Benchmark 9 are currently being undertaken by secondary schools in England based on a recent survey for Gatsby<sup>43</sup>. We use two of them to inform our assessment of the costs currently being incurred by treating them as proxies for how far different activities are currently being undertaken:

- The proportions of schools ensuring access to up to date guidance on risk assessment is used as an indicator of how far schools are reviewing their risk policy on an annual basis; and
- The proportions of schools where all teachers assess the risks and benefits of every practical activity is used as an indicator how far risk and benefits are considered for each lesson.

Table 54: Secondary schools currently achieving Benchmark 9

	% of schools
Schools that ensure access to up-to-date guidance including model risk assessments is given	57%
Schools where all teachers assess the risks and benefits for every practical activity, and act accordingly	50%
Schools where it is clearly understood that responsibility for safety is shared between the school as the employer, the teacher and the technician:	
• By all science teachers	75%
• By all science technicians	79%

<sup>43</sup> Pye Tait Consulting (2016) Good Practical Science Benchmark Survey.

	% of schools
Schools where a balanced and proportionate approach to managing risks, with support by senior management in doing so, is adopted by:	
• All science teachers	61%
• All science technicians	72%

Source: Pye Tait Consulting (2016) Good Practical Science Benchmark Survey

Table 55 estimates the costs of each activity currently being incurred across all types of secondary schools on a per pupil basis.

Table 55: Costs currently incurred by secondary schools in relation to Benchmark 9 (£ per pupil per school year)

Activity	A	B	C	D	E	F	Weighted average cost	% of schools undertaking each activity	Average cost currently incurred
Annual review risk guidance policy	£3	£2	£2	£2	£2	£2	£2	57%	£1
Assess risks and benefits of every practical science activity	£2	£1	£1	£1	£1	£1	£1	50%	£1
<b>Total average cost</b>	<b>£4</b>	<b>£3</b>	<b>£3</b>	<b>£4</b>	<b>£3</b>	<b>£3</b>	<b>£3</b>		
<b>Total average cost currently incurred</b>	<b>£2</b>	<b>£2</b>	<b>£1</b>	<b>£2</b>	<b>£2</b>	<b>£1</b>	<b>£2</b>		

Source: PwC analysis

## What are the likely additional costs of all schools achieving the benchmark?

Finally, we consider the additional costs that schools would need to incur to achieve Benchmark 9 in full.

Table 56 shows the additional recurring costs associated with achieving Benchmark 9 for schools achieving, not achieving and partly achieving the benchmark.

About one third of schools (35%) are already fully achieving Benchmark 9 and will incur no additional costs.

Nearly two thirds of schools (64%) are partly achieving Benchmark 9. On average, these schools would incur further annual recurring costs of £2 per pupil to achieve the benchmark fully.

Only 1% of schools are not currently achieving any part of Benchmark 9. We estimate that, on average, these schools would incur annual recurring costs of £3 per pupil per school year.

As these costs primarily relate to staff time, whether or not they represent additional costs for schools depends upon whether or not staff time can be reallocated to enable the activities associated with Benchmark 9 to be undertaken in full. Since the amount of time required is very small (less than 1% of an FTE per school), we believe this may be possible without significant opportunity cost (rather than by recruiting additional members of staff).

Table 56: Additional costs which would be incurred by secondary schools in relation to Benchmark 9

Achievement of benchmark	% of schools	Achievement of activity	% of schools	Recurring costs currently incurred (£ per school year)	Additional recurring costs by activity (£ per school year)
Not at all	1%	Review risk guidance policy	1%	£0	£2
		Teacher and technician assessment of the risks and benefits of every practical activity	0%	n/a	£1

<b>Achievement of benchmark</b>	<b>% of schools</b>	<b>Achievement of activity</b>	<b>% of schools</b>	<b>Recurring costs currently incurred (£ per school year)</b>	<b>Additional recurring costs by activity (£ per school year)</b>
Partly	64%	Review risk guidance policy	64%	£1	£1
		Teacher and technician assessment of the risks and benefits of every practical activity	65%	£1	£1
Achieved	35%	Benchmark 9	35%	£3	n/a

*Source: PwC analysis*

# 13 *Benchmark 10: Assessment fit for purpose*

## *Introduction*

In this Section we assess the potential costs of Benchmark 10. We follow the same structure as that used in the other Sections which analyse the estimated costs of other Benchmarks.

### **Summary**

*The aim of Benchmark 10 is that both formative and summative assessment of pupils' work in science should include assessment of their practical knowledge, skills and behaviours.*

*We expect the costs associated with Benchmark 10 to be staff costs only; there are no expenses. We estimate that the total recurring staff costs would range from £93 per pupil per school year in a medium sized school without a sixth form to £136 per pupil per school year in a small school with no sixth form (or 2% of the school's revenue expenditure).*

*Drawing on a recent survey for Gatsby, we estimate that 3% of schools are currently fully achieving Benchmark 10. These schools would incur no further costs.*

*The overwhelming majority of schools (85%) are partly achieving the benchmark. On average, we estimate that these schools would face recurring costs of £79 per pupil per school year to achieve the benchmark.*

*The remaining 12% of schools are not achieving any part of Benchmark 10. We estimate that, on average, these schools would face recurring costs of £102 per pupil per school year to implement Benchmark 10.*

*As these costs are staff time only, whether or not they represent additional costs for schools depends upon whether or not staff time can be reallocated to enable the activities associated with Benchmark 10 to be undertaken in full. Since the total staff time needed is relatively small (314 hours or about one quarter of an FTE), we think schools are likely to be able to reallocate time amongst teaching staff by reducing the time devoted to non-practical assessment rather than by recruiting additional members of staff without compromising other activities. Thus, schools would not need to increase their overall expenditure to achieve Benchmark 10.*

## *Delivering the benchmark*

### *What is the benchmark?*

#### **Vision:**

*Assessment of pupils' work in science should include assessment of their practical knowledge, skills and behaviours. This applies to both formative and summative assessment.*

#### **Benchmark:**

*Teachers should reflect on pupils' practical skills and knowledge when awarding a grade for science.*

*Teachers should regularly use practical activities as an opportunity to formatively assess pupils' understanding of science.*

## What activities will be needed to achieve the benchmark?

We have identified two main activities which we would expect a school delivery team to undertake if it is to achieve Benchmark 10:

- Using practical activities to assess formatively pupils' understanding of science; and
- Reflecting on pupils' practical skills and knowledge when awarding a grade for science.

## Baseline costs

### What are the expected staff costs of achieving the benchmark?

Table 57 shows the estimated time and financial costs associated with delivering Benchmark 10 in a school which is appropriately resourced. Our cost estimate assumes that the school is undertaking all the activities envisaged by the benchmark on an established basis. We have identified no one-off costs associated with adopting Benchmark 10 for the first time.

Our detailed assumptions for each activity are set out in Appendix G.

In total, we estimate that each Head of Department (and Subject Leader) would spend 105 hours per school year at a cost to the school of £5,618 and each class based teacher would spend 209 hours per school year at a cost to the school of £8,831. There is no technician time required to achieve Benchmark 10. We do not expect the SLT member to spend any time on delivering this benchmark nor do we expect technicians to be involved.

Table 57: Time spent on recurring activities needed to achieve Benchmark 10 (Hours per school year per person and £ per school year)

Activity	SLT member	Head of Department (and Subject Leaders)	Class based teachers	Technicians
Teachers use practical activities to formatively assess pupils' understanding of science <sup>44</sup>	0	84	167	0
Teachers reflect on pupils' practical skills and knowledge when awarding a grade for science	0	21	42	0
<b>Total hours per role</b>	<b>0</b>	<b>105</b>	<b>209</b>	<b>0</b>
<b>Total employment cost per role (£)</b>	<b>£0</b>	<b>£5,618</b>	<b>£8,831</b>	<b>£0</b>

Source: PwC analysis

### What are the expected expenses of achieving the benchmark?

There are no expenses associated with the delivery of Benchmark 10 which means that the only costs of achieving it relate to the cost of staff time described above.

### What is the total baseline costs of achieving the benchmark?

We consider how school characteristics, notably the number of pupils and the number of year groups taught, influence the estimated cost of achieving Benchmark 10. To do this, we examine six schools with different combinations of these characteristics.

Table 58 presents the results of our analysis. It shows how the cost of delivering Benchmark 10 varies between different types of school. For example, the total costs for a large school with pupils across Years 7-13 (School F) are more than four times those of a small secondary school with pupils only in Years 7-11 (School A).

The costs per pupil also vary. The smallest schools (School A and D) incur the highest costs of £136 and £121 per pupil respectively, as they do not benefit as much from economies of scale.

<sup>44</sup> We assume that class based teachers spend 5½ hours per week and subject leaders spend 2.8 hours per week assessing practical work and we also assume that the ratio of time spent on formative to that on summative assessment is 4 to 1.

Table 58: Recurring costs of achieving Benchmark 10 by school size and year groups taught (£ per school year)

School	SLT member	Head of Department (and Subject Leaders)	Class based teachers	Technicians	Expenses	Total average cost per school	Average cost per pupil
A	£0	£11,237	£17,661	£0	£0	<b>£28,898</b>	<b>£136</b>
B	£0	£22,474	£35,323	£0	£0	<b>£57,797</b>	<b>£93</b>
C	£0	£28,092	£70,646	£0	£0	<b>£98,738</b>	<b>£94</b>
D	£0	£16,855	£26,492	£0	£0	<b>£43,348</b>	<b>£121</b>
E	£0	£22,474	£70,646	£0	£0	<b>£93,120</b>	<b>£103</b>
F	£0	£28,092	£114,800	£0	£0	<b>£142,892</b>	<b>£102</b>
<b>Weighted average cost per pupil</b>							<b>£102</b>

Source: PwC analysis

### How sensitive are the baseline costs to the key assumptions?

In addition to our general assumptions set out in Section 2, the estimated cost of delivering Benchmark 10 is based on our estimate of the average cost of different teaching staff across England. In practice, we estimate that staff costs are 15% higher in inner London and in the Rest of England (excluding London area) they are 4% lower. The detailed assumptions and calculations which sit behind these figures are included in Appendix B.

### What costs are currently being incurred by schools in relation to the benchmark?

Table 59 summarises how far the different activities associated with delivery of Benchmark 10 are currently being undertaken by secondary schools in England based on a recent survey for Gatsby<sup>45</sup>.

Around one in seven schools say that their teachers of science use practical activities ‘very regularly’ to assess formatively pupils’ understanding of science. We treat these schools as achieving this element of Benchmark 10.

Respondents were also asked to use a scale from 1 to 10<sup>46</sup> to rate how far teachers take assessment of practical science activities into account when awarding students’ their overall grades. The average score received was 5 indicating that schools have some way to go to realise Benchmark 10, which we define as a score of 10.

Table 59: Secondary schools currently achieving Benchmark 10

Schools where teachers use practical activities as an opportunity very regularly <sup>47</sup> to formatively assess pupils’ understanding of science	16% of schools
Average extent to which teachers reflect on pupils’ practical skills and knowledge when awarding a grade for science	Average score is 5 (out of 10) <sup>48</sup>

Source: Pye Tait Consulting (2016) Good Practical Science Benchmark Survey

<sup>45</sup> Pye Tait Consulting (2016) Good Practical Science Benchmark Survey.

<sup>46</sup> A score of 1 was defined as not at all whereas a score of 10 meant fully and completely.

<sup>47</sup> Note that if ‘very or quite regularly’ are used to define the benchmark, this changes the percentage to 66%.

<sup>48</sup> A scale of 1-10 was used, where 1 meant not at all, and 10 meant fully and completely.



Table 60 estimates the cost of each activity currently being incurred across all types of secondary schools on a per pupil basis.

Table 60: Costs currently incurred by secondary schools in relation to Benchmark 10 (£ per pupil per school year)

Activity	A	B	C	D	E	F	Weighted average cost	% of schools undertaking each activity	Average cost currently incurred
Teachers use practical activities to formatively assess students' understanding of science	£109	£74	£75	£97	£82	£82	£82	16%	£13
Teachers reflect on students' practical skills and knowledge when awarding a grade for science	£27	£19	£19	£24	£21	£20	£20	50% <sup>49</sup>	£1
<b>Total average cost</b>	<b>£136</b>	<b>£93</b>	<b>£94</b>	<b>£121</b>	<b>£103</b>	<b>£102</b>	<b>£102</b>		
<b>Total average cost currently incurred</b>	<b>£31</b>	<b>£21</b>	<b>£21</b>	<b>£28</b>	<b>£23</b>	<b>£23</b>	<b>£23</b>		

Source: PwC analysis

## What are the likely additional costs of all schools achieving the benchmark?

Finally, we consider the additional costs that schools would need to incur to achieve Benchmark 10 in full.

Table 61 shows the additional recurring costs associated with achieving Benchmark 10 for schools achieving, not achieving and partly achieving the benchmark.

Only 3% of schools are currently fully achieving Benchmark 10 but they will incur no additional costs.

The overwhelming majority of schools (85%) are achieving parts of Benchmark 10. On average, we estimate that these schools would face annual recurring costs of £79 per pupil to achieve the benchmark.

The remaining 12% of schools are not achieving any part of Benchmark 10. We estimate that, on average, these schools would face recurring costs of £102 per pupil to implement Benchmark 10.

As these costs are only staff time, whether or not they represent additional costs for schools depends upon whether or not staff time can be reallocated to enable the activities associated with Benchmark 10 to be undertaken in full. Since the average staff time needed is relatively small (about one quarter of a FTE), we think schools are likely to be able to reallocate time from other non-practical work activities without recruiting additional members of staff.

Table 61: Additional costs which would be incurred by secondary schools in relation to Benchmark 10

Achievement of benchmark	% of schools	Achievement of activity	% of schools	Recurring costs currently incurred (£ per pupil per school year)	Additional recurring costs by activity (£ per pupil per school year)
Not at all	12%	Teachers use practical activities to formatively assess students' understanding of science	12%	£0	£82

<sup>49</sup> This is calculated as the proportion of the maximum point on the scale (10) which we use as a proxy for how far this part of Benchmark 10 is being achieved in full.

<b>Achievement of benchmark</b>	<b>% of schools</b>	<b>Achievement of activity</b>	<b>% of schools</b>	<b>Recurring costs currently incurred (£ per pupil per school year)</b>	<b>Additional recurring costs by activity (£ per pupil per school year)</b>
		Teachers reflect on students' practical skills and knowledge when awarding a grade for science	12%	n/a	£20
Partly	85%	Teachers use practical activities to formatively assess students' understanding of science	85%	£13	£69
		Teachers reflect on students' practical skills and knowledge when awarding a grade for science	85%	£10	£10
Achieved	3%	Benchmark 10	3%	£102	n/a

Source: PwC analysis

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# 14 Summary of costs of the benchmarks

This final Section summarises the results of our overall assessment of the costs of each benchmark.

Table 62 shows the average costs per pupil per school year which are already being incurred by secondary schools or which would need to be incurred by them if they are to fully meet the respective benchmark. It distinguishes between those schools which have not achieved any part of the benchmark ('Not at all'), those which have achieved some parts of it ('Partly') and those which have achieved all of it ('Achieved'). The table also shows the proportions of schools which we estimate fall into each of the three categories.

First, for those schools which have not achieved any part of the benchmark, we distinguish between any additional one-off costs that a school might need to incur and the additional recurring costs that the average school in this category would face.

Second, for those schools which have only partly achieved the benchmark, we estimate the recurring costs which are currently being incurred as well as the further one-off costs and recurring costs that we expect that the average school in this category would face.

Finally, for those schools which have achieved all of the benchmark, we estimate the recurring costs that the average school is currently incurring.

As we explain in previous sections, some care is needed in interpreting the cost estimates. In particular, it is important to recall that where schools need to start undertaking activities so as to achieve a benchmark in full, this does not mean that they need to recruit more teachers or technicians and/or increase their total spending on delivering science. In several cases, they can meet the Benchmark by reallocating teaching time to delivering more practical science (at the expense of other forms of teaching). For example, they can substitute lessons involving well planned practical science for non-practical lessons.

Two key points stand out from Table 62:

- The most costly benchmarks are Benchmarks 2 (Purposeful practical science), 4 (Frequent and varied practical science) and 10 (Assessment fit for purpose); and
- The majority of schools has not fully achieved any of the benchmarks: the strongest performance is for Benchmark 6 (Technical support) and Benchmark 9 (A balanced approach to risk).

Table 63 analyses the average recurring and one-off costs per pupil of each of the activities we have costed as part of our assessment of the ten benchmarks. It shows the cost per pupil for each of the six typical schools which underpin our analysis. Also shown is a weighted average of the cost per pupil across all secondary schools in England.

The costs included are the staff time and the associated expenses.

The results in this table can be used by SLT members and Heads of Department as a tool to support their planning and budgeting for the delivery of practical science in line with Gatsby's benchmarks.

Assessing the costs of benchmarks of good practice in practical science

Table 62: Summary of costs per pupil per school year already incurred or needing to be incurred by an average secondary school by benchmark

Benchmark	Not at all			Partly			Achieved		
	% of schools	Additional one-off costs (£ per school year)	Additional recurring costs (£ per school year)	% of schools	Recurring costs currently incurred (£ per school year)	Additional one-off costs (£ per school year)	Additional recurring costs (£ per school year)	% of schools	Recurring costs currently incurred (£ per school year)
1. Planned practical science	77%	£10	£5	10%	£1	£2	£4	13%	£5
2. Purposeful practical science	0%	n/a	n/a	72%	£47	n/a	£80	28%	£127
3. Expert teachers	0%	£3	n/a	85%	£8	£3	£11	15%	£18
4. Frequent and varied practical science									
• Lesson delivery	17%	n/a	£113	77%	£49		£64	6%	£113
• Biology field trip	40%	n/a	£1	40%	<£1	n/a	<£1	60%	£1
5. Laboratory facilities and equipment	0%	n/a	£60	92%	£23	n/a	£37	8%	£60
6. Technical support	0%	<£1	n/a	57%	£38	<£1	£8	43%	£46
7. Real experiments, virtual enhancements					Not applicable				
8. Investigative projects	9%	n/a	£57	76%	£9	n/a	£49	15%	£57
9. A balanced approach to risk	1%	n/a	£3	64%	£2	n/a	£1	35%	£3
10. Assessment fit for purpose	12%	n/a	£102	85%	£23	n/a	£79	3%	£102

Source: PwC analysis

Table 63: Average costs per pupil by activity by benchmark by school size and year groups taught (£ per pupil per school year)

		Recurring/ one-off	A	B	C	D	E	F	Weighted average cost
Number of pupils			212	621	1,053	359	904	1,401	
Years 12-13			N	N	N	Y	Y	Y	
Benchmark	Activity								
1. Planned practical science	Review the policy	R	£9	£6	£4	£8	£4	£4	£5
	Communicate policy	R	£1	£0	£0	£0	£0	£0	£0
	Overview	R	£1	£0	£0	£1	£0	£0	£0

Assessing the costs of benchmarks of good practice in practical science

		Recurring/ one-off	A	B	C	D	E	F	Weighted average cost
	Total recurring		£10	£7	£5	£9	£5	£4	£5
	Engage staff and develop policy	O	£18	£12	£9	£16	£9	£7	£10
	Total one-off		£18	£12	£9	£16	£9	£7	£10
2. Purposeful practical science	Plan the practical activities to be covered by each class throughout the year	R	£6	£4	£4	£6	£4	£4	£4
	Use research into effective science education to identify new/ different practical activities	R	£4	£3	£2	£3	£2	£2	£2
	Trial and practice new practical activities	R	£11	£8	£7	£10	£8	£8	£8
	Explain the purpose for every practical activity and how it relates to the rest of what they are teaching	R	£23	£15	£15	£20	£16	£15	£16
	Lesson planning including how to introduce each practical	R	£132	£91	£86	£118	£92	£88	£93
	Lesson planning on how to follow up each practical	R	£1	£1	£1	£1	£1	£1	£1
	Lesson planning to take account of pupils' special needs	R	£1	£1	£1	£1	£1	£1	£1
	Review lesson plan post-delivery	R	£1	£1	£1	£1	£1	£1	£1
	Total recurring		£180	£123	£117	£160	£125	£120	£127
3. Expert teachers	Annual review of teacher expertise	R	£2	£1	£0	£1	£0	£0	£1
	CPD for existing teachers	R	£20	£13	£12	£18	£13	£12	£13
	Recruitment & induction in response to natural wastage	R	£3	£2	£2	£3	£2	£2	£2
	CPD for NQTs	R	£3	£2	£2	£3	£2	£2	£2
	Total recurring		£28	£18	£17	£24	£18	£17	£18
	Recruitment & induction to fill vacancies/unqualified teachers	O	£4	£2	£2	£3	£2	£2	£2
	Total one-off		£4	£2	£2	£3	£2	£2	£2
4. Frequent and varied practical science	Lesson delivery	R	£164	£113	£104	£146	£111	£105	£113
	Biology field trip	R	n/a	n/a	n/a	£2	£1	£1	£1
	Total recurring		£164	£113	£104	£148	£112	£106	£114
5. Laboratory facilities and equipment	Development of facilities	R	£40	£29	£26	£35	£24	£22	£26
	Purchase of capital equipment	R	£31	£27	£27	£31	£26	£26	£27
	Ongoing maintenance of facilities and equipment	R	£4	£3	£3	£3	£3	£3	£3
	Consumable resources	R	£2	£2	£2	£2	£2	£2	£2
	Outdoor space	R	£2	£2	£2	£2	£1	£1	£1
	Total recurring		£77	£61	£58	£72	£56	£53	£58
	Set up and tidy up of practical activities	R	£52	£41	£39	£54	£44	£42	£43

Assessing the costs of benchmarks of good practice in practical science

		Recurring/ one-off	A	B	C	D	E	F	Weighted average cost
6. Technical support	Provide professional development opportunities for technicians	R	£3	£2	£2	£3	£3	£3	£3
	Staff recruitment	R	<£1	<£1	<£1	<£1	<£1	<£1	<£1
	Total recurring		£45	£36	£34	£48	£39	£37	£38
	Recruitment & induction to fill vacancies	O	<£1	<£1	<£1	<£1	<£1	<£1	<£1
	Total one-off		<£1	<£1	<£1	<£1	<£1	<£1	<£1
7. Real experiments, virtual enhancements	None								
8. Investigative project	Provide opportunities for pupils to do open ended investigative projects	R	£54	£56	£58	£58	£59	£57	£59
9. A balanced approach to risk	Annual review risk guidance policy	R	£3	£2	£2	£2	£2	£2	£2
	Assess risks and benefits of every practical science activity	R	£2	£1	£1	£1	£1	£1	£1
	Total recurring		£4	£3	£3	£4	£3	£3	£3
10. Assessment fit for purpose	Teachers use practical activities to formatively assess students' understanding of science	R	£74	£75	£97	£82	£82	£82	£109
	Teachers reflect on students' practical skills and knowledge when awarding a grade for science	R	£19	£19	£24	£21	£20	£20	£27
<b>Total recurring</b>			<b>£93</b>	<b>£94</b>	<b>£121</b>	<b>£103</b>	<b>£102</b>	<b>£102</b>	<b>£136</b>

Source: PwC analysis

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# *Appendices*

# Appendix A: School characteristics by type

This appendix provides details of the six school types that we have used to underpin our analysis of the costs of delivering each of the benchmarks of good practice in the delivery of practical science. Table 64 summarises the key characteristics of each individual schools. We also summarise the number of schools of a similar type across England and the number of pupils for which they provide a secondary education.

Table 64: Key characteristics of different school types

	School A	School B	School C	School D	School E	School F
Number of pupils	212	621	1,053	359	904	1,401
Sixth form (Y/N)	N	N	N	Y	Y	Y
Number of year groups	5	5	5	7	7	7
<b>Assumptions</b>						
Number of science teachers	4	8	13	6	12	18
Number of science teacher vacancies	0.05	0.10	0.17	0.08	0.16	0.23
Number of NQTs in the science department	0.38	0.77	1.25	0.58	1.15	1.73
Number of Heads of Department (and Subject Leaders)	2	4	5	3	4	5
Number of class based teachers	2	4	8	3	8	13
Number of technicians	0.8	2.2	3.5	1.7	3.5	5.2
Number of technician vacancies	0.0	0.0	0.1	0.0	0.1	0.1
Teacher technician ratio	4.8	3.7	3.7	3.6	3.5	3.4
Pupil teacher ratio	53	77.6	81	59.8	75.3	77.8
Number of laboratories	2	7	12	3	8	13
Number of prep rooms	3	3	3	3	3	3
Number of fume cupboards	1	1	1	3	3	3
Number of sixth form project laboratories	0	0	0	1	1	1
<b>School population in England</b>						
Number of similar schools in England	158	544	495	399	766	980
Number of pupils in England	72,019	339,739	492,742	274,329	799,901	1,452,912

Source (s): DfE (2010) Extended Services Evaluation: End of Year One Report, Table 5.11 and SFR 21 2016 Table 1



## Appendix B: Staff costs by staff type

This appendix shows how we have derived the costs of employment for each of the four categories of school staff that we expect to be involved in the delivery of the benchmarks:

- SLT members;
- Heads of Department (and Subject Leaders);
- Class based teachers; and
- Technicians.

Each table shows the estimated average annual salary and the additional staff costs. These are expressed on an annual and hourly basis using information on the average number of contracted hours worked each week.

### SLT members

Table 65: Estimated staff costs of SLT members (2016/2017)

Location	Estimated annual salary in 2015/2016 (£)	Estimated annual salary in 2016/2017 (£) <sup>50</sup>	Estimated additional staff costs (£)	Annual cost (£)	Contracted hours worked per year	Cost per hour (£)
England	£58,400	£58,984	£23,594	£82,578	1,265	£65
England without London	£56,281	£56,844	£22,737	£79,581	1,265	£63
Inner London	£66,957	£67,627	£27,051	£94,678	1,265	£75
Outer London	£61,886	£62,505	£25,002	£87,507	1,265	£69
The Fringe Area	£57,958	£58,538	£23,415	£81,953	1,265	£65

Source: PwC analysis based on DfE SFR 21 Table 9c and DfE (2014) Fairer schools funding 2015 to 2016 Annex C: Area Cost Adjustment (ACA)

<sup>50</sup> We assume that salaries increase by 1% from 2015/2016.

## Heads of Department (and Subject Leaders)

Table 66: Estimated staff costs of Heads of Department (and Subject Leaders) (2016/2017)

Location	Estimated annual salary in 2015/2016 (£)	Estimated annual salary in 2016/2017 (£) <sup>51</sup>	Estimated additional employment cost (£)	Annual cost (£)	Contracted hours worked per year	Cost per hour (£)
England	£48,100	£48,581	£19,432	£68,013	1,265	£54
England without London	£46,355	£46,818	£18,727	£65,545	1,265	£52
Inner London	£55,148	£55,699	£22,280	£77,979	1,265	£62
Outer London	£50,971	£51,481	£20,592	£72,074	1,265	£57
The Fringe Area	£47,736	£48,213	£19,285	£67,499	1,265	£53

Source: PwC analysis based on DfE SFR 21 Tables 9b&9c and DfE (2014) Fairer schools funding 2015 to 2016 Annex C: Area Cost Adjustment (ACA)

## Class based teachers

Table 67: Estimated staff costs of class based teachers (2016/2017)

Location	Estimated annual salary in 2015/2016 (£)	Estimated annual salary in 2016/2017 (£) <sup>52</sup>	Estimated additional employment cost (£)	Annual cost (£)	Contracted hours worked per year	Cost per hour (£)
England	£37,800	£38,178	£15,271	£53,449	1,265	£42
England without London	£36,428	£36,793	£14,717	£51,510	1,265	£41
Inner London	£43,339	£43,772	£17,509	£61,281	1,265	£48
Outer London	£40,057	£40,457	£16,183	£56,640	1,265	£45
The Fringe Area	£37,514	£37,889	£15,156	£53,045	1,265	£42

Source: PwC analysis based on DfE SFR 21 Tables 9b and DfE (2014) Fairer schools funding 2015 to 2016 Annex C: Area Cost Adjustment (ACA)

<sup>51</sup> We assume that salaries increase by 1% from 2015/2016.

<sup>52</sup> We assume that salaries increase by 1% from 2015/2016.

## Technicians

Table 68: Estimated staff costs of technicians (2016/2017)

Location	Estimated annual salary in 2015/2016 (£)	Estimated annual salary in 2016/2017 (£) <sup>53</sup>	Estimated additional employment cost (£)	Annual cost (£)	Contracted hours worked per year	Cost per hour (£)
England	£13,921	£14,060	£5,624	£19,684	1,406	£14
England without London	£13,416	£13,550	£5,420	£18,970	1,406	£13
Inner London	£15,961	£16,120	£6,448	£22,568	1,406	£16
Outer London	£14,752	£14,899	£5,960	£20,859	1,406	£15
Fringe	£13,815	£13,954	£5,581	£19,535	1,406	£14

Source: PwC analysis based on CLEAPPS (2009) *Technicians and their jobs (G228)*, data for technicians courtesy of TeachVac (December 2016), ONS, ASHE, Provisional data for 2016 and DfE (2014) *Fairer schools funding 2015 to 2016 Annex C: Area Cost Adjustment (ACA)*

<sup>53</sup> We assume that salaries increase by 1% from 2015/2016.

## Appendix C: Recurring costs by Benchmark by school type

This appendix summarises the average annual recurring costs per pupil of each of the activities we expect schools to undertake if they are meeting the requirements of the benchmark. The cost estimates assume that each school is undertaking all the activities on an established basis. As such, the costs exclude all one-off costs that schools may need to incur to meet the requirements for the first time. The costs are provided for each of the six school types that we use to underpin our analysis.

Table 69: Average annual recurring costs by benchmark (£ per pupil per school year)

Benchmark	School A	School B	School C	School D	School E	School F
1. Planned practical science	£10	£7	£5	£9	£5	£4
2. Purposeful practical science	£182	£124	£117	£162	£125	£120
3. Expert teachers	£29	£19	£18	£25	£19	£18
4. Frequent and varied practical science	£164	£113	£104	£148	£112	£106
5. Laboratory facilities and equipment	£77	£61	£58	£72	£56	£53
6. Technical support	£55	£44	£42	£58	£47	£45
7. Real experiments, virtual enhancements			Not applicable			
8. Investigative projects	£12	£11	£11	£8	£8	£8
9. A balanced approach to risk	£4	£3	£3	£4	£3	£3
10. Assessment fit for purpose	£136	£93	£94	£121	£103	£102

Source: PwC analysis

Table 70: Average number of recurring hours by staff type by benchmark (Hours per school per school year)

<b>Benchmark &amp; staff type</b>	<b>School A</b>	<b>School B</b>	<b>School C</b>	<b>School D</b>	<b>School E</b>	<b>School F</b>
<i>1. Planned practical science</i>						
SLT time	3	3	3	3	3	3
Subject leaders time	34	69	86	52	69	86
Class based teacher time	2	4	8	3	8	13
Total hours per school	39	76	97	58	80	102
<i>2. Purposeful practical science</i>						
Subject leaders time	369	738	923	554	738	923
Class based teacher time	412	824	1,649	618	1,649	2,679
Technician time	59	152	245	117	246	363
Total hours per school	840	1,715	2,817	1,289	2,633	3,965
<i>3. Expert teachers</i>						
SLT time	6	6	6	6	6	6
Subject leaders time	46	93	116	70	93	116
Class based teacher time	40	80	161	60	161	261
Total hours per school	93	180	283	136	260	383
<i>4. Frequent and varied practical science</i>						
Subject leaders time	365	730	912	547	730	912
Class based teacher time	350	699	1,398	531	1,405	2,279
Technician time	32	82	132	63	140	203
Total hours per school	746	1,511	2,443	1,141	2,275	3,394
<i>6. Technical support</i>						
Subject leaders time	48	97	121	73	97	121
Class based teacher time	57	114	228	86	228	371
Technician time	440	1,140	1,840	880	1,843	2,719
Total hours per school	546	1,351	2,189	1,038	2,168	3,210

<b>Benchmark &amp; staff type</b>	<b>School A</b>	<b>School B</b>	<b>School C</b>	<b>School D</b>	<b>School E</b>	<b>School F</b>
<i>8. Investigative projects</i>						
Class based teacher time	15	30	61	16	43	71
Technician time	13	33	53	18	38	56
Total hours per school	28	63	114	34	81	126
<i>9. A balanced approach to risk</i>						
Subject leaders time	9	17	21	13	17	21
Class based teacher time	8	16	32	12	32	52
Technician time	4	11	18	8	18	26
Total hours per school	21	44	71	33	67	100
<i>10. Assessment fit for purpose</i>						
Subject leaders time	209	418	523	314	418	523
Class based teacher time	418	836	1,672	627	1,672	2,717
Total hours per school	627	1,254	2,195	941	2,090	3,240

Source: PwC analysis

## Appendix D: Expenses by Benchmark on recurring basis

This appendix summarises the average out of pocket expenses we expect schools to incur as they undertake each of the activities we expect them to undertake if they are meeting the requirements of the benchmark. The estimates assume that each school is undertaking all the activities on an established basis. As such, the expenses exclude all one-off expenses that schools may need to incur as they meet the requirements for the first time.

Table 71: Expenses per activity by benchmark

Benchmark	Activity	Expense	Cost (£)
2. Purposeful practical science	Use research into effective science education to identify new/ different practical activities	Subscription fees for scientific teaching resources	£500 per school year
3. Expert teachers	Recruitment & induction	Advertising costs: buying advert in TES NQT health safety checks/induction	£975 per vacancy £1,060 per NQT
4. Frequent and varied practical science	Lesson delivery	Facilitating a biology field trip for each KS5 class	£450 per class <25 £550 per class >25
5. Laboratory facilities and equipment	Development of facilities Purchase of capital equipment Ongoing maintenance of facilities and equipment Consumable resources	Capital costs of developing new laboratory facilities, including suitable preparation and storage space Capital costs of purchasing laboratory equipment (e.g. microscopes, Bunsen burners and power packs). Costs of maintaining the facilities and equipment (e.g. servicing microscopes and balance Costs of the consumable resources associated with the practical science (e.g. chemicals, batteries and glassware).	£58 per pupil (combined )
6. Technical support	Recruitment & induction	Advertising costs: buying advert in local paper for three weeks	£440 per vacancy
8. Investigative projects	Provide opportunities for pupils to do open-ended extended investigative projects in science	Materials required to allow pupils to complete investigative open-ended projects	£40 per pupil

## Appendix E: One-off costs by Benchmark

This appendix summarises the average one-off costs per pupil which some schools may need to incur as they meet the requirements of a benchmark for the first time.

Table 72: One-off costs by activity (£ per pupil)

Benchmark	Activity	Description of cost	Average cost per pupil (£)
1	Engage staff and develop a policy	Developing a practical science policy, covering the entire pupil body.	£10
1	Engage staff in policy	Communicating the practical science policy to all relevant stakeholders within the school.	£1
3	Recruitment & induction	Recruitment and induction of new teachers to fill existing vacancies and to provide enough qualified teachers to meet the benchmark	£2
6	Recruitment & induction	Recruitment and induction of new technicians to fill existing vacancies to meet the benchmark	<£1
<b>Total average cost</b>			<b>£11</b>



## Appendix F: Laboratory and equipment costs

This appendix explains how we have estimated the costs of providing the laboratory space and associated equipment which some schools may need to acquire in order to deliver Benchmark 5.

Our assessment of the costs of developing and maintaining school laboratories was informed by consultations with advisers with experience of developing and operating laboratories in secondary schools in England, namely CLEAPSS and Innova Design Solutions Ltd. During these consultations, we identified four main elements of the capital costs of developing new facilities for practical science:

- The cost of developing the laboratories themselves;
- The cost of installing a fume cupboard(s) and ducting in some laboratories;
- The cost of developing preparation rooms; and
- The cost of developing additional laboratories for schools with a sixth form.

Our consultations suggested that, on average, schools require a space of between 80m<sup>2</sup> and 90m<sup>2</sup> per laboratory to accommodate a class of up to 30 to 32 pupils working in pairs. Such a space is estimated to cost, on average, £37,500 to develop (i.e. to install workbenches, storage, ventilation and gas, water and electricity points).

Teaching practical chemistry also requires that at least one laboratory has a fume cupboard. We estimate that each cupboard will cost £4,125 installed.

Schools also require preparation rooms for staff to store equipment and consumables and prepare the materials required for each practical activity. Our consultations indicated that the cost of developing such a preparation room, including installing workspace, storage, ventilation and gas, water and electricity points, would be £30,000 per preparation room. We assume that one preparation room is needed per science subject, however, more preparation rooms may be required in schools where the laboratories are spread across the school campus to avoid the health and safety risks associated with staff having to transport chemicals, radioactive sources etc. over significant distances or up or down stairs.

Our consultations also indicated that schools with a sixth form would need to develop additional laboratories to accommodate smaller class sizes and extended practical science investigations. We estimate that each school with a sixth form would develop one additional laboratory at a cost of £37,500 per school. The number of laboratories, therefore, depends on how many pupils are on the roll and the year groups taught.

We consulted suppliers of laboratory equipment to secondary schools in England to determine the costs associated with purchasing and maintaining the equipment required to deliver practical science at Key Stages 3, 4 and 5 in biology, chemistry and physics. We consulted three suppliers, namely Breckland Scientific Supplies Ltd, Philip Harris Ltd and SLS Ltd.

On this basis, we estimate the average cost and expected lifespan of each individual item of equipment. We then estimate the annualised cost per item by dividing the cost of each item by its expected lifespan (in years). Next, we divide the individual items into five different categories of laboratory equipment:

- Class/laboratory sets of standard items (e.g. goggles, clamps, Bunsen burners, tripods);

- Subject specific equipment for use by pupils in Key Stage 3 and 4 (see Table 73);
- Subject specific equipment for use by pupils in Key Stage 5 (see Table 73);
- Shared items required to deliver practical science in Key Stage 3 and 4 (see Table 74); and
- Shared items required to deliver practical science in Key Stage 5 (see Table 74).

Our consultations suggested that the costs of a class set of standard items of equipment, such as goggles, clamps, Bunsen burners, tripods etc. would range from £1,500 to £2,000 per set and that schools would have one set per laboratory. Due to the high use and relatively low cost of these sets, we assume an average lifespan of one year (i.e. that schools will need to replace lost or damaged items annually). We estimate, therefore, that the cost of each class set is £1,750 per laboratory per school year.

Table 73 shows the subject specific equipment that the suppliers we consulted suggest for secondary schools for use by pupils undertaking practical activities in Key Stages 3 to 5. It also presents our analysis of the average unit cost, the suggested number of units per laboratory and the expected lifespan of each item. We use the list of items in Table 73 to indicate the type and scale of equipment a school would purchase for use by pupils. It has been compiled for the purpose of our analysis only. On this basis, we estimate that the annualised capital costs of purchasing subject specific equipment to deliver practical activities in Key Stages 3 and 4 biology, chemistry and physics would be nearly £1,300 per school year and around £1,050 per school year for Key Stage 5 biology, chemistry and physics. We assume that schools with more than one laboratory for each subject would buy a set of subject specific equipment for each subject laboratory.

Table 73: Annualised capital costs of purchasing laboratory equipment used by pupils by Key Stage and subject

Key Stage	Subject	Equipment	Average unit cost (£)	Number of units per laboratory	Lifespan (years)	Total purchase cost per laboratory (£)	Annualised purchase cost per laboratory (£)
3 & 4	Biology	Microscopes	£113	14	7	£1,547	£221
3 & 4	Biology	Balances (student use)	£173	8	6	£1,380	£240
3 & 4	Biology	Prepared slides	£5	30	3	£135	£54
3 & 4	Physics	Power packs	£173	14	20	£2,372	£119
3 & 4	Physics	Ammeter	£20	15	5	£300	£60
3 & 4	Physics	Voltmeter	£20	15	5	£300	£60
3 & 4	Physics	Electronics kit (circuits/components)	£215	13	5	£2,688	£538
5	Biology	A-level Microscopes	£250	10	10	£2,500	£250
5	Biology	Micrometer eye pieces	£72	14	5	£987	£197
5	Chemistry	Burette flask	£225	10	5	£2,250	£450
5	Physics	Light gates	£70	10	5	£700	£140

Source: PwC analysis based on consultations with Breckland, Philip Harris, SLS. All figures are rounded to the nearest whole number.

Table 74 shows the shared items that the suppliers we consulted recommend to secondary schools for delivering practical activities in Key Stages 3 to 5. It also presents our analysis of the average unit cost based on the suggested number of units per school and the expected lifespan of each item. On this basis, we estimate that the annualised capital costs of purchasing all the shared items of equipment needed to deliver practical activities at Key Stages 3 and 4 in biology, chemistry and physics would be about £1,750 per school year. They would be similar for Key Stage 5 biology, chemistry and physics.

Table 74: Annualised capital costs of purchasing shared items of equipment by Key Stage and subject

Key Stage	Subject	Equipment	Average unit cost (£)	Number of units per school	Lifespan (years)	Total purchase cost per laboratory (£)	Annualised purchase cost per laboratory (£)
3 & 4	Biology	Autoclave	£1,150	1	8	£1,150	£153
3 & 4	Biology	Incubator	£630	1	9	£630	£72
3 & 4	Biology	Electronic balances (tech use)	£600	1	8	£600	£80
3 & 4	Biology	Data logging (associated sensors below)	£1,000	1	20	£1,000	£50
3 & 4	Biology	Temperature	£200	1	10	£200	£20
3 & 4	Biology	Light	£250	1	10	£250	£25
3 & 4	Biology	Humidity	£100	1	10	£100	£10
3 & 4	Biology	Oxygen	£180	1	2	£180	£120
3 & 4	Biology	Co2	£200	1	10	£200	£20
3 & 4	Biology	Colorimeter	£90	5	5	£450	£90
3 & 4	Biology	PH	£100	1	2	£100	£67
3 & 4	Biology	Heartrate	£90	1	10	£90	£9
3 & 4	Biology	Trolleys	£95	3	5	£261	£52
3 & 4	Biology	Water still	£975	1	13	£975	£78
3 & 4	Biology	Skeleton model	£200	1	20	£200	£10
3 & 4	Biology	Nervous system model	£90	1	20	£90	£5
3 & 4	Biology	Eye model	£35	1	20	£35	£2
3 & 4	Biology	Ear model	£70	1	20	£70	£4
3 & 4	Biology	Flower model	£30	1	20	£30	£2
3 & 4	Biology	Heart model	£35	1	20	£35	£2
3 & 4	Biology	Kidney	£50	1	20	£50	£3
3 & 4	Biology	Skin model	£60	1	20	£60	£3

Key Stage	Subject	Equipment	Average unit cost (£)	Number of units per school	Lifespan (years)	Total purchase cost per laboratory (£)	Annualised purchase cost per laboratory (£)
3 & 4	Biology	DNA model	£35	1	20	£35	£2
3 & 4	Biology	Human torso model	£90	1	20	£90	£5
3 & 4	Biology	Anatomical model	£250	1	20	£250	£13
3 & 4	Biology	Digital microscopes	£350	1	6	£350	£56
3 & 4	Chemistry	Hot plate stirrers	£295	4	5	£1,106	£221
3 & 4	Physics	Protactinium generator	£225	1	10	£225	£23
3 & 4	Physics	Signal generator lamp	£260	1	10	£260	£26
3 & 4	Physics	Dynamo demo models	£60	1	10	£60	£6
3 & 4	Physics	g by free fall'	£280	1	10	£280	£28
3 & 4	Physics	Vacuum pump	£435	1	10	£435	£44
3 & 4	Physics	GM Tubes (including lead & counter)	£200	1	10	£200	£20
3 & 4	Physics	Energy Kit (wind)	£140	10	5	£1,400	£280
3 & 4	Physics	Model of national grid	£125	1	10	£125	£13
3 & 4	Physics	Dual meter	£300	1	10	£300	£30
3 & 4	Physics	Oscilloscope	£300	1	10	£300	£30
3 & 4	Physics	Van der Graaf generator	£325	2	8	£488	£65
5	Biology	Water baths	£313	2	10	£703	£70
5	Biology	Electrophoresis	£515	1	10	£515	£52
5	Biology	Microwave oven	£75	1	10	£75	£8
5	Biology	Microwave vector	£42	1	10	£42	£4
5	Biology	Thin layer chromatography	£135	1	10	£135	£14
5	Biology	Mitosis model	£187	1	10	£187	£19
5	Biology	Quadrats(squares)	£24	13	5	£300	£60
5	Biology	Quadrats (points)	£115	13	5	£1,438	£288
5	Biology	Mitosis model	£175	1	10	£175	£18
5	Biology	Centrifuge	£644	1	10	£644	£64
5	Biology	Breathing monitor	£490	1	10	£490	£49

Key Stage	Subject	Equipment	Average unit cost (£)	Number of units per school	Lifespan (years)	Total purchase cost per laboratory (£)	Annualised purchase cost per laboratory (£)
5	Biology	PH meter probe	£100	10	6	£1,000	£167
5	Biology	Haemocytometer	£85	10	5	£850	£170
5	Biology	Chronometer	£100	5	8	£450	£60
5	Biology	3 decimal-place balance	£400	3	8	£1,200	£160
5	Chemistry	Hot plate	£33	5	5	£165	£33
5	Chemistry	Jointed glassware	£90	5	5	£450	£90
5	Physics	Radioactive sources	£570	1	13	£570	£46
5	Physics	Linear air tracker & blower	£380	1	15	£380	£25
5	Physics	Stroboscope	£220	1	10	£220	£22
5	Physics	Pico scope	£170	1	10	£170	£17
5	Physics	Ripple tank	£430	1	10	£430	£43
5	Physics	Laser	£215	1	10	£215	£22
5	Physics	Spectrophotometer	£450	1	10	£450	£45
5	Physics	Teletron tube and holder	£765	1	10	£765	£77
5	Physics	Spectrometer	£350	1	10	£350	£35
5	Physics	Radioactive sensor	£200	1	10	£200	£20
5	Physics	Radioactive storage	£160	1	10	£160	£16
5	Physics	Radioactive bench	£100	1	10	£100	£10
5	Physics	Radiation monitor & counter	£550	1	15	£550	£37

Source: PwC analysis based on consultations with Breckland, Philip Harris, SLS. All figures are rounded to the nearest whole number.

Our consultations indicated that maintenance costs varied by item:

- Those associated with laboratory facilities are, by definition, negligible over the 20 year lifespan of these facilities.
- Class sets are not expected to incur any maintenance costs.
- Where relevant, the annualised costs associated with maintaining laboratory equipment are shown in Table 75: some items are not expected to incur any maintenance costs and these are omitted from the table. On this basis, we estimate that annual maintenance costs are slightly less than £700 per school year per laboratory for equipment used by Key Stage 3 and 4 pupils in biology, chemistry and physics and just over £60 per school year for laboratory equipment used by pupils in Key Stage 5 biology, chemistry and physics.

Table 75: Annualised costs of maintaining laboratory equipment used by pupils by Key Stage and subject

Key Stage	Subject	Equipment	Maintenance cost per unit (£)	Number of units per laboratory	Maintenance frequency (years)	Total maintenance cost per laboratory (£)	Annualised maintenance cost per laboratory (£)
3 & 4	Biology	Microscopes	£31	14	7	£430	£61
3 & 4	Biology	Balances (student use)	£13	8	3	£100	£40
3 & 4	Physics	Power packs	£13	14	6	£172	£31
3 & 4	Physics	Electronics kit (circuits/components)	£45	13	1	£563	£563
5	Biology	A-level microscopes	£31	10	5	£313	£63

Source: PwC analysis based on consultations with Breckland, Philip Harris, SLS. All figures are rounded to the nearest whole number.

Table 76 shows the annualised costs of maintaining the shared items that the suppliers we consulted would recommend to secondary schools for delivering practical activities in Key Stages 3 to 5. Some items are not expected to require any maintenance so the table only includes those items expected to incur maintenance costs. On this basis, we estimate annual maintenance costs of just over £100 per school year for shared equipment used in Key Stage 3 and 4 biology, chemistry and physics and £250 per school year for shared equipment used in Key Stage 5 biology, chemistry and physics.

Table 76: Annualised costs of maintaining shared items of equipment by Key Stage and subject

Key Stage	Subject	Equipment	Maintenance cost per unit (£)	Number of units per school	Maintenance frequency (years)	Total maintenance cost per school (£)	Annualised maintenance cost per school (£)
3 & 4	Biology	Water still	£250	1	5	£250	£50
3 & 4	Biology	Digital microscopes	£13	1	5	£13	£3
3 & 4	Chemistry	Hot plate stirrers	£55	4	5	£206	£46
3 & 4	Physics	Van der Graaf generator	£10	2	3	£15	£6
5	Biology	Electrophoresis	£35	1	1	£35	£35
5	Biology	PH meter probe	£40	10	2	£400	£200
5	Biology	3 decimal-place balance	£13	3	3	£38	£15

Source: PwC analysis based on consultations with Breckland, Philip Harris, SLS. All figures are rounded to the nearest whole number.

Our consultations indicated that schools purchase more consumables in their first year than in subsequent years. Specifically, in the first year of operation they will need to purchase all of the consumable materials required to deliver Benchmark 5, while in subsequent years they will only need to replenish depleted stocks and/or replace broken equipment such as glassware. Based on our consultations, we estimate the total cost of consumables to be £4 per pupil in the first year and £2.40 per pupil per school year thereafter.

## Appendix: G: Principal assumptions

The table below provides details of the principal assumptions which underpin our assessment of the costs of meeting the ten benchmarks of good practice in the delivery of practical science. The first part of the table is devoted to a set of general assumptions which apply to most (if not all) of the benchmarks. The latter part of the table details those assumptions which are important for specific benchmarks.

Table 77: Key assumptions underlying cost estimates by benchmark

Assumption	Benchmark
Small schools have a Head of Department for each subject (i.e. one Head of Biology, one Head of Chemistry and one Head of Physics)	All
Medium sized schools have a Head of Department for each subject plus a Head of Science	All
Large schools have a Head of Department for each subject, a Head of Science and Deputy Head of Science	All
Teachers are contracted to work 1,265 hours over 195 days a year - 190 for pupil contact and five allocated for in-service training <sup>54</sup>	All
Schools have 38 weeks of teaching time per year	
SLT members, Heads of Departments and class based teachers all work 6 paid hours per day <sup>55</sup>	All
Technicians work 37 hours per week <sup>56</sup>	All
Total technician hours per week = total science teaching hours per week × 0.65 <sup>57</sup>	All
Each SLT member earns, on average, £58,400 per school year <sup>58</sup>	All
Heads of Departments (and Subject Leaders) earn, on average, £48,100 per school year (i.e. the mid-point between the median salaries for class based teachers and the SLT member)	All
Class based teachers earn, on average, £37,800 per school year <sup>59</sup>	All
Technicians earn £10 per hour on average <sup>60</sup>	All
All KS3 pupils take biology, chemistry and physics	All

<sup>54</sup> TES.

<sup>55</sup> TES.

<sup>56</sup> Data for technicians courtesy of TeachVac (December 2016).

<sup>57</sup> SCORE (2013) Benchmarks for Secondary Schools.

<sup>58</sup> DfE, SFR 21, Table 9c Full and part-time regular leadership teachers in state funded schools by salary bands, average salary, sector, gender and age, November 2015.

<sup>59</sup> DfE, SFR 21, Table 9b Full and part-time regular classroom teachers in state funded schools by salary bands, average salary, sector, gender and age, November 2015.

<sup>60</sup> PwC analysis based on CLEAPPS (2009), Technicians and their jobs (G228), data on technicians courtesy of TeachVac (December 2016) and ONS, ASHE, Provisional data for 2016).

Assumption	Benchmark
23.1% of KS4 pupils take triple science (i.e. biology, chemistry and physics) <sup>61</sup>	All
58.2% of KS4 pupils take core and additional science or double science (i.e. 57.4% take core and additional and 0.8% take double science) <sup>62</sup>	All
24.7% of KS5 pupils take biology <sup>63</sup>	All
20.8% of KS5 pupils take chemistry <sup>64</sup>	All
14.2% of KS5 pupils take physics <sup>65</sup>	All
Schools will produce a written policy that explains why teachers use practical science, the outcomes they expect from it and how they achieve those outcomes	1
The policy will be communicated to members of the science department once per academic year	1
Teachers will state the purpose of every practical activity during the lesson and explain how it relates to the rest of what they are teaching	2
If half of all science classes involve some element of a practical activity, science teachers would spend 10 hrs on average teaching practical lessons (i.e. 50% of 20 hours per week teaching time) <sup>66</sup>	2 & 4
If half of all science classes involve some element of a practical activity, on average Heads of Departments would spend 8.5 hrs teaching practical lessons (i.e. 50% of 17 hours per week teaching time) <sup>67</sup>	2 & 4
On average, secondary teachers in England spend 8 hours per week on lesson planning <sup>68</sup> . If half of all lessons involve a practical activity then teachers will spend an average of 4.0 hours per week on planning practical lessons	2 & 9
Heads of Departments in England spend 7.1 hours per week on average on lesson planning <sup>69</sup> . If half of all lessons involve a practical activity then teachers will spend an average of 3.6 hours per week on planning practical lessons	2 & 9
As part of their lesson plan teachers will plan how to introduce and follow it up each practical, take account of pupils' special needs and assess the risks and benefits of every practical activity: we assume that each activity will increase planning time by 1% per activity	2 & 9
The qualifications and training of all applicants for teaching roles within the science department will be considered as part of the school's recruitment process, therefore, no additional recruitment cost will be incurred, i.e.:	3
<ul style="list-style-type: none"> <li>• At post-16 level, teachers should have a post-A level science qualification related to the science subject they teach (biology, chemistry, physics), together with relevant pedagogical training</li> <li>• At pre-16 level, if teachers do not have a post-A level science qualification related to the subject they teach, they should have had sufficient additional training to give them the confidence and subject knowledge to conduct effective practical work at that level</li> </ul>	
1.3% of all science teaching posts are vacant (Source: DfE (2015) School Workforce Census Data, Table 15)	

<sup>61</sup> DfE (2016) SFR 48, Table 1c.

<sup>62</sup> DfE (2016) SFR 48, Table 1c.

<sup>63</sup> PwC analysis of DfE (2017) SFR 05, Table 2a.

<sup>64</sup> PwC analysis of DfE (2017) SFR 05, Table 2a.

<sup>65</sup> PwC analysis of DfE (2017) SFR 05, Table 2a.

<sup>66</sup> DfE (2014) Teachers' workload diary survey 2013, Figure 10.

<sup>67</sup> DfE (2011) Teachers' workload diary survey 2010, Table 3.

<sup>68</sup> DfE (2014) Teachers' workload diary survey 2013, Figure 13 and OECD, TALIS, 2013.

<sup>69</sup> DfE (2011) Teachers' workload diary survey 2010, Table A20.



<b>Assumption</b>	<b>Benchmark</b>
There is one NQT post for every 10.4 teachers in England (Source: DfE (2016) SFR 21, Table 7a)	
The costs associated with giving teachers access to virtual environments and simulated experiments are included under Benchmark 5	5 & 7
The ratio of technicians (FTE) to teachers is 1:3	6
Teachers in England spend 2.2 hours per week on average engaging in extra-curricular activities <sup>70</sup>	8
Secondary teachers in England spend 11 hours per week on average assessing/ marking pupils work and reports <sup>71</sup> : if half of their lesson time is devoted to practical activity, half of their marking will be devoted to the assessment of practical work (i.e. 5½ hrs)	10
The ratio of time spent on formative and summative assessments is 4:1	
Heads of Departments in England spend 5½ hours on average per week on assessing/ marking pupils work and reports <sup>72</sup> : if half of their lesson time is devoted to practical activity, half of their marking will be devoted to the assessment of practical work (i.e. 2.8 hrs)	10
The ratio of time spent on formative and summative assessments is 4:1	

<sup>70</sup> OECD, TALIS, 2013.

<sup>71</sup> DfE (2014) Teachers' workload diary survey 2013, Figure 13 and OECD, TALIS, 2013.

<sup>72</sup> DfE (2011) Teachers' workload diary survey 2010, Table A20.

# Appendix H: Recruitment/retention of teachers and technicians

This appendix explains how we estimate the costs of recruiting and retaining the teachers and technicians needed to deliver the benchmarks. It is especially relevant to Benchmarks 3 and 6.

## *Expert teachers - Teacher recruitment & retention*

Benchmark 3 envisages that secondary schools should have science teachers with the appropriate training and/or qualifications to carry out practical science with confidence and knowledge of the underlying principles.

Evidence from both official statistics published by the Department for Education and the survey of schools undertaken for Gatsby<sup>73</sup> suggests that English secondary schools will need to recruit new science teachers for three reasons in order to achieve Benchmark 3:

1. To fill existing vacancies;
2. To replace those existing teachers who do not have the qualifications implied by the benchmark; and
3. To replace teachers who are expected to leave (science) teaching because they find alternative careers, retire or die in service.

For the purpose of estimating the costs of achieving Benchmark 3 we consider each reason separately.

First, the most recent School Workforce Census shows that the number of vacancies was equivalent to 1.3% of the teaching posts across all the sciences<sup>74</sup>. We estimate that this equates to 458 teaching vacancies (see Table 78).

Table 78: Estimated number of vacancies for science teachers (all secondary schools)

Type of school	State-funded pupils	Independent pupils	Total pupils	Science teachers	Vacancies
A	50,436	21,583	72,019	705	10
B	333,850	5,889	339,739	3,321	45
C	491,887	855	492,742	4,816	66
D	141,565	132,764	274,329	2,868	37

<sup>73</sup> Pye Tait Consulting (2016) Good Practical Science Benchmark Survey.

<sup>74</sup> See Table 15 in SFR21.

Type of school	State-funded pupils	Independent pupils	Total pupils	Science teachers	Vacancies
E	703,911	95,990	799,901	8,351	107
F	1,399,060	53,852	1,452,912	15,165	194
<b>Total</b>	<b>3,120,709</b>	<b>310,933</b>	<b>3,431,642</b>	<b>35,227</b>	<b>458</b>

Source: PwC analysis

Second, we consider how many existing teachers do not have the qualifications and training implied by Benchmark 3. These vary depending on the level at which the subject is being taught: at post-16 level, teachers are expected to have a post-A level qualification related to the science subject they teach and at pre-16 they are expected to have had sufficient training to give them the knowledge and confidence they need to teach practical science.

Evidence on how many teachers fulfil each element of the benchmark comes from two potential sources:

- The School Workforce Census estimates the proportion of hours taught by subject by teachers with no relevant post A-level qualification (i.e. a more stringent requirement than the benchmark requires at pre-16)<sup>75</sup>. The proportion ranges from 25.4% for physics to 7.9% for biology (across the three single subjects) and 5.1% for combined science. These findings can be interpreted in different ways depending on how much weight is given to having specific science subject specialists. We estimate that the number of unqualified teachers in 2015/6 could be between 2,981 and 5,846 depending on how the estimate is derived (see Table 79).

Table 79: Estimated number of teachers of practical science without the qualifications and training implied by Benchmark 3 (all secondary schools)

Type of school	Science teachers	Unqualified teachers - generalists	Unqualified teachers - specialists
A	705	46	90
B	3,321	304	596
C	4,816	448	878
D	2,868	138	270
E	8,351	685	1,343
F	15,165	1,360	2,668
<b>Total</b>	<b>35,227</b>	<b>2,981</b>	<b>5,846</b>

Source: PwC analysis

- Alternatively, the survey of schools undertaken for Gatsby suggests that about 13% of post-16 teachers are not appropriately qualified and around 18% of pre-16 teachers do not have the benchmark training and qualifications<sup>76</sup>. Applying these proportions to the existing teacher workforce implies that between 4,702 and 6,254 teachers would need to be replaced for all schools to achieve the benchmark (see Table 80).

<sup>75</sup> See Table 13 of SFR20.

<sup>76</sup> Pye Tait Consulting (2016) Good Practical Science Benchmark Survey.

Table 80: Estimated number of teachers without the qualifications and training implied by Benchmark 3 (all secondary schools)

Type of school	Science teachers	Based on pre-16 teachers	Based on post-16 teachers
A	705	94	125
B	3,321	443	590
C	4,816	643	855
D	2,868	383	509
E	8,351	1,115	1,483
F	15,165	2,024	2,692
<b>Total</b>	<b>35,227</b>	<b>4,702</b>	<b>6,254</b>

Source: PwC analysis

Finally, secondary schools need to replace teachers as they leave (science) teaching because they find alternative careers, retire or, in the worst case, die in service. The DfE's Teacher Supply Model estimates these rates by the specialist subject taught<sup>77</sup>. It suggests that, on average, 15-16% of science teachers need to be replaced each year (see Table 81). This is slightly more than the average across the whole teacher workforce.

Table 81: Estimated number of science teachers needing replacement due to natural wastage (all secondary schools)

Type of school	Science teachers	Leavers
A	705	78
B	3,321	367
C	4,816	532
D	2,868	317
E	8,351	922
F	15,165	1,674
<b>Total</b>	<b>35,227</b>	<b>3,889</b>

Source: PwC analysis

As we do not have separate data at the same level of granularity for independent schools, we assume that the number of teachers that need to be recruited in independent schools is proportionate to the number of pupils in the different types of school. Table 82 shows our results.

<sup>77</sup> Department for Education, 'Teacher Supply Model 2016/7'.

Table 82: Estimated science teacher recruitment needs in independent secondary schools

Type of school	Science teachers	Vacancies	Unqualified teachers <sup>78</sup>	Leavers	Total
A	211	3	14	23	40
B	58	1	5	6	12
C	8	0	1	1	2
D	1,388	18	67	153	238
E	1,002	13	82	111	206
F	562	7	50	62	120
<b>Total</b>	<b>3,230</b>	<b>41</b>	<b>219</b>	<b>357</b>	<b>617</b>

Source: PwC analysis

Table 83 summarises our estimates of the number of science teachers that secondary schools will need to recruit in order to meet Benchmark 3. We see the need to fill existing vacancies and replace unqualified teachers as a one-off activity whereas we see the replacement of teachers because of natural wastage as a recurring activity.

Table 83: Overall estimate of science teacher recruitment needs (all secondary schools)

Type of school	Total teachers	Vacancies	Unqualified teachers <sup>79</sup>	Leavers	Total
A	705	10	46	78	134
B	3,321	45	304	367	716
C	4,816	66	448	532	1,045
D	2,868	37	138	317	491
E	8,351	107	685	922	1,713
F	15,165	194	1,360	1,674	3,228
<b>Total</b>	<b>35,227</b>	<b>458</b>	<b>2,981</b>	<b>3,889</b>	<b>7,328</b>

Source: PwC analysis

For schools, there are two costs of recruiting science teachers:

- The cost of advertising each post – we assume that each vacancy will be advertised in the TES; and
- The time that existing staff need to spend interviewing potential recruits and then inducting them.

<sup>78</sup> Based on a need for general science teachers rather than specific subject specialists.

<sup>79</sup> Based on a need for general science teachers rather than specific subject specialists.

Table 84 summarises our estimates of the cost of recruiting specialist teachers in each of the six school types. We treat the cost of filling vacancies and replacing unqualified teachers as a one-off cost whereas we assume that the cost of replacing teachers who leave through natural wastage is a recurring cost which schools will face every year.

Table 84: Estimated cost of recruiting each science teacher (all secondary schools)

	SLT member	Subject leaders	Class based teachers	Technicians	Expenses	Total cost
Hours required for each recruitment & induction	6	6	6	1		
Cost of each recruitment & induction (£)	£423	£349	£274	£14	£975	£2,035

Source: PwC analysis

In addition, it could be argued that (at least some) teachers' wages would need to rise if schools are to have a sustainable supply of teachers. Such a view would be consistent with the labour market evidence in the House of Commons Education Select Committee report<sup>80</sup> and the report of the Teachers' Review Body<sup>81</sup>.

The potential cost to schools of such a wage increase depends on two key parameters:

- How sensitive the supply of science teachers is to the wages offered (i.e. the wage elasticity of supply of science teachers); and
- Whether any wage increase would need to be offered to all teachers or only those who are newly recruited.

Evidence from the literature suggests that the supply of teachers is relatively inelastic with respect to wages/salaries (i.e. a large change in wages/salaries is needed to prompt even a relatively small change in the supply of teachers).

On the other hand, we note that if wages/salaries were increased, the higher costs for schools would be offset by the reduced recruitment costs in the future through lower rates of natural wastage.

### *Technical support – recruitment and retention of technicians*

Benchmark 6 envisages that all secondary schools should have enough technical support to enable teachers to carry out frequent and effective practical science.

There are two key reasons why schools may need to recruit technicians to achieve Benchmark 6:

1. To fill existing vacancies; and
2. To replace existing technicians who are expected to leave schools as a result of natural wastage, especially because they find alternative careers.

<sup>80</sup> School Teachers Review Body, Twenty-Sixth Report, 2016

<sup>81</sup> House of Commons Education Committee, 'Recruitment and retention of teachers: Fifth report of session 2016-17', 2017.

For the purpose of estimating the costs of achieving Benchmark 6 we consider each reason separately.

First, evidence from previous research for Gatsby suggests that the number of technician vacancies was equivalent to 2% of the existing technician posts across all the sciences<sup>82</sup>. We estimate that this equates to around 223 technician vacancies (see Table 85).

Table 85: Estimated number of vacancies for technicians (all secondary schools)

Type of school	Science teachers	Technicians	Vacancies
A	705	223	4
B	3,321	1,050	21
C	4,816	1,523	30
D	2,868	907	18
E	8,351	2,640	53
F	15,165	4,794	96
<b>Total</b>	<b>35,227</b>	<b>11,136</b>	<b>223</b>

Source: PwC analysis

Second, secondary schools need to replace existing technicians as they leave schools because they find alternative careers, retire or, in the worst case, die in service. We have found no evidence on the wastage rate specifically for technicians. We assume, therefore, that it is the same as the one we use to estimate the need to replace science teachers as part of Benchmark 3. This means we assume that, on average, 15-16% of technicians need to be replaced each year.

Table 86: Estimated number of technicians needing to be replaced each year due to natural wastage (all secondary schools)

Type of school	Science teachers	Technicians	Leavers
A	705	223	19
B	3,321	1,050	89
C	4,816	1,523	129
D	2,868	907	77
E	8,351	2,640	223
F	15,165	4,794	406
<b>Total</b>	<b>35,227</b>	<b>11,136</b>	<b>942</b>

Source: PwC analysis

As we do not have separate data for independent schools, we assume that the number of technicians that need to be recruited in independent schools is proportionate to the number of pupils in each type of school.

<sup>82</sup> See Table 15 in SFR21

Table 87 summarises our estimates of the number of technicians that secondary schools will need to recruit in order to meet Benchmark 6. We see the need to fill vacancies (including achieving the optimal level of support) as a one-off activity whereas we see the replacement of technicians because of natural wastage as a recurring activity. We consider the possible substitution of teachers with technicians as a sensitivity.

Table 87: Overall estimate of technician recruitment needs (all secondary schools)

Type of school	Technicians	Vacancies	Leavers	Total	Vacancies per school	Leavers per school
A	223	4	19	23	0.01	0.06
B	1,050	21	89	110	0.04	0.16
C	1,523	30	129	159	0.07	0.28
D	907	18	77	95	0.02	0.10
E	2,640	53	223	276	0.06	0.25
F	4,794	96	406	502	0.09	0.39
<b>Total</b>	<b>11,136</b>	<b>223</b>	<b>942</b>	<b>1,165</b>		

Source: PwC analysis

Evidence from several sources suggests that English secondary schools struggle to recruit sufficient technicians to provide technical support with the result that science teachers take on more responsibility than is optimal.

To substitute technicians for teachers so that teachers can spend more of their time teaching pupils.

Finally, we consider the scope for substituting teachers with technicians.

For schools, there are two costs of recruiting technicians:

- The cost of advertising each post – we assume that each post is advertised in local media; and
- The time that existing staff need to spend interviewing potential recruits and then inducting them.

Table 88 summarises our estimates of the cost of recruiting technicians. We treat the cost of filling vacancies as a one-off cost whereas we assume that the cost of replacing technicians who leave through natural wastage is a recurring one which schools will face every year.

Table 88: Estimated cost of recruiting technicians (£)

	SLT member	Subject leaders	Class based teachers	Technicians	Expenses	Total cost
Hours required for each recruitment & induction	0	6	1	4		
Cost of each recruitment & induction (£)	0	£349	£42	£52	£440	£883

Source: PwC analysis



In addition, it could be argued that (at least some) technicians' wages would need to rise if schools are to have a sustainable supply. Such a view would be consistent with the experience of school staff and labour market evidence.

The potential cost to schools of such a wage increase depends on two key parameters:

- How sensitive the supply of technicians is to the wages offered (i.e. the wage elasticity of supply of technicians); and
- Whether any wage increase would need to be offered to all technicians or only those who are newly recruited.

Evidence from our interviews suggests that the supply of technicians is more elastic with respect to wages/salaries than that of teachers (i.e. a relatively small change in wages/salaries prompts a significant change in the supply of technicians).

On the other hand, we note that if wages/salaries were increased, the higher costs for schools would be at least partly offset by the reduced future recruitment costs through lower rates of natural wastage.



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140327-075751-NM-OS