APPENDIX 4: THE SCHOOL SURVEY

GATSBY

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EXECUTIVE SUMMARY

The table below summarises the proportion of schools and colleges[1] surveyed, that achieve each component within the 10 benchmarks. Table 2 (which follows) shows the proportion of schools and colleges achieving *all* components within the 10 benchmarks.

Please note that there may be instances where there are small changes to wording in the final version of the full Good Practical Science report and what is found within this appendix. These changes are stylistic and do not alter any data or findings presented.

Please note some charts do not total 100% due to rounding.

Table 1: Proportion of schools that achieve each component within the benchmarks

Benchmarks		% of schools that achieve each component within the benchmark
1. Planned practical science	Every school 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 value of having a written policy lies in the process of its production	
	Schools that have a written policy	23%[2]
	Schools with a written policy where the head(s) of department, science teachers and technicians were all involved in its development	31%
	Schools *with a written policy* that have discussions among the science department team, including all teachers and technicians, as and when required, about:	
	– Why teachers use practical science, the outcomes they expect from it and how they achieve those outcomes	44%
	– The different approaches to practical science in different age groups	42%
	– How special needs are accommodated	59%
	– Use of opportunities for practical science outside the school, in universities, industry, science centres etc.	50%
	All schools that have discussions among the science department team, including all teachers and technicians, as and when required, about:	
	– 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	54%
	– How special needs are accommodated	67%
	– Use of opportunities for practical science outside the school, in universities, industry, science centres etc	58%
	Schools with a written policy annually reviewing this against practice	67%[3]
	Schools with a member of the senior leader team with an overview of practical science	40%
	Schools with a written policy that have a member of the senior leader team with an overview of practical science	10%

[1] For ease the term 'schools' is used to refer to schools and sixth form colleges.
[2] However this may not always correspond exactly to the benchmark requirements – see section 4.
[3] Includes respondents saying they will review the policy more than once a year.

Benchmarks		% of schools that achieve each component within the benchmark
2. Purposeful practical science	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	
	Schools where all teachers should have a clear purpose for every practical activity and know how it relates to the rest of what they are teaching	40%
	Schools where all teachers plan to their satisfaction, how to introduce each practical science activity to students before it is started	36%
	Schools where all teachers plan, to their satisfaction, how to follow up each practical science activity with students	32%
	Schools where all teachers take account of students' special needs in their planning, so all students can participate equally	36%
3. Expert teachers	Teachers should have had subject specialist training (both initial and continuing) in 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	
	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)	72%
	Schools where all teachers at post-16 level have relevant pedagogical training relevant to their specialist subject	55%
	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	27%
	Schools where all science teachers have annual reviews of training and development needs in relation to practical science	34%
	Schools where all science teachers have time for professional reflection with colleagues where so required	39%
	Schools where all science teachers have regular training specific to practical science	22%
4. Frequent and varied practical science	Students should experience a practical activity in at least half of their science lessons. These activities can be short, but should be varied in type	
	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	
	– Key Stage 3 science	68%
	– Key Stage 4 biology	33%
	– Key Stage 4 chemistry	55%
	– Key Stage 4 physics	47%
	– Post-16 biology	15%
	– Post-16 chemistry	28%
	– Post-16 physics	24%
	– Post-16 applied science	38%

Benchmarks		% of schools that achieve each component within the benchmark
	Schools where all science lessons are at least 50 minutes long	88%
	Schools where for practical activities over the course of the year all of the following are used: investigations, projects, collaborative research, experiments to confirm theory, experiments to show phenomena, and practising techniques	
	– Pre-16 sciences	32%
	– Post-16 sciences	34%
5. Laboratory facilities and equipment	Schools should have enough laboratories to make it possible for every teacher to do frequent practical science safely. Each laboratory should have sufficient equipment for students to work in small groups	
	Schools where the availability of laboratories is never a barrier to carrying out practical activities in the science subjects taught	31%
	Schools where all laboratories have sufficient space to safely accommodate the size of classes that will occupy them	40%
	Schools where all laboratory space is flexible enough to allow students to work individually, in pairs and in small groups	43%
	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	42%
	Schools where all laboratories give ready access to technology available to teachers to enable collection and analysis of digital data	27%
	Schools that have a preparation space or spaces with well-organised, safe storage with easy access to laboratories	71%
	Schools where all laboratories are accessible to students with any Special Educational Needs and Disabilities (SEND) encountered in the school	50%
	Schools where all laboratory facilities are such that students can carry out extended practical science investigations (see Benchmark 8)	28%
	Schools that have an accessible outdoor space where practical activities can take place	82%
6. Technical support	Science departments should have enough technical support to enable teachers to carry out frequent and effective practical science	
	Schools with sufficient specialist 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%

Benchmarks		% of schools that achieve each component within the benchmark
7. Real experiments, virtual enhancements	Teachers should use digital technologies to support and enhance practical experience, but not to replace it	
	Schools that use virtual environments and simulated experiments to replace practical science experiences little of the time	58%
	Schools where all science teachers have access to evidence about what works, in relation to digital technologies	18%
	Schools where all science teachers have training in the use of digital technologies	17%
8. Investigative projects	Students should have opportunities to do open-ended and extended investigative projects	
	Schools where all students 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 students can carry out extended practical science investigations	28%
9. A balanced approach to risk	Students' experience of practical science should not be restricted by unnecessary risk aversion	
	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%
	Schools that ensure access to authoritative and up-to-date guidance including model risk assessments, is given:	
	– To all science teachers	63%
	– To all science technicians	85%
	Schools where all science teachers assess the risks and benefits for every practical activity, and act accordingly	51%
	Schools where a balanced and proportionate approach to managing risks, with support by senior management in doing so, is adopted by:	
	– All science teachers	60%
	– All science technicians	72%
10. Assessment fit for purpose	Assessment of students' work in science should include assessment of their practical knowledge, skills and behaviours. This applies to both formative and summative assessment	
	Schools where teachers reflect on students' practical skills and knowledge when awarding a grade for science rated at 8 or above (using a scale of 1–10, where 1 is 'not at all' and 10 is 'fully and completely')	17%
	Schools where teachers use practical activities as an opportunity very or quite regularly to formatively assess students' understanding of science	65%

Table 2: Proportion of schools that achieve all components within the benchmarks

Benchmarks		% of schools that achieve all components within the benchmark
1. Planned practical science	Every school 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 value of having a written policy lies in the process of its production	8%
2. Purposeful practical science	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	24%
3. Expert teachers	Teachers should have had subject specialist training (both initial and continuing) in 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	3%
4. Frequent and varied practical science	Students should experience a practical activity in at least half of their science lessons. These activities can be short, but should be varied in type	3%
5. Laboratory facilities and equipment	Schools should have enough laboratories to make it possible for every teacher to do frequent practical science safely. Each laboratory should have sufficient equipment for students to work in small groups	3%
6. Technical support	Science departments should have enough technical support to enable teachers to carry out frequent and effective practical science	42%
7. Real experiments, virtual enhancements	Teachers should use digital technologies to support and enhance practical experience, but not to replace it	9%
8. Investigative projects	Students should have opportunities to do open-ended and extended investigative projects	4%
9. A balanced approach to risk	Students' experience of practical science should not be restricted by unnecessary risk aversion	27%
10. Assessment fit for purpose	Assessment of students' work in science should include assessment of their practical knowledge, skills and behaviours. This applies to both formative and summative assessment	15%

Tables 3 and 4 show the proportion of schools achieving each component, and all components, in respect of the benchmarks that have been relaxed. For example, instead of taking *into consideration* all *schools with a written policy, the relaxed Benchmark 1 is met by schools with a written policy, as well as those that have plans in place to develop a written policy.*

Table 3: Proportion of schools that achieve each component within the benchmarks – where benchmarks are relaxed

Benchmarks		% of schools that achieve each component within the benchmark
1. Planned practical science	Every school 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 value of having a written policy lies in the process of its production	
	Schools that have a written policy or have plans in place to develop one	32%[4]
	Schools with a member of the senior leader team with an overview of practical science, or have plans in place to nominate one	41%
2. Purposeful practical science	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	
	Schools where all, or the vast majority, of teachers should have a clear purpose for every practical activity and know how it relates to the rest of what they are teaching	83%
	Schools where all, or the vast majority, of teachers plan to their satisfaction, how to introduce each practical science activity to students before it is started	76%
	Schools where all, or the vast majority, of teachers plan, to their satisfaction, how to follow up each practical science activity with students	69%
	Schools where all, or the vast majority, of teachers take account of students' special needs in their planning, so all students can participate equally	70%

[4] However this may not always correspond exactly to the benchmark requirements – see section 4.

Table 3: Proportion of schools that achieve each component within the benchmarks – where benchmarks are relaxed

Benchmarks		% of schools that achieve each component within the benchmark
3. Expert teachers	Teachers should have had subject specialist training (both initial and continuing) in 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	
	Schools where all, or the vast majority, of teachers at post-16 level have a post-A-level science qualification related to the science subject they teach (biology, chemistry, physics)	91%
	Schools where all, or the vast majority, of teachers at post-16 level have relevant pedagogical training relevant to their specialist subject	81%
	Schools where all, or the vast majority, of 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	44%
	Schools where all, or the vast majority, of science teachers have annual reviews of training and development needs in relation to practical science	46%
	Schools where all, or the vast majority, of science teachers have time for professional reflection with colleagues where so required	55%
	Schools where all, or the vast majority, of science teachers have regular training specific to practical science	39%

Benchmarks		% of schools that achieve each component within the benchmark
4. Frequent and varied practical science	Students should experience a practical activity in at least half of their science lessons. These activities can be short, but should be varied in type	
	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 [5]	
	– Key Stage 3 science	68%
	– Key Stage 4 biology	33%
	– Key Stage 4 chemistry	55%
	– Key Stage 4 physics	47%
	– Post-16 biology	15%
	– Post-16 chemistry	28%
	– Post-16 physics	24%
	– Post-16 applied science	38%
	Schools where all science lessons are at least 50 minutes long[6]	88%
	Schools where for practical activities over the course of the year all or most of the following are used: investigations, projects, collaborative research, experiments to confirm theory, experiments to show phenomena, and practising techniques	
	– Pre-16 sciences	71%
	– Post-16 sciences	75%

[5] NB this aspect of Benchmark 4 is not relaxed.
[6] NB this aspect of Benchmark 4 is not relaxed.

Benchmarks		% of schools that achieve each component within the benchmark
5. Laboratory facilities and equipment	Schools should have enough laboratories to make it possible for every teacher to do frequent practical science safely. Each laboratory should have sufficient equipment for students to work in small groups	
	Schools where the availability of laboratories is never or not at all often a barrier to carrying out practical activities in the science subjects taught	63%
	Schools where all or most laboratories have sufficient space to safely accommodate the size of classes that will occupy them	77%
	Schools where all or most laboratory space is flexible enough to allow students to work individually, in pairs and in small groups	71%
	Schools where all or most laboratories have sufficient equipment to make it possible for teachers to do standard practical activities expected in their specialist subject at that level	74%
	Schools where all or most laboratories give ready access to technology available to teachers to enable collection and analysis of digital data	43%
	Schools that have a preparation space or spaces with well-organised, safe storage with easy access to laboratories, or mostly have this	94%
	Schools where all or most laboratories are accessible to students with any Special Educational Needs and Disabilities (SEND) encountered in the school	69%
	Schools where all or most laboratory facilities are such that students can carry out extended practical science investigations (see Benchmark 8)	51%
	Schools that have an accessible outdoor space where practical activities can take place[7]	81%

[7] NB this aspect of the benchmark has not been relaxed (being a 'yes' or 'no' response).

Benchmarks		% of schools that achieve each component within the benchmark
6. Technical support	Science departments should have enough technical support to enable teachers to carry out frequent and effective practical science	
	Schools with sufficient specialist technical expertise to support practical work in each of biology, chemistry and physics[8]	66%
	Schools where all or most science technicians are given regular opportunities to have professional development	70%
7. Real experiments, virtual enhancements	Teachers should use digital technologies to support and enhance practical experience, but not to replace it	
	Schools that use virtual environments and simulated experiments to replace practical science experiences little or some of the time	91%
	Schools where all, or the vast majority, of science teachers have access to evidence about what works, in relation to digital technologies	29%
	Schools where all, or the vast majority, of science teachers have training in the use of digital technologies	27%
8. Investigative projects	Students should have opportunities to do open-ended and extended investigative projects	
	Schools where all, or the vast majority, of students have opportunities to do open-ended extended investigative projects in science over the course of their school career	24%
	Schools where all or most laboratory facilities are such that students can carry out extended practical science investigations	51%
9. A balanced approach to risk	Students' experience of practical science should not be restricted by unnecessary risk aversion	
	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, or the vast majority, of science teachers	90%
	– By all or most science technicians	89%
	Schools that ensure access to authoritative and up-to-date guidance including model risk assessments, is given:	
	– To all, or the vast majority, of science teachers	78%
	– To all or most science technicians	90%
	Schools where all, or the vast majority, of science teachers assess the risks and benefits for every practical activity, and act accordingly	85%
	Schools where a balanced and proportionate approach to managing risks, with support by senior management in doing so, is adopted by:	
	– All, or the vast majority of, science teachers	83%
	– All or most science technicians	84%

[8] NB this aspect of the benchmark has not been relaxed (being a 'yes' or 'no' response).

Benchmarks		% of schools that achieve each component within the benchmark
10. Assessment fit for purpose	Assessment of students' work in science should include assessment of their practical knowledge, skills and behaviours. This applies to both formative and summative assessment[9]	
	Schools where teachers reflect on students' practical skills and knowledge when awarding a grade for science rated at 8 or above (using a scale of 1–10, where 1 is 'not at all' and 10 is 'fully and completely')	16%
	Schools where teachers use practical activities as an opportunity very or quite regularly to formatively assess students' understanding of science	65%

Table 4: Proportion of schools that achieve all components within the benchmarks – where benchmarks have been relaxed

Benchmarks		% of schools achieving all components within the benchmark
1. Planned practical science	Every school 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 value of having a written policy lies in the process of its production	14%
2. Purposeful practical science	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	58%
3. Expert teachers	Teachers should have had subject specialist training (both initial and continuing) in 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	7%
4. Frequent and varied practical science	Students should experience a practical activity in at least half of their science lessons. These activities can be short, but should be varied in type	5%
5. Laboratory facilities and equipment	Schools should have enough laboratories to make it possible for every teacher to do frequent practical science safely. Each laboratory should have sufficient equipment for students to work in small groups	15%
6. Technical support	Science departments should have enough technical support to enable teachers to carry out frequent and effective practical science	53%
7. Real experiments, virtual enhancements	Teachers should use digital technologies to support and enhance practical experience, but not to replace it	20%
8. Investigative projects	Students should have opportunities to do open-ended and extended investigative projects	14%
9. A balanced approach to risk	Students' experience of practical science should not be restricted by unnecessary risk aversion	54%
10. Assessment fit for purpose[10]	Assessment of students' work in science should include assessment of their practical knowledge, skills and behaviours. This applies to both formative and summative assessment	15%

[9] NB this benchmark has not been relaxed.
[10] NB this benchmark has not been relaxed.

Table 5 shows the proportion of schools that reach at least one benchmark (full and relaxed). Just over a third (36%) reach no benchmarks (full), and 8% reach no benchmarks when they are relaxed. No school reaches more than seven full benchmarks, and no school reaches more than eight relaxed benchmarks.

Table 5: Proportion of schools reaching different numbers of benchmarks (full and relaxed)

% of schools that:	Full benchmarks	Relaxed benchmarks
Reach at least one benchmark	64%	92%
Reach at least two benchmarks	37%	78%
Reach at least three benchmarks	20%	58%
Reach at least four benchmarks	11%	38%
Reach at least five benchmarks	6%	23%
Reach at least six benchmarks	1%	10%
Reach at least seven benchmarks	0.3%	3%
Reach eight benchmarks	0%	0.8%

1. INTRODUCTION

1. Practical science gives students the necessary skills for higher education and employment, deepens their knowledge of scientific ideas and enables them to engage in the processes of science. It can only flourish when teachers are confident in its use, schools and colleges are sufficiently resourced and the practical skills gained by students are appropriately recognised in science qualifications.
2. The Gatsby Foundation has asked Sir John Holman to make recommendations for 'Good Practical Science' in schools and sixth form colleges in England. To date this study has comprised desk-based research and visits to schools and education experts in six countries which perform well in international comparisons of science education.
3. A draft set of 10 benchmarks has been developed as a result of the study. The Gatsby Foundation believes that if achieved by all schools and colleges, these benchmarks will enable better practical science in England. The aim of this research is to ascertain the extent to which whether schools and colleges are able to meet the benchmarks, as well as to understand how senior staff may interpret and use the benchmarks.
4. The results of this survey, and other evidence being gathered, will be used in the redevelopment of the benchmarks for the final report, and to inform implementation plans. Concurrent research is taking place to estimate the financial costs of achieving the benchmarks.
5. The school and college survey, analysis of the data and reporting, have been undertaken by Pye Tait Consulting.

2. METHODOLOGY

1. The survey of secondary schools and colleges in England was undertaken via a self-completion online questionnaire. The questionnaire was designed by Pye Tait Consulting, in collaboration with Sir John Holman and the Gatsby Foundation, and scripted using survey software. The survey was piloted prior to launch, and minor amendments made to two questions.
2. Invitations to take part in the survey were sent out to senior contacts and heads of science in schools and colleges, sourced through a reputable supplier of education online databases. The survey was conducted between 28th November 2016 and 26th January 2017.
3. Returns were provided by 417 respondents. Post-data cleaning removed five duplicate responses and five responses which had not been fully completed. This resulted in returns from 408 unique institutions, and these data were used for the analysis. The survey therefore achieved a sample of 10% of secondary schools in England.
4. Following submission of the draft report, it was decided to remove Further Education institutions (12 respondents) from the analysis, as these institutions were considerably larger in size (student numbers) and subject to different funding arrangements, which could skew the data.
5. The achieved margin of error for the whole of the survey is ±4.62% at the 95% confidence interval. The margins of error for school sizes, types and region are higher, therefore cross-tabulations using these or other criteria within this report should be treated with caution. The margin of error per question may also be affected by variations in the base number of responses.
6. Follow up in-depth interviews were undertaken with 20 respondents. A question in the survey asked respondents to indicate their willingness to take part in a follow up telephone interview – 72% agreed to a follow up interview. Respondents for the in-depth interviews were selected to obtain a cross-section of school types, sizes and region.
7. A semi-structured topic guide for the in-depth interviews was designed using top-level analysis of the survey data, to identify key emerging messages to be probed in more detail. Telephone interviews took place during 26th January and 7th February 2017.
8. Using Snap Software, Chi Squared tests were carried out on the variables to investigate whether the data were independent (i.e. the variables differ from one another), or whether there was a relationship. Where the Chi Squared result is significant ($p < 0.05$), the null hypothesis, that there is no relationship between the variables, can be rejected. In certain cases, as is usual with such surveys, low-count cells have been encountered. This is entirely normal given that certain responses (for example a rating of 1 on a 1–10 rating scale) will inevitably attract low numbers of respondents. However, the reader is cautioned that, where there are high proportions of low-count cells, and taking into account the precise question under consideration, the resulting significance levels should be used with care. High proportions of low-count cells are indicated in footnotes in the main body of the report where applicable.

9. Using SPSS, where an ordinal scaled variable was analysed together with a nominal scaled variable, pair-wise Mann-Whitney U-Tests were performed. Where there were more than two groups of Independent Variables, a Kruskal Wallis test was carried out initially to investigate if there were any statistical differences between the variables (such as by size). Further Mann Whitney U tests were then carried out if the Kruskal Wallis highlighted a significance, in order to establish further details concerning the significance.
10. The significance (p) level was set to 0.05 for all tests. Results are described as significant where the p value is less than 0.05, and marginally significant when the p level is between 0.05 and 0.10. Results where the p value is more than 0.10 are interpreted as not significant.

3. SURVEY RESPONDENTS

Table 6: Profile of survey respondents

Total		408	%
Job role	Head(s) of science	314	77%
	Science teacher	29	7%
	Curriculum leader, programme/course leader or science coordinator	21	5%
	Assistant head *and* head of science	12	3%
	Assistant head/principal	12	3%
	Assistant/deputy head of science	8	2%
	Senior science technicians or science technicians	8	2%
	Other	4	1%
Institution type	Academy (includes converter/sponsor-led/special)	208	50%
	Community school (includes special)	43	10%
	Grammar school	14	3%
	Foundation School (includes Special)	12	3%
	Free School (includes Special)	12	3%
	Further Education [11]	12	3%
	Other Independent School (includes Special)	35	8%
	Middle (deemed secondary state-funded)	18	4%
	Middle (deemed secondary independent)	4	1%
	Pupil Referral Unit	4	1%
	Sixth Form Centre	20	5%
	Studio School	1	0%
	University Technical College	5	1%
	Voluntary Aided School	18	4%

[11] Further Education institutions are included here in the breakdown of survey respondents, but were excluded from analysis as explained on page 16.

Total		408	%
Institution type	Voluntary Controlled School	3	1%
	Other	6	1%
Institution size[12]	Less than 300 pupils	40	10%
	301– 600 pupils	60	15%
	601–900 pupils	93	23%
	901–1500 pupils	155	39%
	1500+ pupils	48	13%
Region	East of England	47	11%
	East Midlands	30	7%
	London	46	11%
	North East	23	6%
	North West	42	10%
	South East	89	22%
	South West	56	14%
	West Midlands	44	11%
	Yorkshire and the Humber	37	9%
Age of students	11–16	131	32%
	11–18	248	61%
	16–18	29	7%
Ofsted grading	Outstanding	99	24%
	Good	179	44%
	Requires improvement	44	11%
	Inadequate	3	1%
	No Ofsted grading available or school name not given	83	20%
Science facilities refurbished in the last five years	Yes	163	40%
	No	245	60%

[12] Not all respondents gave a response to this question.

4. BENCHMARK 1 – PLANNED PRACTICAL SCIENCE

Every school 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.

The value of having a written policy lies in the process of its production. This process should include discussion among the science department team, including all teachers and technicians, about:

- Why teachers use practical science, the outcomes they expect from it and how they achieve those outcomes
- The different approaches to practical science in different age groups
- How special needs are accommodated
- Any use of opportunities for practical science outside the school, in universities, industry, science centres etc.

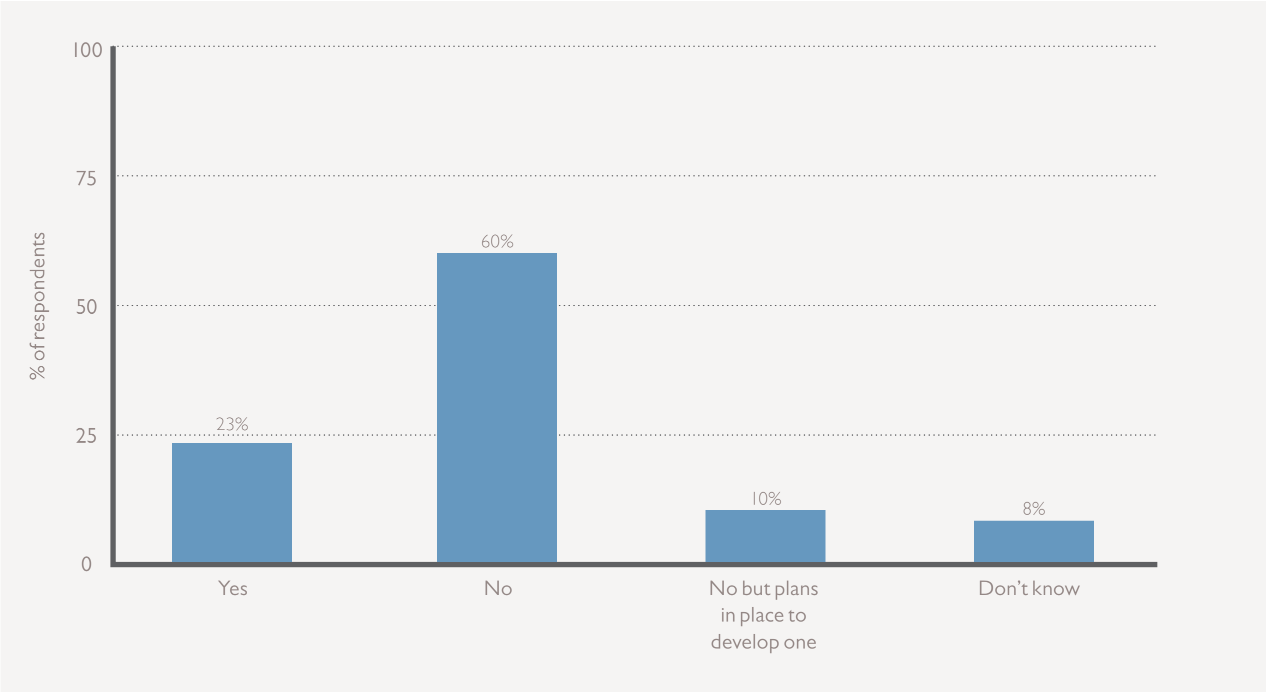
The policy should be annually reviewed against practice.

There should be a member of the senior leader team with an overview of practical science.

1. Nearly a quarter of survey respondents (23%) have a written policy on the use of practical science. A further 10% of respondents say they have plans to develop a policy (Figure 1). A higher proportion of independent schools (51%) have a written policy in place compared with the average for all institution types (Figure 2).[13]
2. A higher proportion of small schools (with fewer than 300 pupils) have a written policy, compared with larger institutions. Nearly double the number of small schools than large schools (1500+ pupils) have a written policy in place – 38% of respondents compared with 20%. Similarly a higher proportion of small schools have plans to develop a policy where one is not currently in place – 15% of respondents compared with 5% (Figure 3). These findings are statistically significant.
3. A slightly higher proportion of schools without sixth forms have a written policy (26% of respondents) compared with those with sixth forms (21% of respondents). Just over a fifth of institutions only teaching pupils aged 16–18 have a written policy (22% of respondents) (Figure 4).

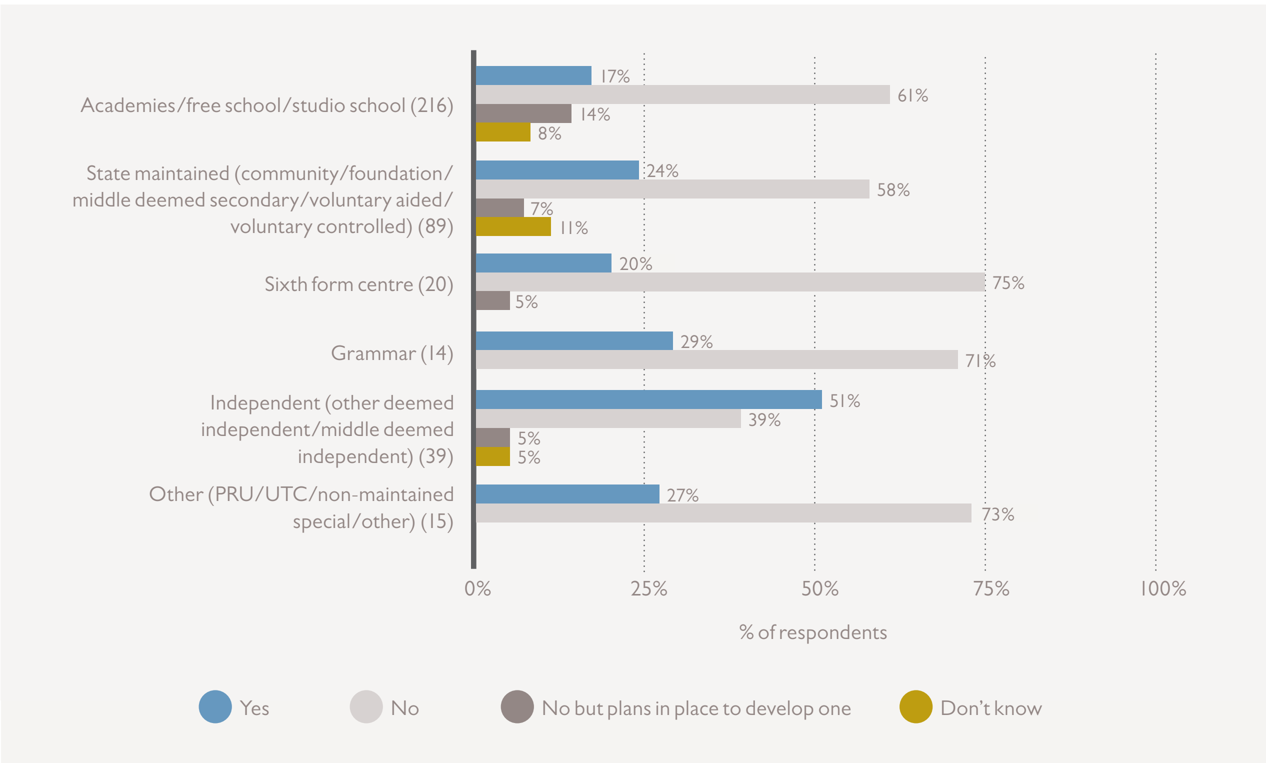
[13] There is evidence of a relationship between these variables, significant at the 1% level, however this does not show that one causes the other, only that there is a relationship. 45.8% of cells have an expected value of less than 5.

Figure 1: Do you have a written policy on the use of practical science?



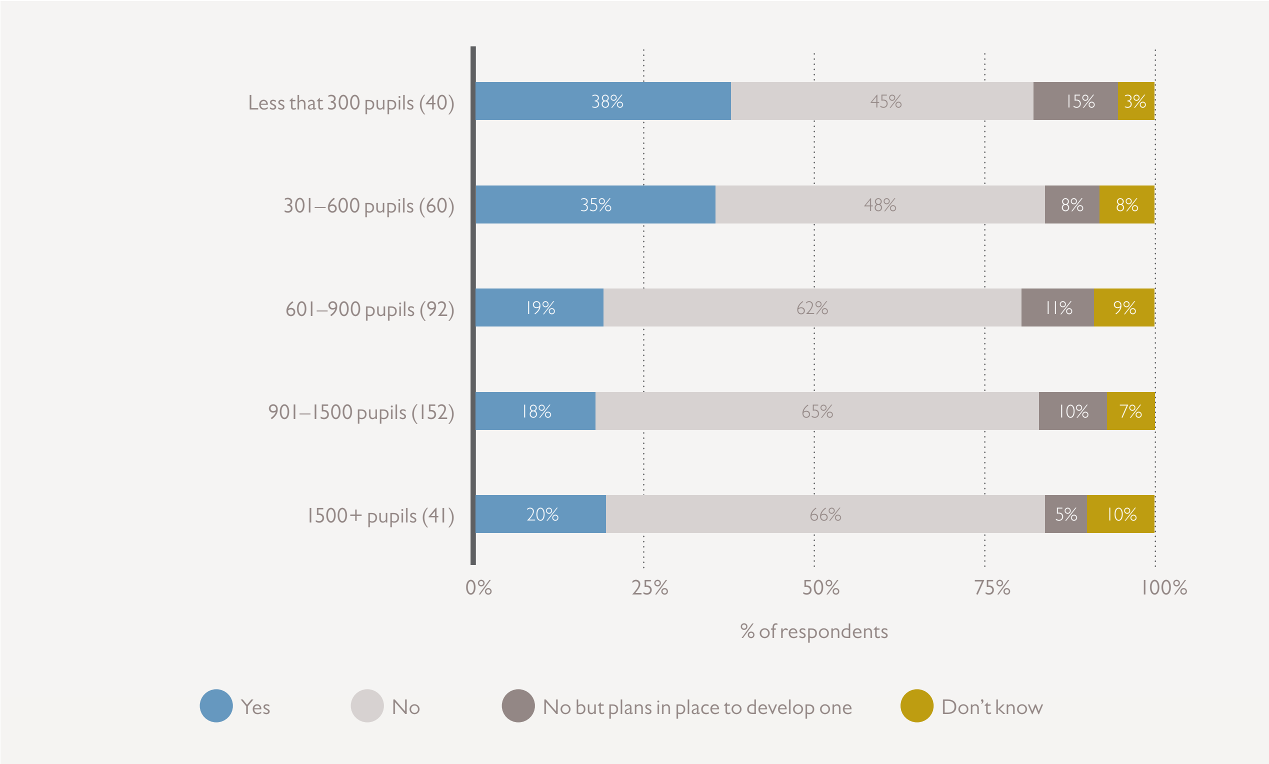
Base 394

Figure 2: Do you have a written policy on the use of practical science? (Institution types)



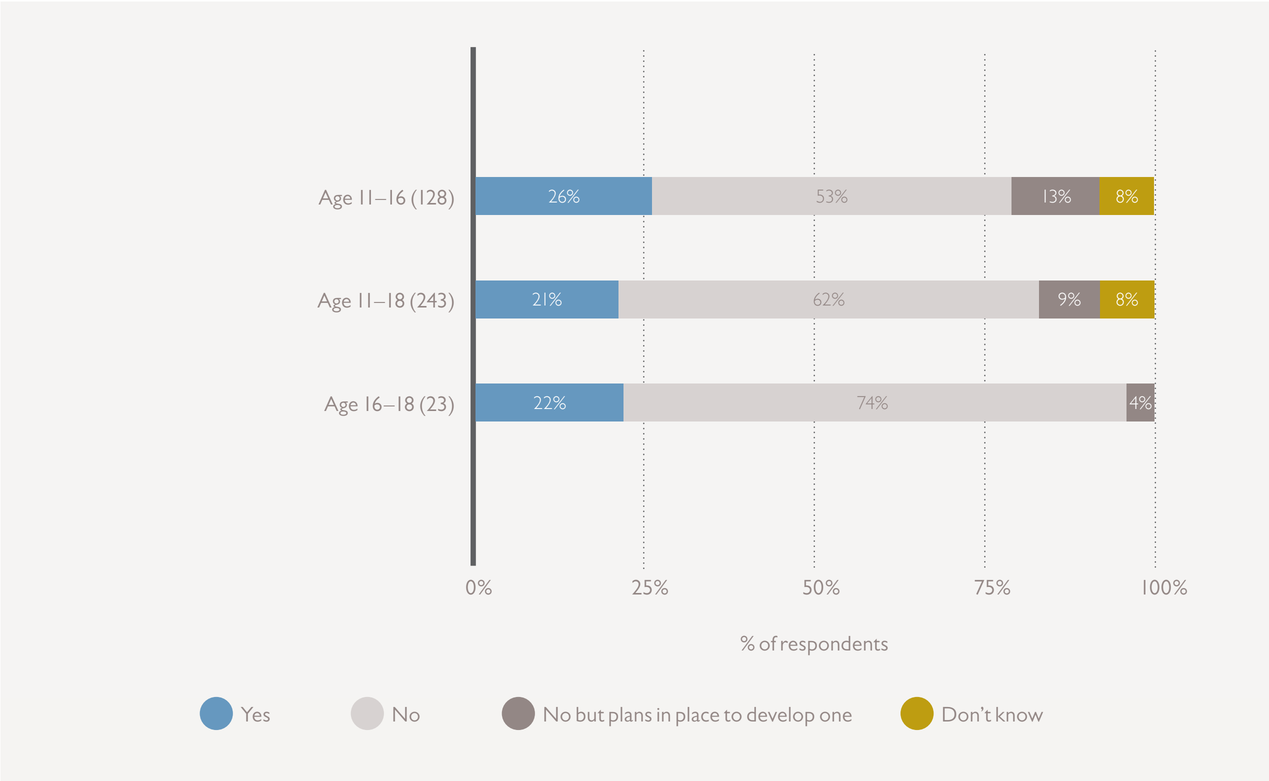
Base numbers are shown in brackets next to institution type

Figure 3: Do you have a written policy on the use of practical science? (Institution sizes)



Base numbers are shown in brackets

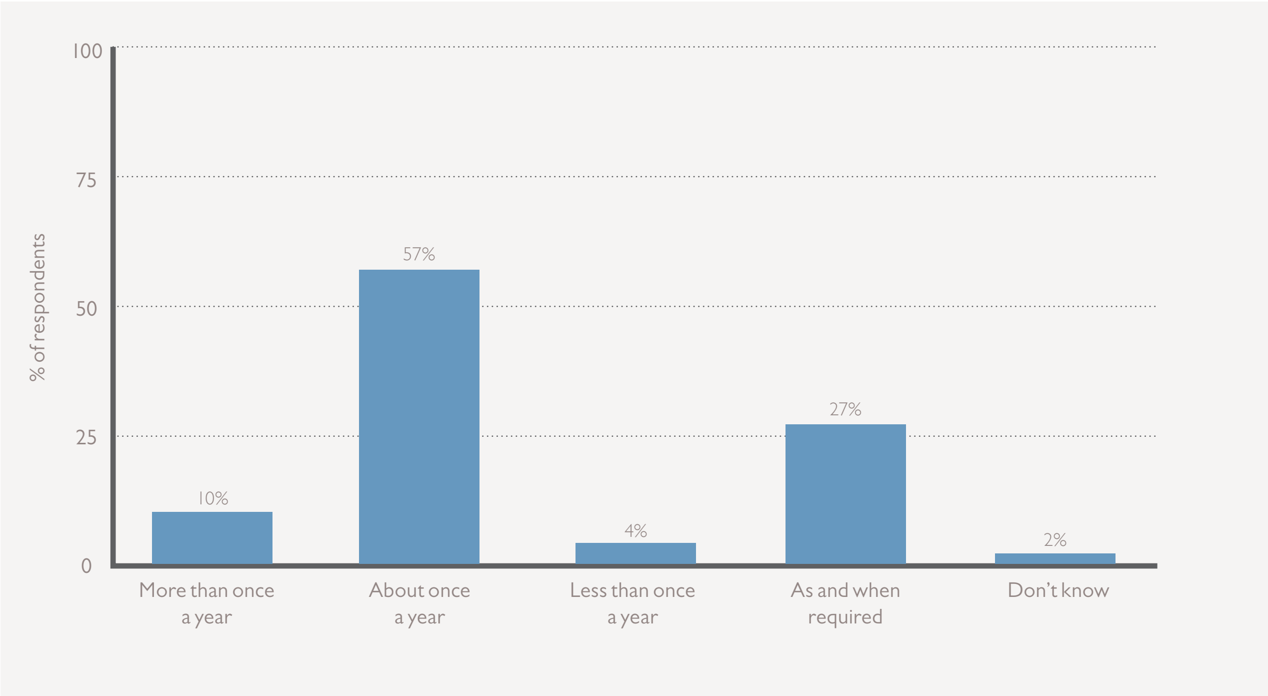
Figure 4: Do you have a written policy on the use of practical science? (Institution age ranges)



Base numbers are shown in brackets

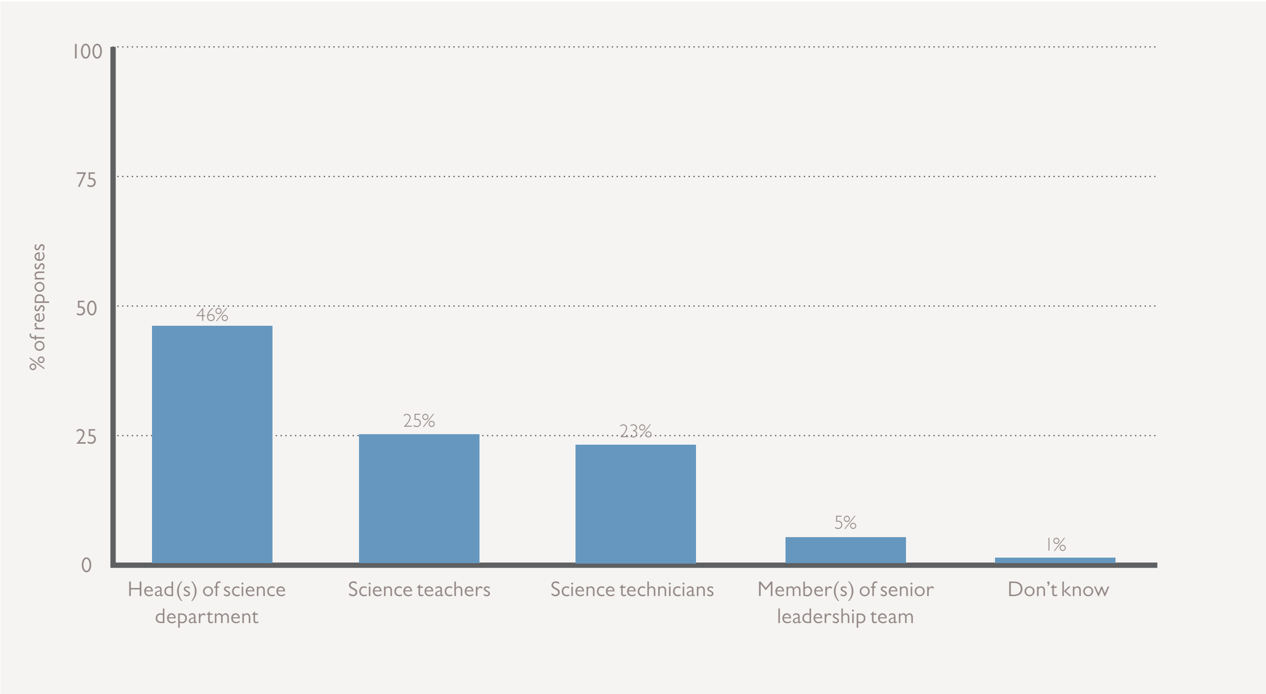
4. Of those respondents that have a written policy in place, 57% will review it about once a year, and 10% will review it more than once a year. Just over a quarter of respondents with a written policy plan to review it as and when required (Figure 5).
5. Respondents with a written policy were asked how it was developed. Nearly half of all survey responses (46%) show that head(s) of science departments were involved in the development of the written policy. A quarter of responses show science teachers were involved, and 23% of responses, that science technicians were involved in the policy development. Only 5% of responses indicate that a member of the senior management team had a role in the development (Figure 6).

Figure 5: How regularly will your policy on the use of practical science be reviewed against practice?



Base 90

Figure 6: Staff involved in developing written policy on the use of practical science



Base responses 188 (respondents were able to select more than one response)

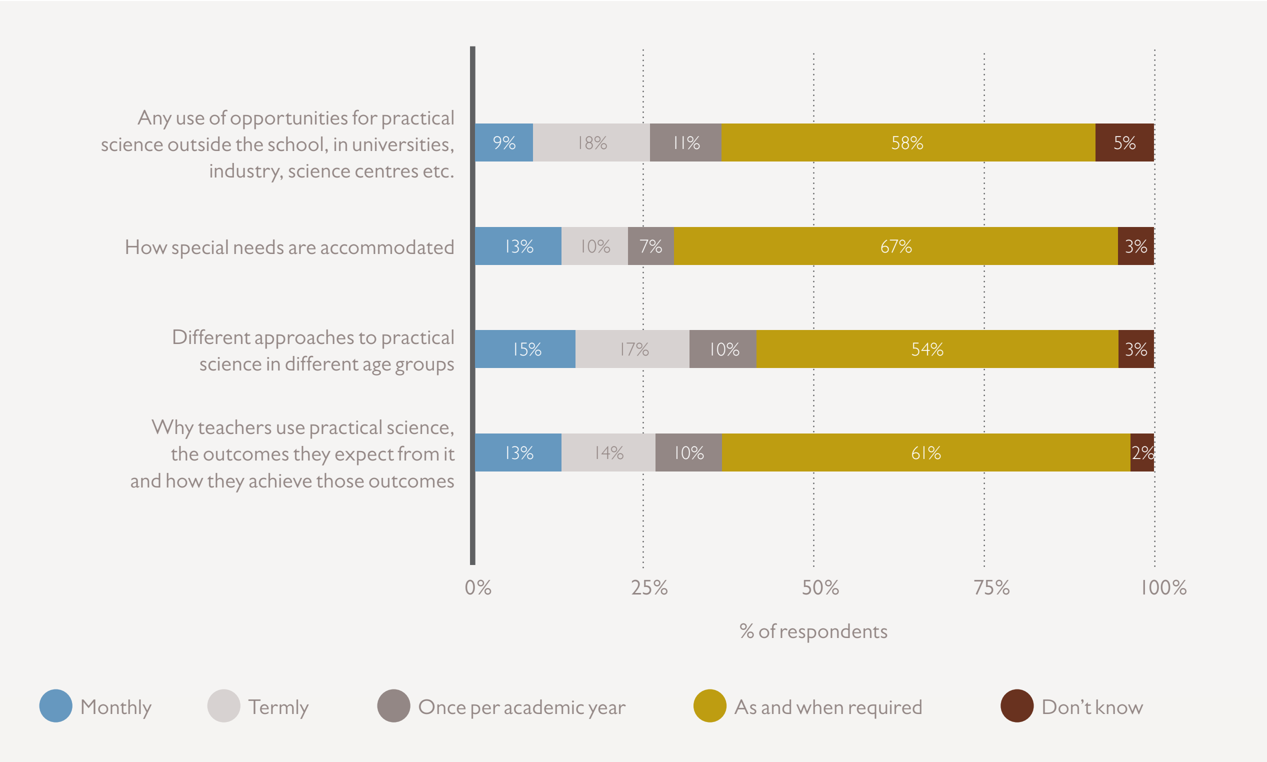
6. It should be noted that qualitative data finds that not all respondents had the same understanding of the written policy as it is set out in the benchmark. For example, 6 of the 20 institutions taking part in a depth interview say their policy is generic to science, rather than specific to practical science as such – but stated they have a practical science policy in their survey response.

> "When asked about a policy on practicals in science lessons I said no as there is no specific policy although it is covered to some extent in the science teaching policy."
>
> Community school, East of England (survey respondent)

7. Equally, it should be taken into consideration that schools without a policy defined in writing may still be operating in a manner that reflects the intention of the benchmark, i.e. regular discussions between the members of the science department and a culture of self-evaluation. For example 61% of respondents say the science department comes together to discuss practical science, the outcomes they expect from it and how they achieve those outcomes, as and when required (Figure 7).

> "We don't have a whole school policy. With the curriculum changes we've been looking at how we can do more practical work and see it have an impact. We want to develop a more holistic approach – not something that's just needed to pass exams. Teachers and technicians will be involved in these discussions – we've already started talking to technicians."
>
> Academy, London (depth interviewee)

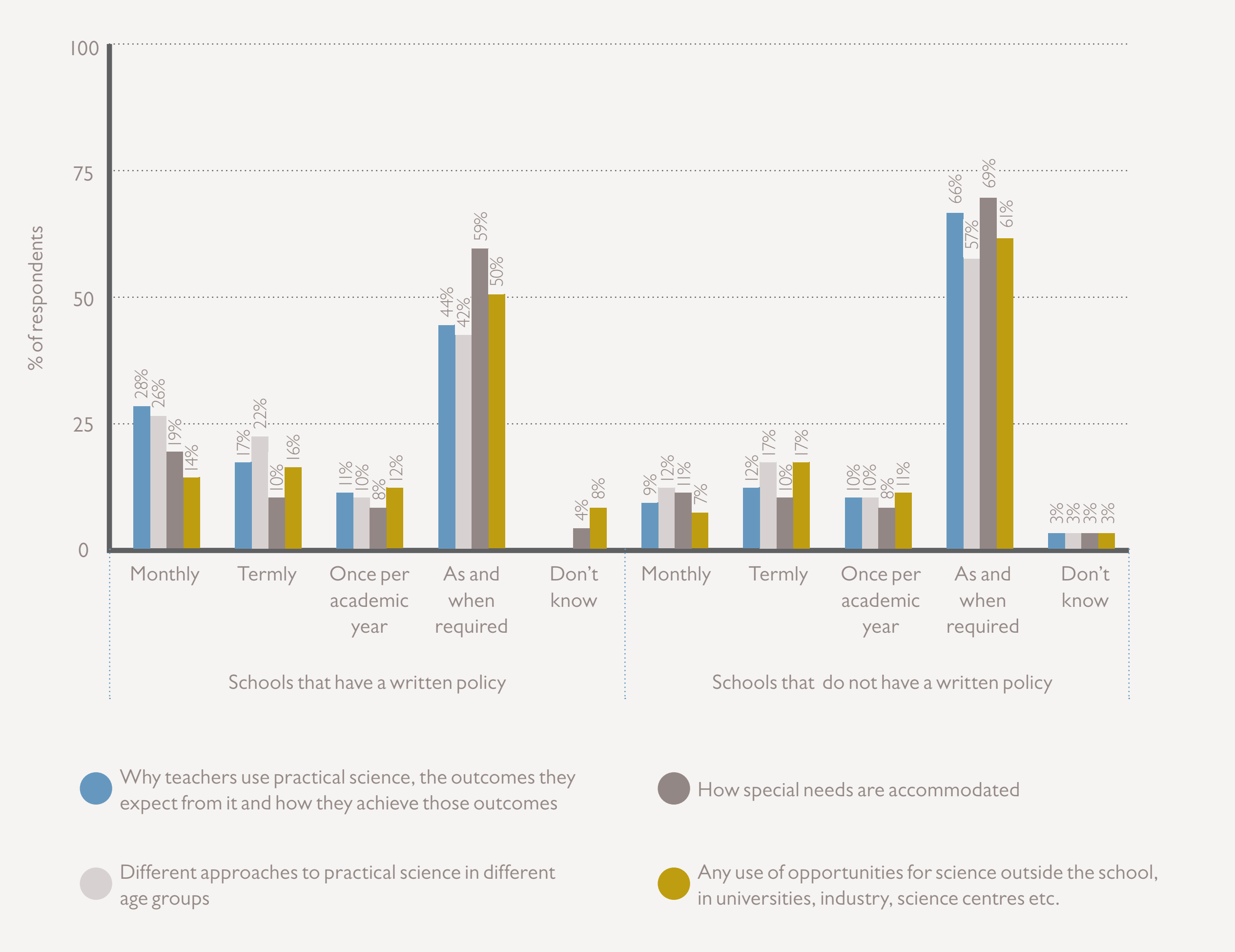
Figure 7: How often does the science department come together to discuss the following?



Base 395

8. Furthermore, higher proportions of respondents that do not have a written policy say the science department comes together for discussions as and when required, compared with schools that do have a written policy (Figure 8).

Figure 8: How often does the science department come together to discuss the following? (Schools that have and do not have a written policy on the use of practical science)



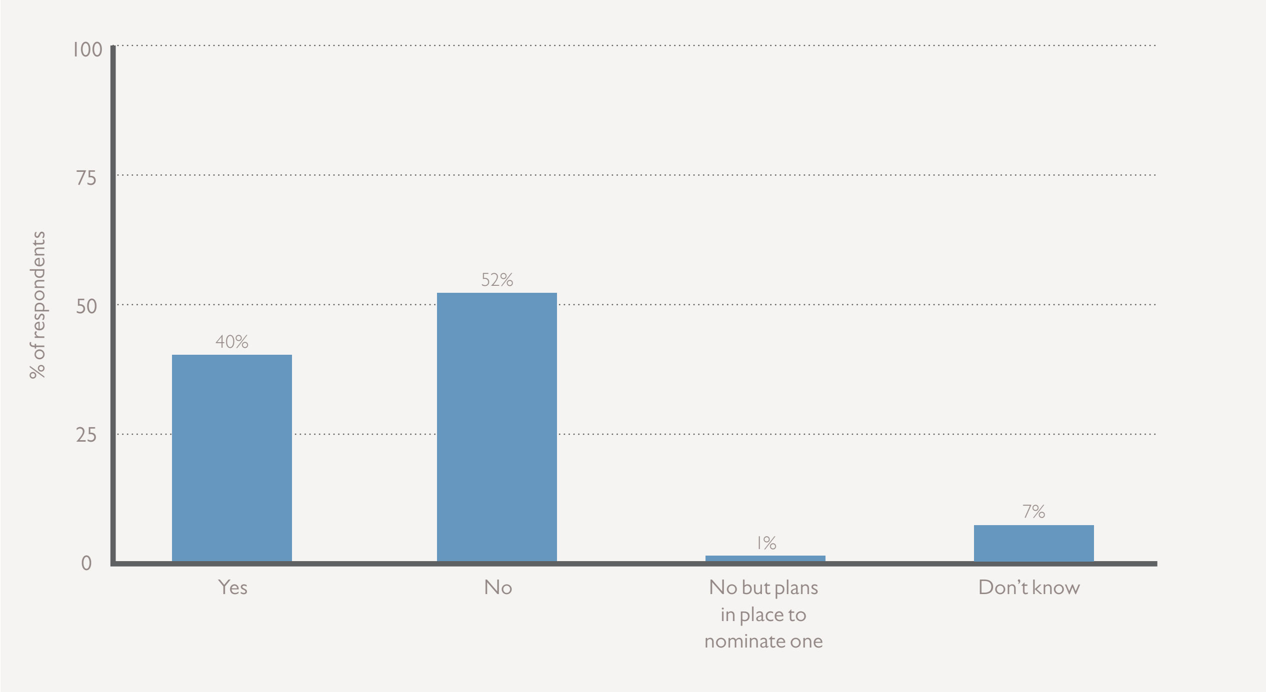
Base 394

9. For 40% of respondents, there is a member of the senior management team (SMT) who acts as a 'sponsor' for practical science, i.e. someone who will act as a sponsor for practical science in senior leadership discussions (Figure 9).

10. Approximately 10% of respondents that have a written policy for practical science have an SMT sponsor.

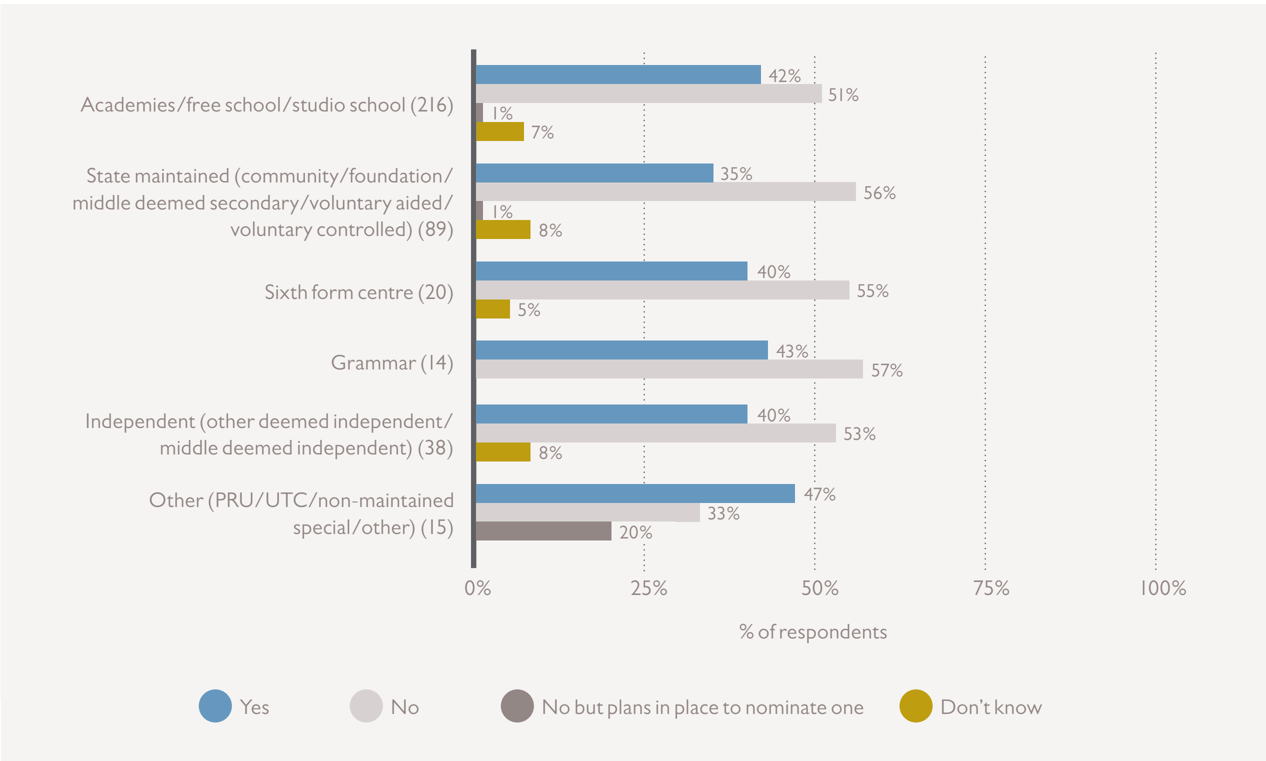
11. A slightly lower proportion of larger schools (1500+ pupils) say they have an SMT sponsor (34% of respondents) compared with schools with fewer than 300 pupils (46% of respondents) (Figure 11). There are no major differences between schools with and without sixth forms, and those that teach years 12 and 13 only (Figure 12).

Figure 9: Is there a member of the senior management team who acts as a 'sponsor' for practical science in your school or college?



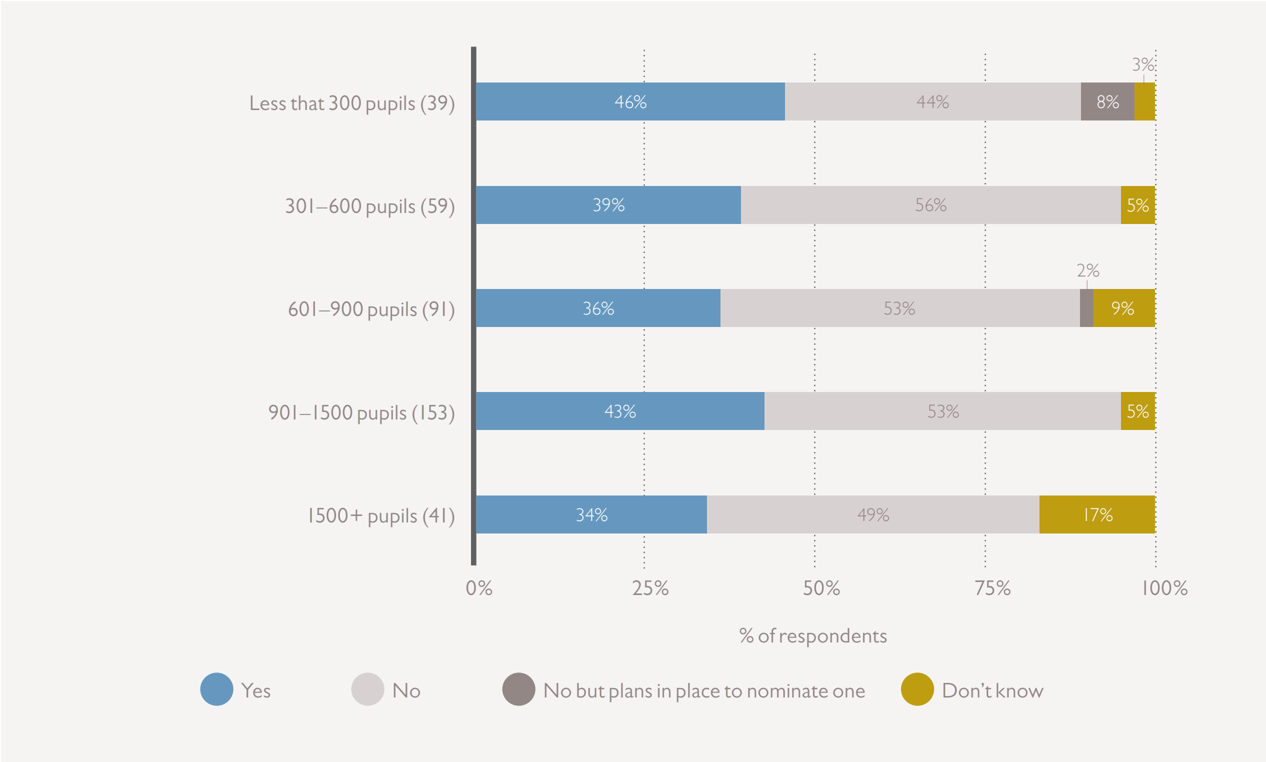
Base 393

Figure 10: Is there a member of the senior management team who acts as a 'sponsor' for practical science in your school or college? (Institution types)



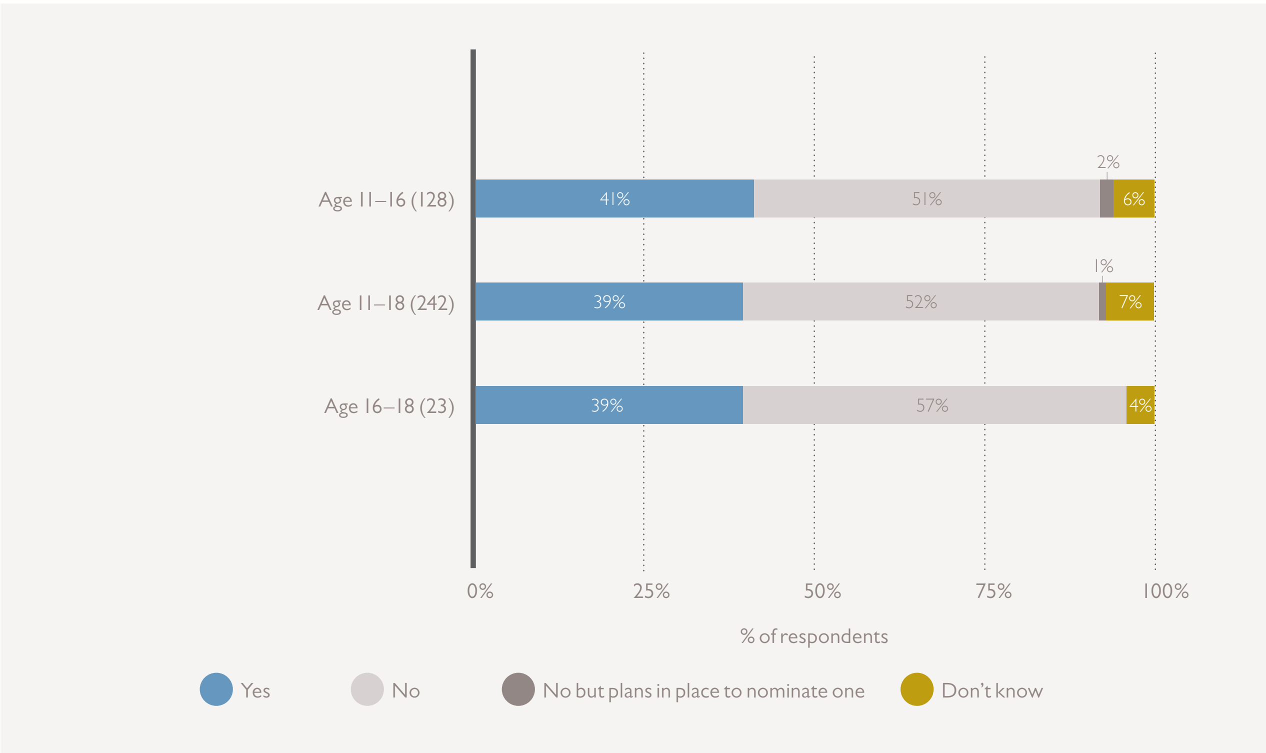
Base numbers are shown in brackets

Figure 11: Is there a member of the senior management team who acts as a 'sponsor' for practical science in your school or college? (Institution sizes)



Base numbers are shown in brackets

Figure 12: Is there a member of the senior management team who acts as a 'sponsor' for practical science in your school or college? (Institution age ranges)



Base numbers are shown in brackets

12. Qualitative evidence strongly emphasises the extent of influence members of the SMT have on the science department, how it operates, its budget, staffing levels and so on. According to interviewees, having an SMT sponsor can make a substantial difference – in particular to the amount of timetabled hours for science, budget and resource allocation.

> [What does an SMT sponsor look like to you?] "Someone who stands up for us if there are budget cuts – someone who'll recognise we still need to fund practical science to deliver the curriculum. Someone who's on our team."
>
> Depth interviewee (did not want institution type or region to be identified)

13. The extent of influence of an SMT sponsor is clearly supported by survey data.[14] For example, 23% of all survey respondents say they have a written policy for practical science. This figure rises to 45% of respondents where there is an SMT sponsor for science. There are also 23% of respondents that have an SMT sponsor, but do not have a written policy for practical science.

> "Unless a member of the SMT is a scientist or a mathematician they hinder science."
>
> Community school, South-West (depth interviewee)

> "There is a distinct under appreciation of the cost of running practical activities as part of the science curriculum at leadership level. Cost is a huge barrier to practical activities. Often large classes work in groups of four or five in practical tasks. We have roughly the same funding as English and Maths and have lost one hour per fortnight of time at KS4. This coupled with national changes mean that we are struggling to budget for many new practical activities."
>
> Academy, North-West (survey respondent)

[14] There are a number of examples relevant to other benchmarks, which are described in subsequent sections of this report.

5. BENCHMARK 2 – PURPOSEFUL PRACTICAL SCIENCE

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.

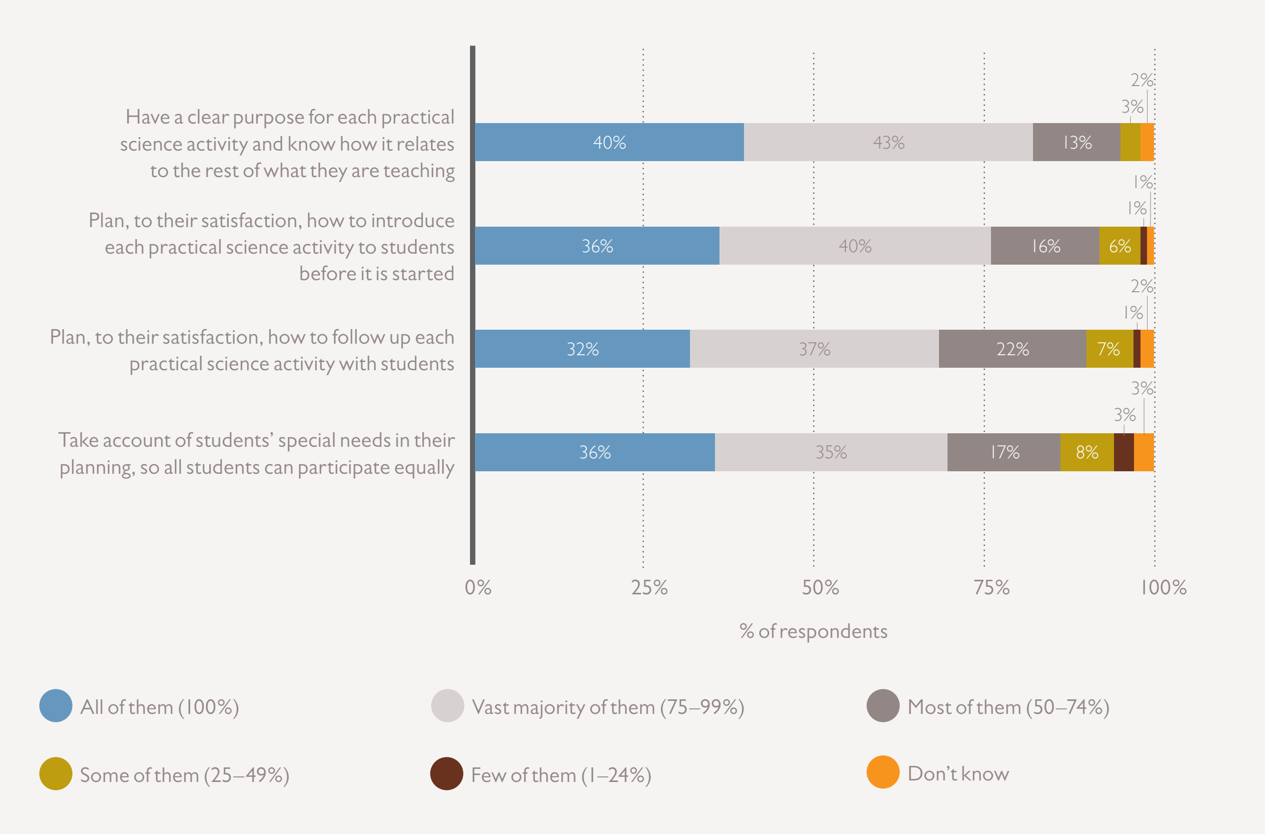
Teachers should have a clear purpose for every practical activity and know how it relates to the rest of what they are teaching.

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

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

1. Respondents were asked to indicate the proportion of their science teaching staff meeting the requirements of Benchmark 2. Data show 40% of respondents say all of their teachers have a clear purpose for practical science and know how it relates to the rest of what they are teaching. A slightly lower proportion of respondents say the same (i.e. all of their teachers do this) in relation to satisfactorily planning to introduce practical science (36% of respondents), satisfactorily planning to follow up practical science activities (32% of respondents), and taking special needs into account when planning (36% of respondents) (Figure 13).

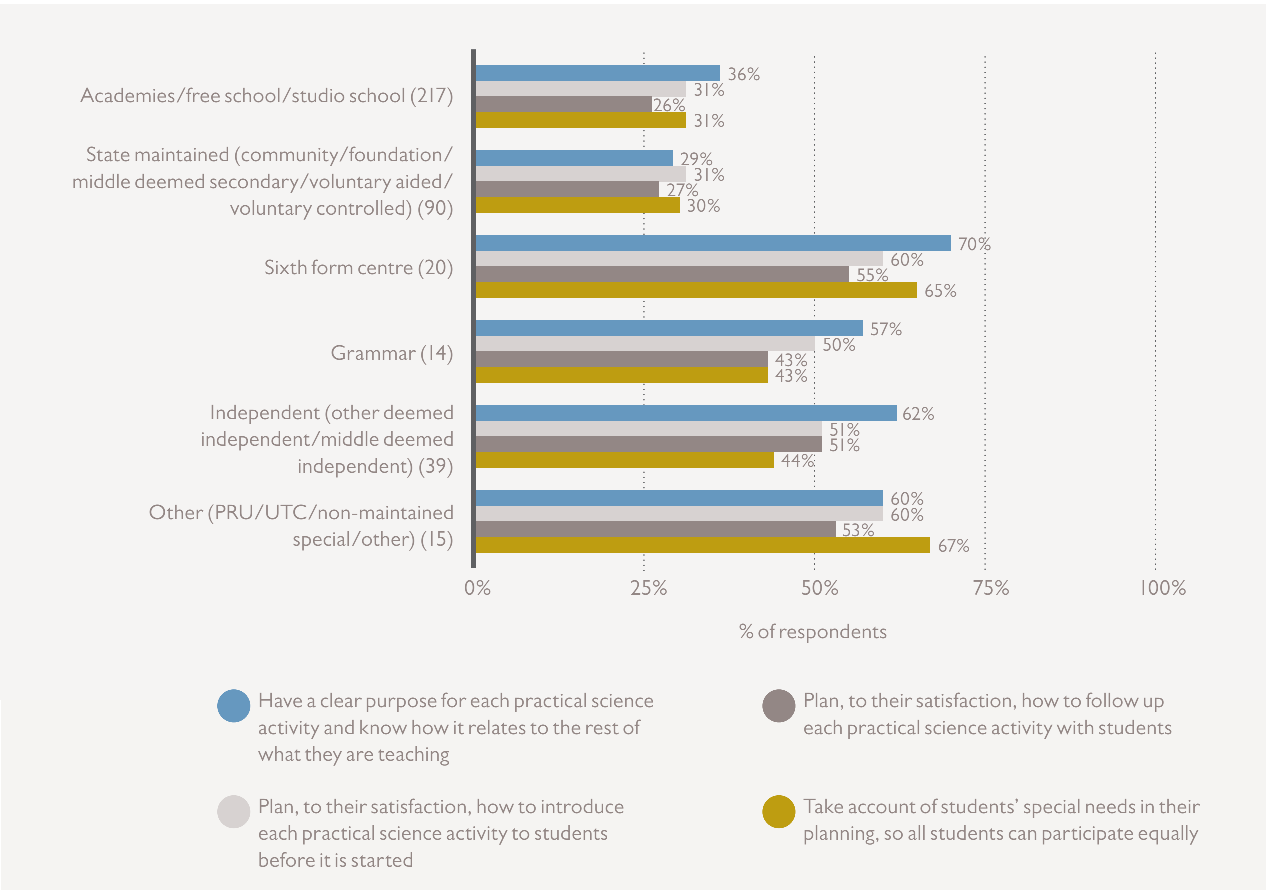
Figure 13: Thinking about the process of planning and carrying out practical science, how many of your teachers…?



Base 394–396

2. A higher proportion of sixth form centres (70%) say all their teachers have a clear purpose for practical science and know how it relates to the rest of what they are teaching,[15] compared with 40% of all respondents (Figure 14).
3. There are differences by institution size, with a much higher proportion of respondents from schools with fewer than 300 pupils saying all of their teachers are able to plan etc., compared with those from larger schools, and in particular those with between 601 and 900 pupils. For example 80% of respondents from schools with fewer than 300 pupils say all of their teachers take account of special needs in their planning, compared with 22% of respondents from schools with between 601 and 900 pupils that say the same (Figure 15). These findings are statistically significant.
4. There are also differences depending on the age range of institutions, with a slightly higher proportion of respondents from schools without a sixth form that say all of their teachers are able to plan etc., compared to schools with sixth forms (Figure 16). A much higher proportion of respondents from institutions teaching years 12 and 13 only[16] (70%) say all of their teachers are able to plan etc., compared with schools with and without sixth forms (Figure 16). These findings are statistically significant.

Figure 14: Respondents that say *all* of their teachers are able to have/do the following (Institution types)

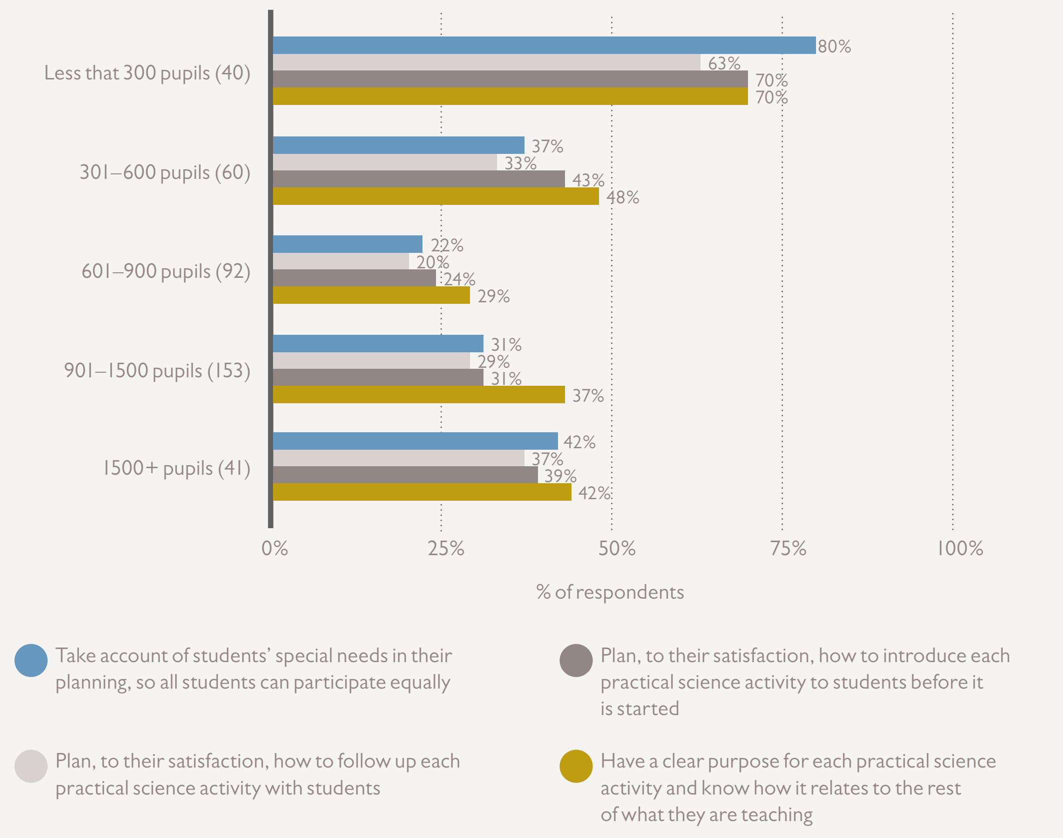


Base numbers are shown in brackets. Data show proportion of respondents that say 'all their teachers' in relation to the options, therefore should not total 100%

[15] There is evidence of a relationship between these variables, significant at the 1% level, however this does not show that one causes the other, only that there is a relationship. 45.2% of cells have an expected value of less than 5.

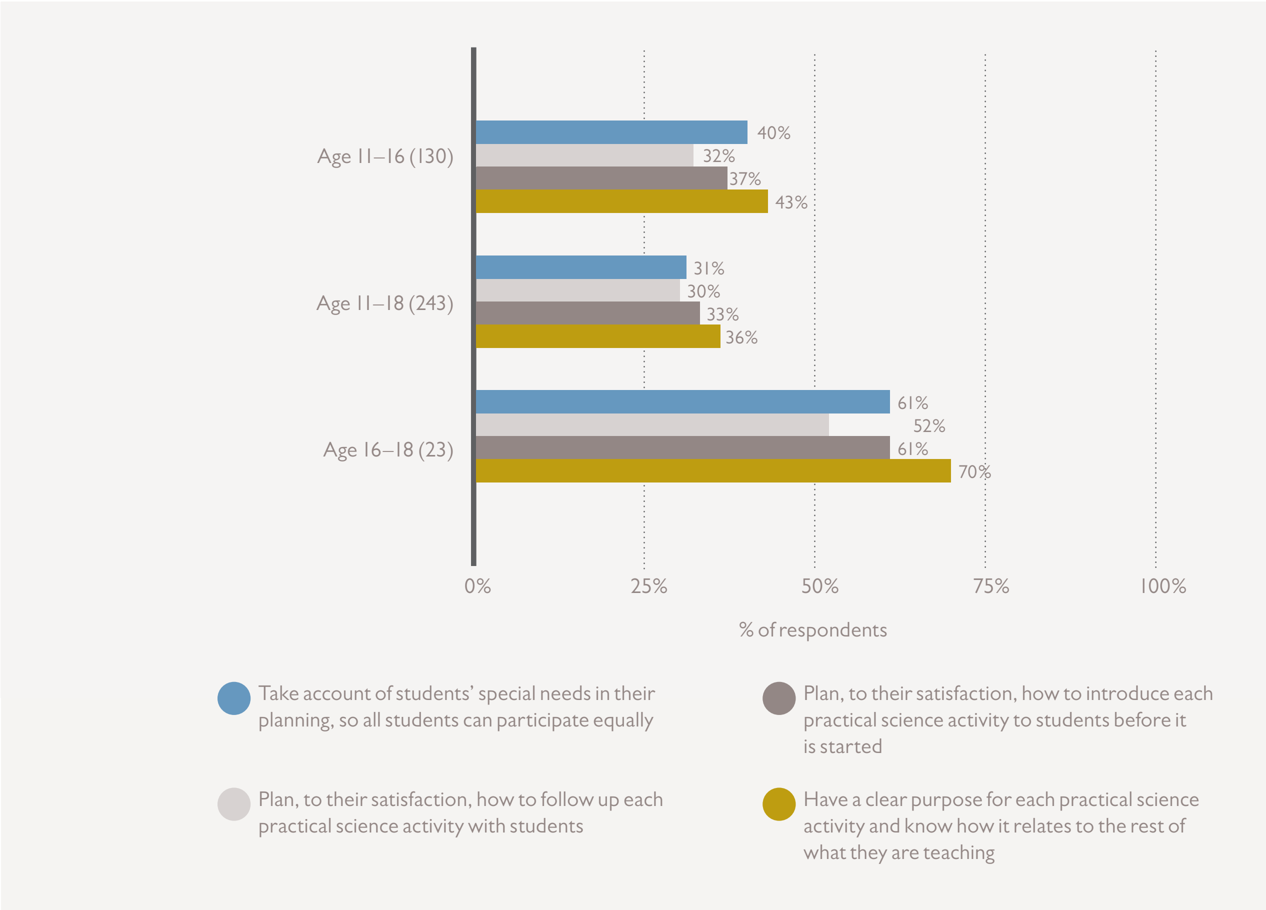
[16] In this context this means only years 12 and 13 from the spectrum of years 7–13 (i.e. institution may also teach learners aged 19+).

Figure 15: Respondents that say *all* of their teachers are able to have/do the following (Institution types)



Base numbers are shown in brackets. Data show proportion of respondents that say 'all their teachers' in relation to the options, therefore should not total 100%

Figure 16: Respondents that say *all* of their teachers are able to have/do the following (Institution types)



Base numbers are shown in brackets. Data show proportion of respondents that say 'all their teachers' in relation to the options, therefore should not total 100%

5. There are a number of enablers identified via qualitative evidence and supported by survey data – i.e. certain types of circumstances make it more likely to enable all teachers to plan etc., as shown in Table 7. For example 54% of respondents say all of their teachers are able to plan, to their satisfaction, how to follow up each practical science activity with students where all teachers have time for professional reflection with colleagues where so required (compared with 36% of all respondents).

Table 7: Enablers for Benchmark 2

	All	All teachers have time for professional reflection with colleagues where so required	All teachers have annual reviews of training and development needs in relation to practical science	Institution has a written policy on practical science
Have a clear purpose for each practical science activity and know how it relates to the rest of what they are teaching	40%	59%	58%	51%
Plan, to their satisfaction, how to introduce each practical science activity to students before it is started	36%	54%	53%	42%
Plan, to their satisfaction, how to follow up each practical science activity with students	32%	49%	47%	38%
Take account of students' special needs in their planning, so all students can participate equally	36%	54%	55%	46%

6. Where all teachers have time for professional reflection as required, this is the most influential enabler according to survey data (Table 7). Qualitative evidence suggests that the SMT is a critical influence as to whether teachers are able to have this time. Survey data find 39% of all respondents say all of their teachers have time for professional reflection with colleagues as required (Figure 17). In turn a lack of time, or a lack of quality time, is deemed to affect the quality and/or volume of practical work that is offered.

> "There's a lot of discussion to be had at all levels about the purpose of practical work in science. Because this is a significant philosophical discussion, there is not time to tackle it fully and make decisions in a joined up way - so there is a tendency to 'do what we've always done'. This leads to possibly more, but lower quality practical work than is necessary."
>
> Academy, London (survey respondent)

6. BENCHMARK 3 – EXPERT TEACHERS

Teachers should have had subject specialist training (both initial and continuing) in 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.

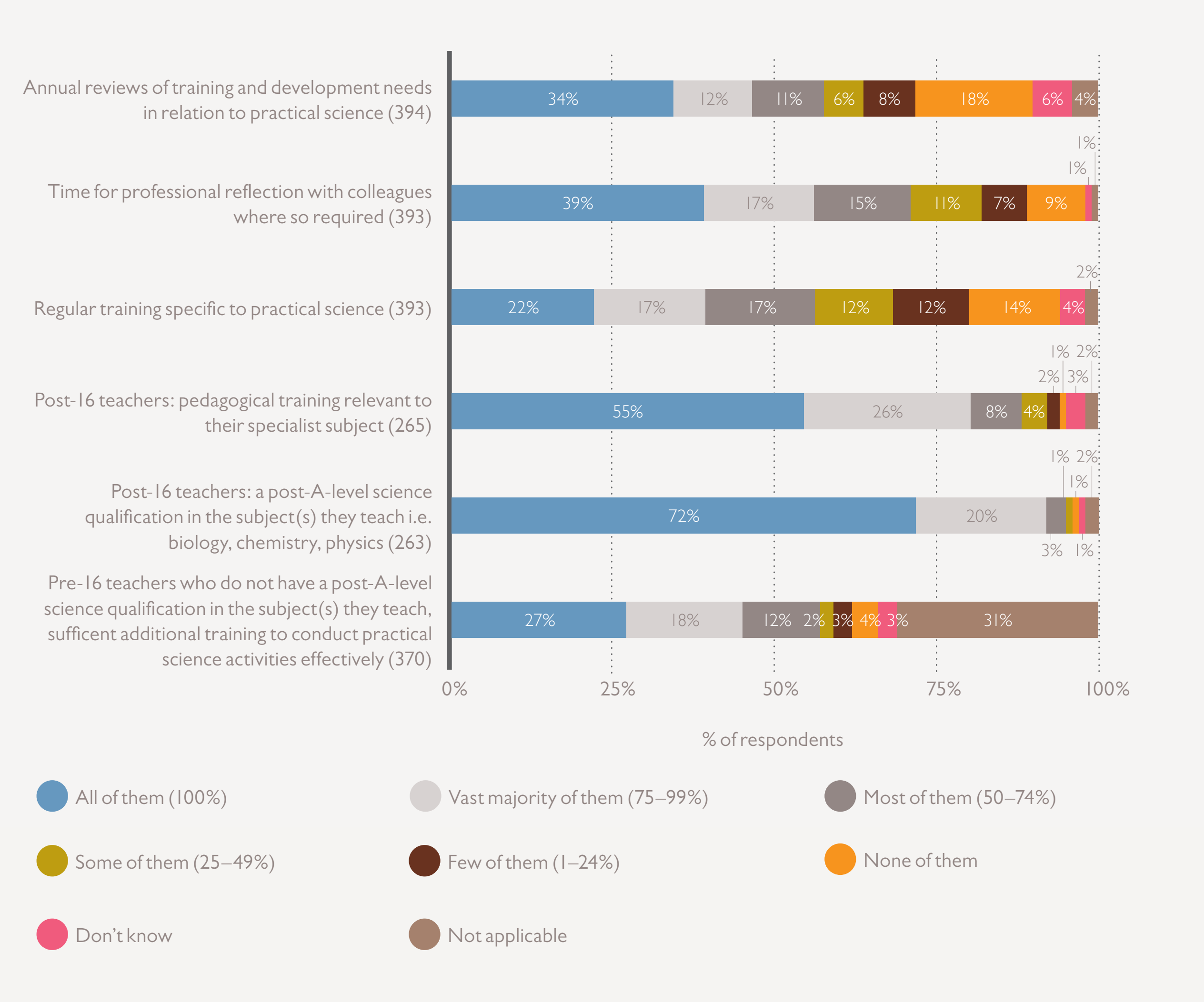
At post-16 level, teachers should have a post-A-level science qualification related to the science subject they teach (biology, chemistry, physics), together with relevant pedagogical training.

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.

1. Respondents were asked about the proportion of their teachers with training and development opportunities specific to practical science. Nearly three-quarters of respondents teaching science at post-16 say all of their teachers have a post A-level science qualification in the subject they teach eg biology (Figure 17).
2. A smaller proportion of all pre-16 science teachers without a post A-level science qualification in the subject they teach have sufficient additional training to conduct practical science activities effectively (27% of respondents say this), compared with the proportion of all post-16 teachers that have pedagogical training relevant to their specialist subject (55% of respondents). It can be assumed that the 31% of respondents that stated 'not applicable' to this question, did so because all of their pre-16 science teachers have a post A-level science qualification in the subject they teach (Figure 17).
3. A comparatively low proportion of all science teachers receive regular training specific to practical science (22% of respondents say this). Just over a third of respondents say all science teachers have annual reviews of training and development needs specific to practical science (Figure 17).

Figure 17: How many of your science teachers have…?



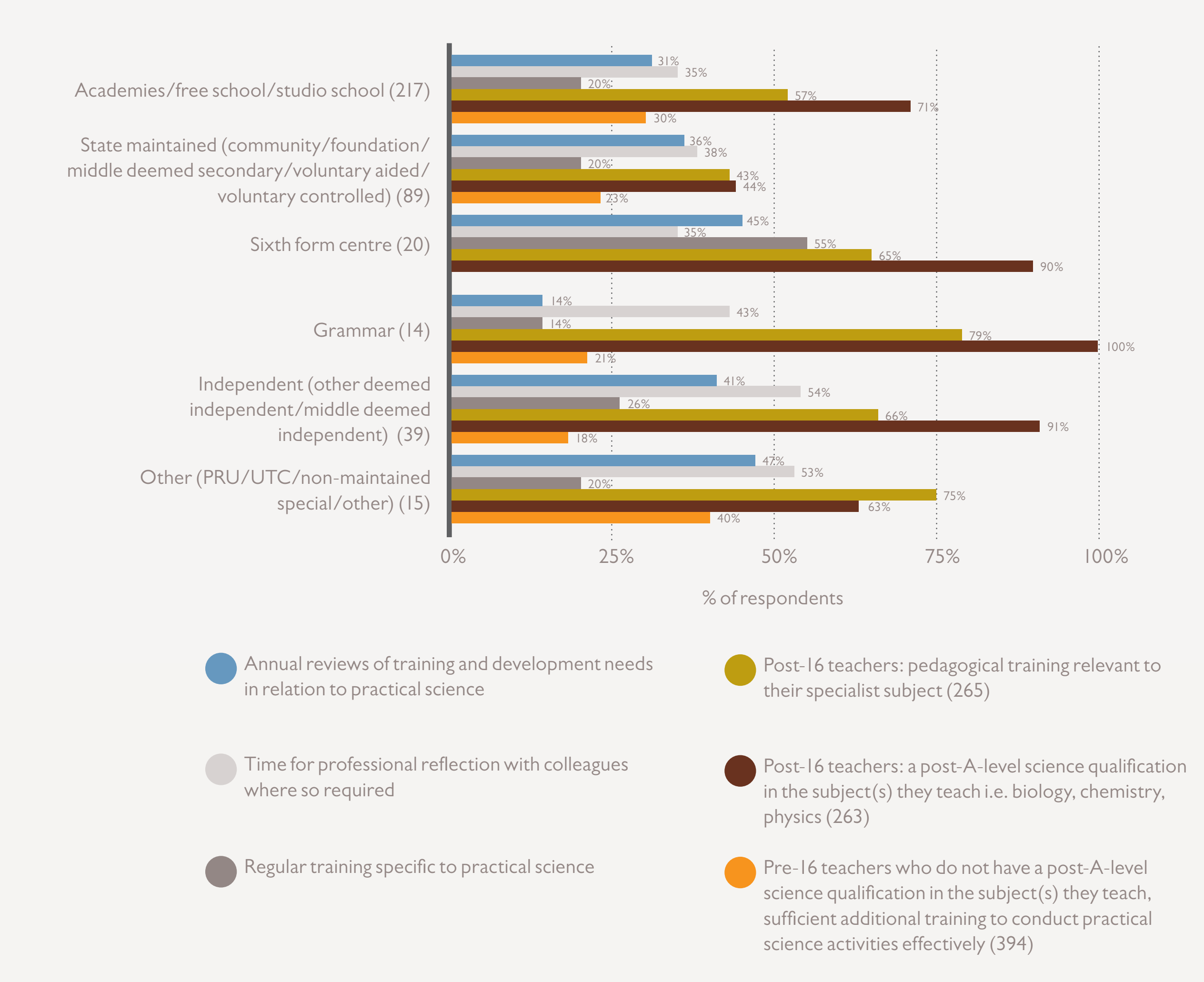
Base numbers are shown in brackets

4. According to the qualitative evidence, respondents say lack of time and funding are the main barriers to training for science teachers. One respondent describes a school culture which is pro-training, but ultimately there is not enough time that can be freed up from the timetable to enable teachers to attend training. Over three-quarters of respondents participating in in-depth interviews say it is just as important to provide Continuing Professional Development (CPD) for experienced teachers, not just the new ones – but that where training is made available, it tends to be for NQTs and less experienced teachers.

5. Just under 10% of survey respondents state that the amount of training received in recent years is out of character (i.e. more than usual), as a result of the changes to the science curriculum. This came from a free text response question at the conclusion of the survey and was not a specific survey question. One respondent commented that training on the new curriculum specification was the first course he had attended "in years". This was supported within qualitative evidence.

6. Over 90% of sixth form centres, grammar schools and independent schools say all their post-16 teachers have a post A-level science qualification in the subject they teach (Figure 18). While these data should be viewed with caution due to low sample sizes, qualitative evidence does support this, with interviewees saying these types of institutions are more likely to be able to recruit qualified subject specialists.

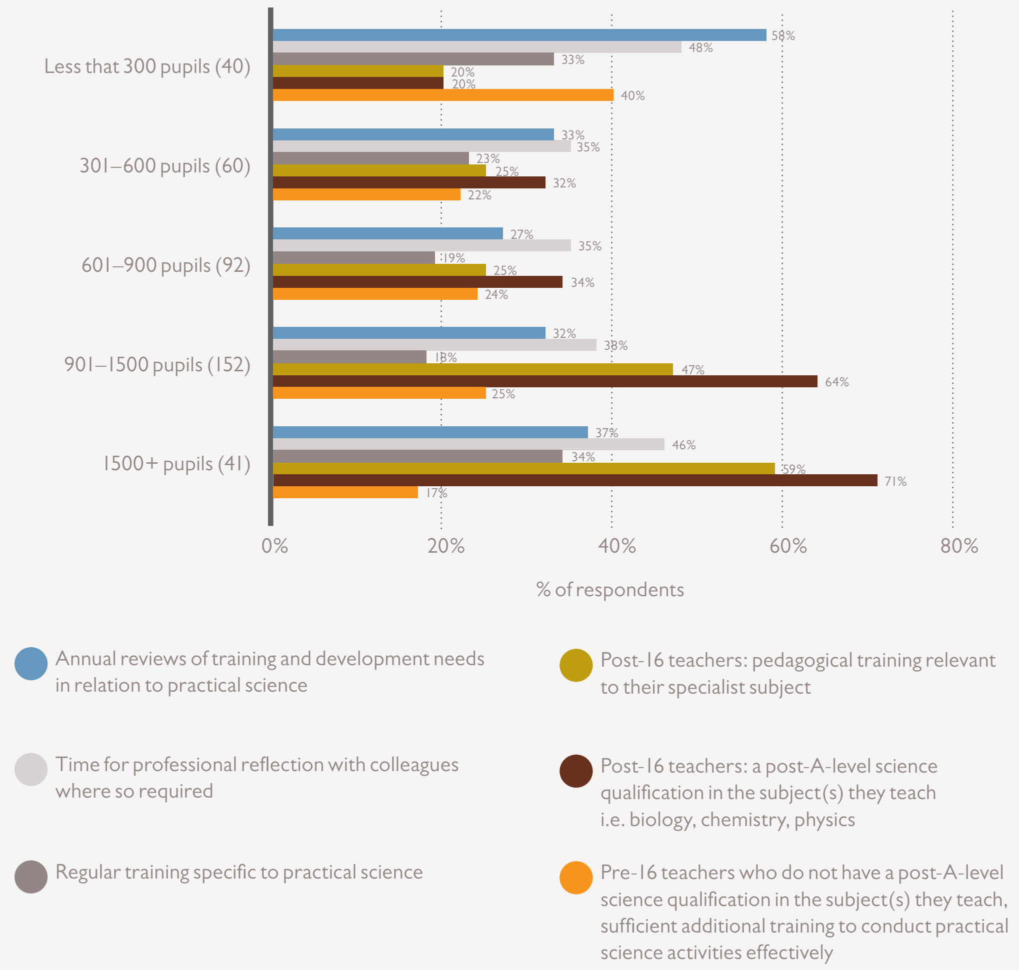
Figure 18: % of respondents saying that *all* their science teachers have…? (Institution types)



Base numbers are shown in brackets. Data show proportion of respondents that say 'all their teachers' in relation to the options, therefore should not total 100%

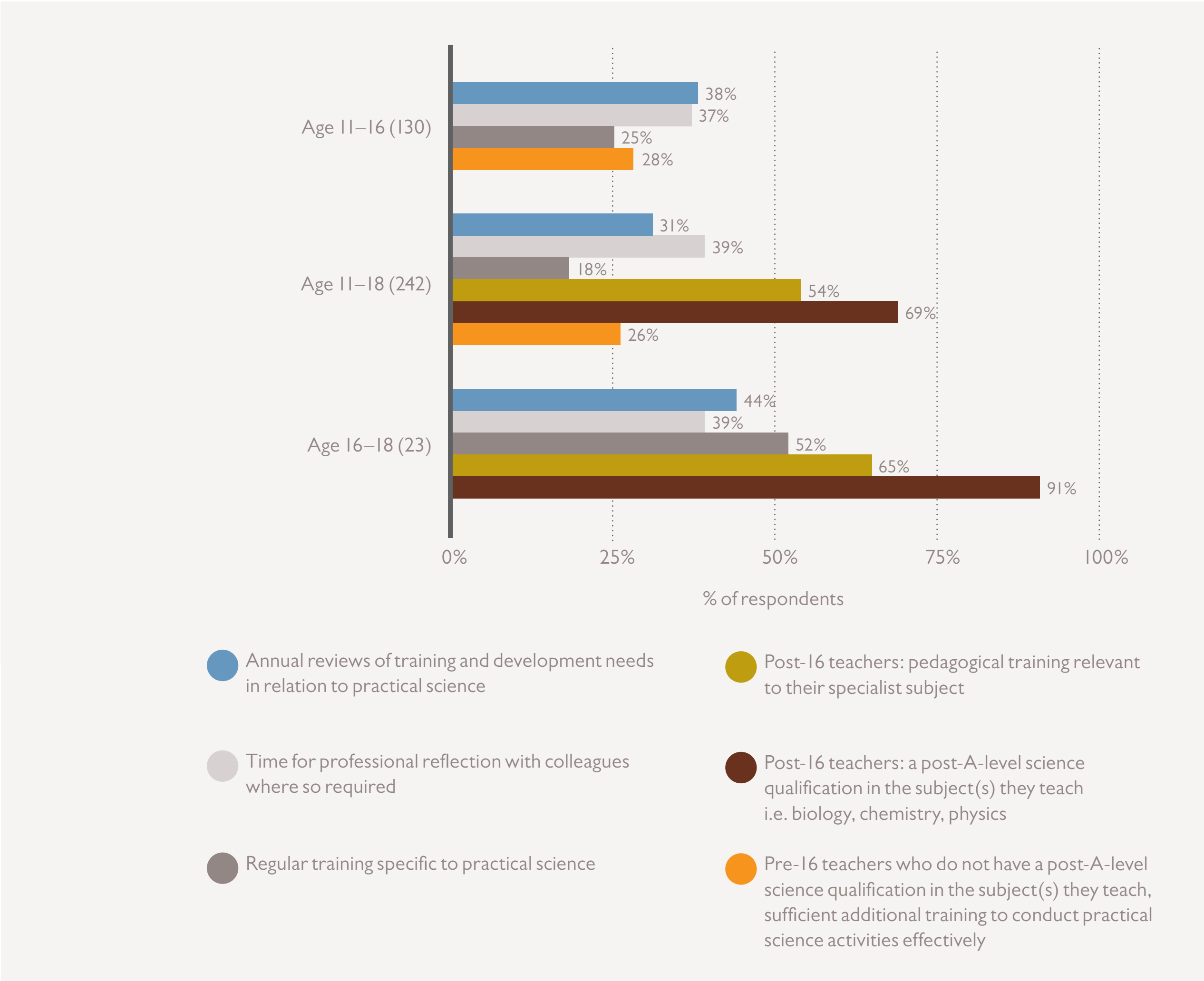
7. A higher proportion of large schools (1500 pupils + - 71% of respondents and 901–1500 – 64% of respondents) say all their post-16 teachers have a post A-level science qualification in the subject they teach compared with smaller schools (only 20% of respondents from schools with fewer than 300 pupils say the same) (Figure 19). This is marginally statistically significant.
8. A higher proportion of institutions teaching years 12 and 13 only say all their teachers have a subject specialist post A-level science qualification (91% of respondents), compared with schools and colleges teaching 11–18 (69% of respondents) (Figure 20). This is marginally statistically significant.

Figure 19: % of respondents saying that *all* their science teachers have…? (Institution sizes)



Base numbers are shown in brackets. Data show proportion of respondents that say 'all their teachers' in relation to the options, therefore should not total 100%

Figure 20: % of respondents saying that *all* their science teachers have…? (Institution age ranges)



Base numbers are shown in brackets. Data show proportion of respondents that say 'all their teachers' in relation to the options, therefore should not total 100%

9. There are differences between schools that have an SMT sponsor and/or a written policy on the use of practical science, compared with those that do not – in relation to the provision of annual reviews, regular training and time for professional reflection with colleagues as required (Table 8). While the direction of the relationship is not clear from quantitative data alone, qualitative evidence strongly indicates that the SMT sponsor and written policy are more likely to result in the provision of sufficient time, training reviews etc.

Table 8: Enablers for Benchmark 3

	All respondents	Respondents with written policy on use of practical science	Respondents with SMT sponsor
Annual reviews of training and development needs in relation to practical science	34%	44%	39%
Regular training specific to practical science	22%	33%	27%
Time for professional reflection with colleagues where so required	39%	47%	43%

10. Respondents from smaller schools (fewer than 300 pupils and 301–600 pupils) interviewed, say it is extremely difficult to recruit subject specialist science teachers. They believe the number of people training to become science teachers is lower in recent years, which is one barrier. However they also say that newly qualified teachers and trainee teachers have concerns about the amount of training they would have in a smaller school, on the presumption that experienced teachers will have less time to support them, than they would in a larger school with more teachers and technicians employed. This is not supported by survey data, which show a higher proportion of respondents from schools with fewer than 300 pupils are actually saying that all their teachers have annual training and development reviews, compared with larger schools (Figure 19). If this is a commonly held perception then it may be acting as a barrier unnecessarily for recruitment in small schools.

11. It is not only small schools that say they experience difficulties. Respondents from a range of institution types that participated in depth interviews, all say it has become increasingly difficult to recruit science teachers. One respondent from a grammar school believes there is insufficient information about career pathways in teaching – and as a result, students are less likely to be engaged in a science teaching career. Furthermore most respondents agree science graduates can earn more in other professions/sectors.

[How easy or difficult is it to recruit subject specialist teachers?] "It's a nightmare. I've been a head of department for 15 years and we are a high performing school. The volume and quality of applications for science teachers have gone downhill year-on-year. It is virtually impossible now to find the right people. Those that seem very experienced on paper have no practical skills base. I have to take 3–4 hours a week to train new teachers in-house – I don't have time to do that but I have no choice."

Grammar school, (depth interviewee)

"It's so hard to find good science teachers. Science graduates can earn more in a non-teaching role."

Free school, London (depth interviewee)

"There are too many redeployed teachers delivering science because of a lack of supply of high quality, trained science teachers; these teachers are often lacking the skills and the courage to implement practical science."

Academy, East of England (survey respondent)

12. Opportunities for professional exchange (either within school or externally with other schools/colleges etc.) vary depending on the school's circumstances. One respondent comments that science teachers need to do this in their own time – for example attending the Association for Science Education (ASE)'s annual conference on a Saturday. In some cases it comes down to physical space – just over half of respondents participating in depth interviews say that working in the same room (eg science common room) is a critical enabler for regular professional discussion. Where meeting space is not available or less readily available, teachers and technicians say it is harder to find opportunities for discussions – even though these are highly valued.
13. Qualitative evidence finds that insufficient CPD (whether formal, accredited provision or informal) or professional exchange, combined with difficulties in recruiting experienced science teachers (and potentially budget constraints as well), is having an impact on the quality and volume of practical science for some schools. Teachers in an understaffed science department need to teach more lessons – as a consequence they have less time available for planning, professional exchange or supporting others (eg less experienced teachers and/or technicians). This in turn acts as a deterrent for experienced science teachers considering joining the school – with the overarching risk that this leads to something of a vicious cycle, which has a detrimental effect for practical science over the longer-term.

7. BENCHMARK 4 – FREQUENT AND VARIED PRACTICAL SCIENCE

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

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.

1. Nearly 60% of respondents say at least half of science lessons at Key Stage 3 involve direct practical activities (whether hands-on or teacher demonstration). Respondents say Key Stage 4 sciences involve fewer direct practical activities by comparison with Key Stage 3. A lower proportion of respondents say at least half of lessons in Key Stage 4 biology involve direct practical activities (33%) compared with Key Stage 4 chemistry (55%) and Key Stage 4 physics (47%) (Table 9).[17]
2. Key Stage 3 science lessons have a higher proportion of lessons involving direct practical activities (average of 55% across all respondents) compared with Key Stage 4 and Post-16 sciences. Key Stage 3 science is the only type of science meeting the benchmark (Table 10).
3. Of the sciences at Key Stage 4, chemistry is the closest to achieving the benchmark (average of 48% of lessons across all respondents) (Table 10).

[17] For this question a small number of responses were excluded where respondents had either not provided a response to the question that asked for the number of students studying post-16 science in each of these subjects, and where the number of students was particularly low (which risked skewing the data).

Table 9: % of 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

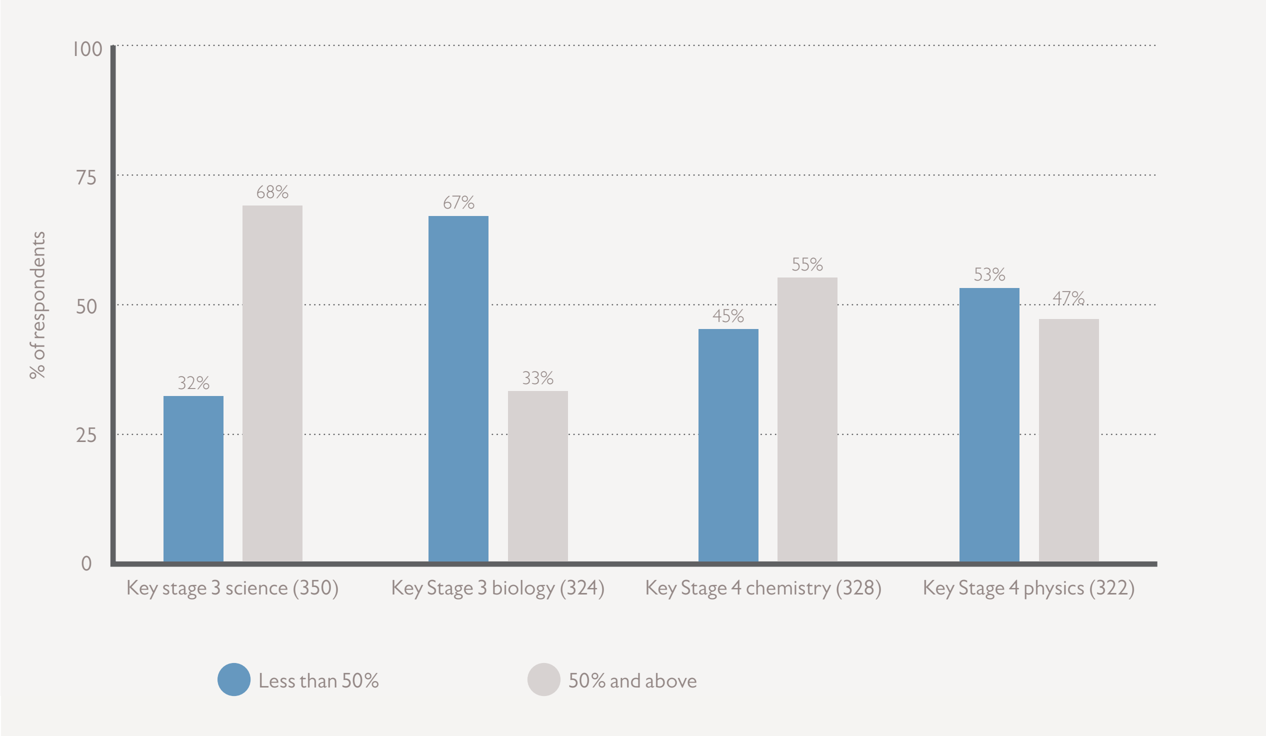
Subject	On average, across the year and across all the sciences, at least half of lessons involve direct practical activities, whether hands-on or teacher demonstration
Key Stage 3 science	68%
Key Stage 4 biology	33%
Key Stage 4 chemistry	55%
Key Stage 4 physics	47%
Post-16 biology	15%
Post-16 chemistry	28%
Post-16 physics	24%
Post-16 applied science	38%

Table 10: Approximate % of lessons that involve direct practical activities, across the sciences

Subject	Approx. % of lessons that involve direct practical activities – all respondents
Key Stage 3 science	55%
Key Stage 4 biology	37%
Key Stage 4 chemistry	48%
Key Stage 4 physics	44%
Key Stage 4 applied science	24%
Post-16 biology	32%
Post-16 chemistry	39%
Post-16 physics	37%
Post-16 applied science	39%

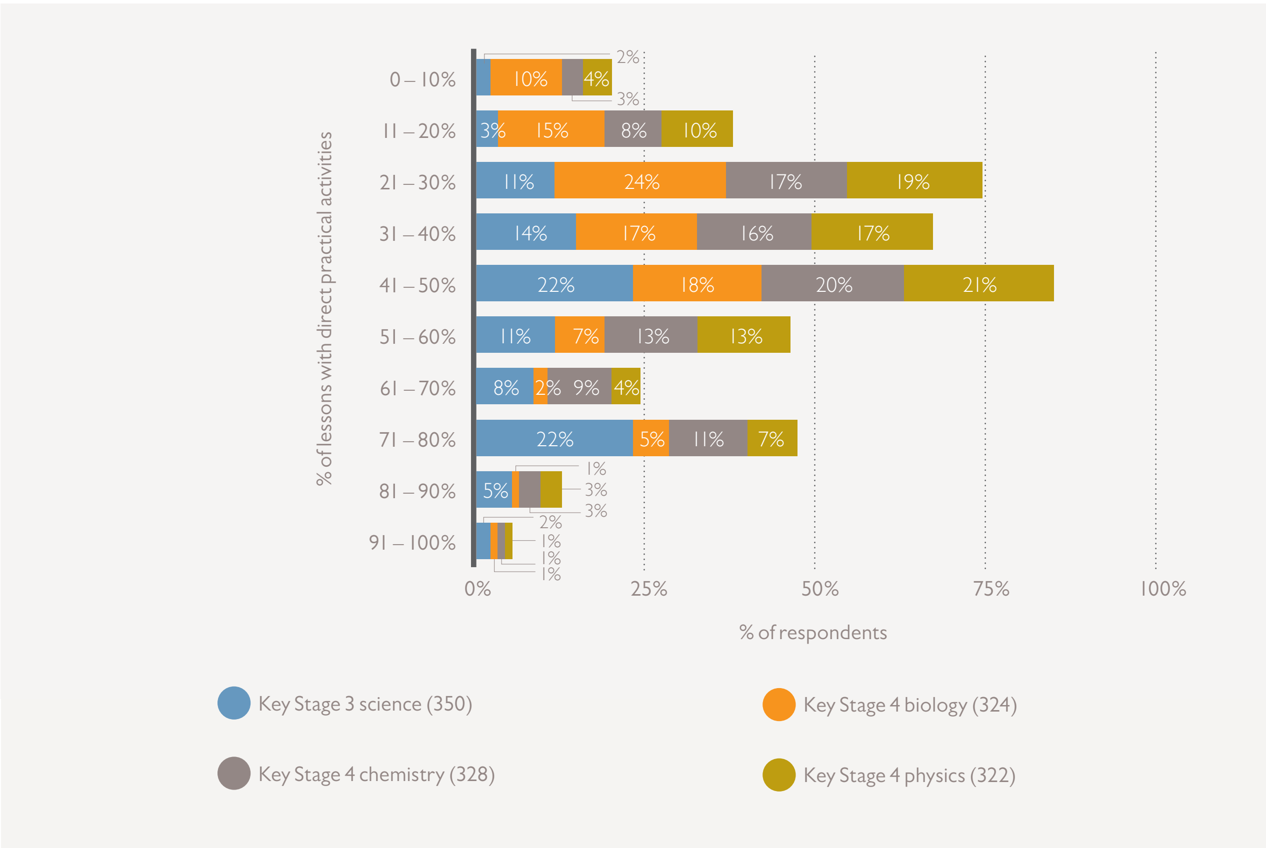
4. Overall, a higher proportion of respondents achieve the benchmarks for Key Stage 4 sciences compared with Post-16 sciences (Figures 21 and 23).

Figure 21: Approximate % of science lessons that involve direct practical activities – respondents above and below the benchmark of 50% (Key Stage 4 sciences)



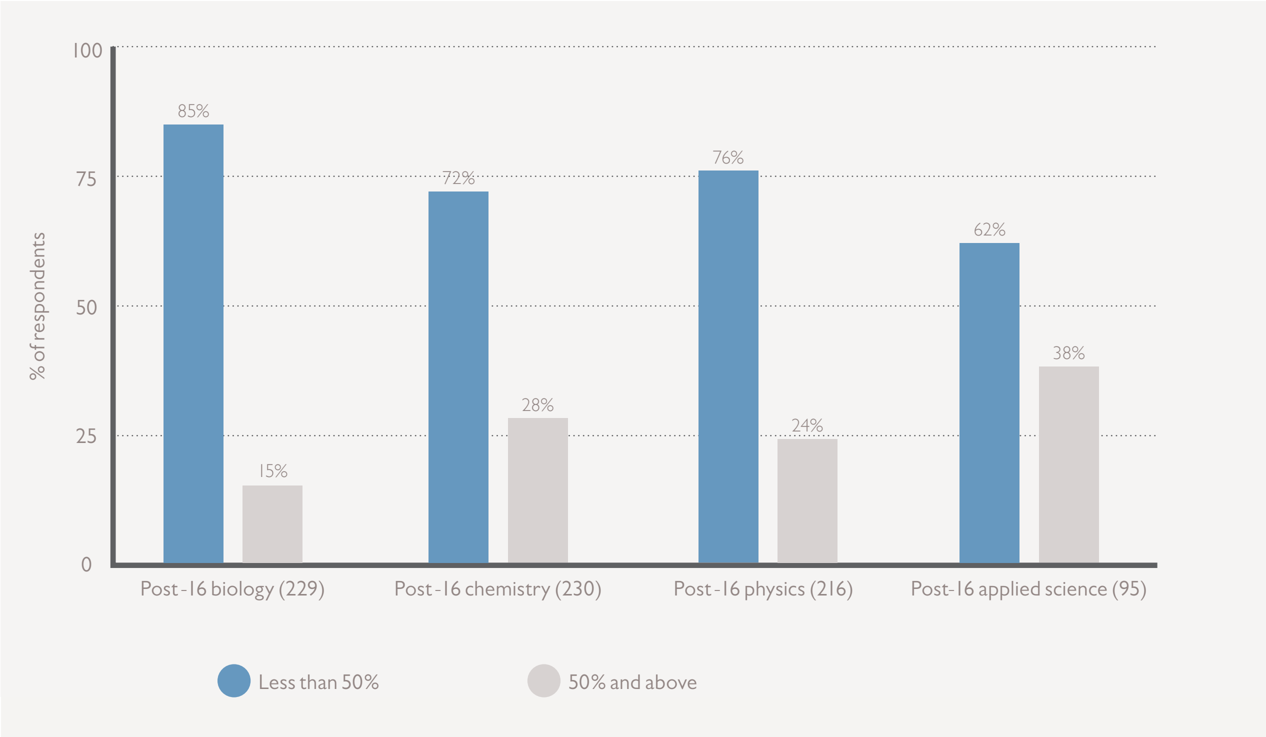
Base numbers are shown in brackets

Figure 22: Approximate % of science lessons that involve direct practical activities – respondent distribution (Key Stage 4 sciences)



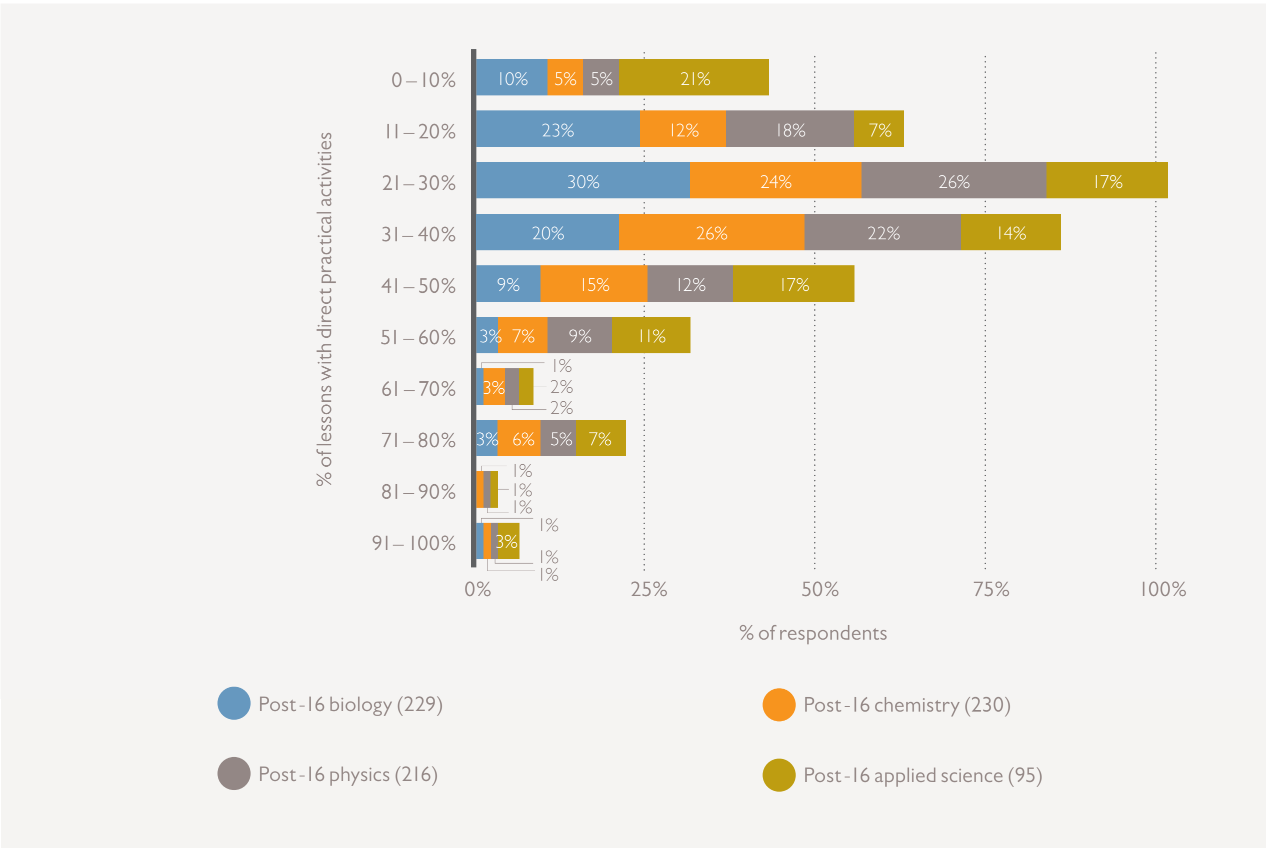
Base numbers are shown in brackets

Figure 23: Approximate % of science lessons that involve direct practical activities – respondents above and below the benchmark of 50% (Post-16 sciences)



Base numbers are shown in brackets

Figure 24: Approximate % of science lessons that involve direct practical activities – respondent distribution (Post-16 sciences)



Base numbers are shown in brackets

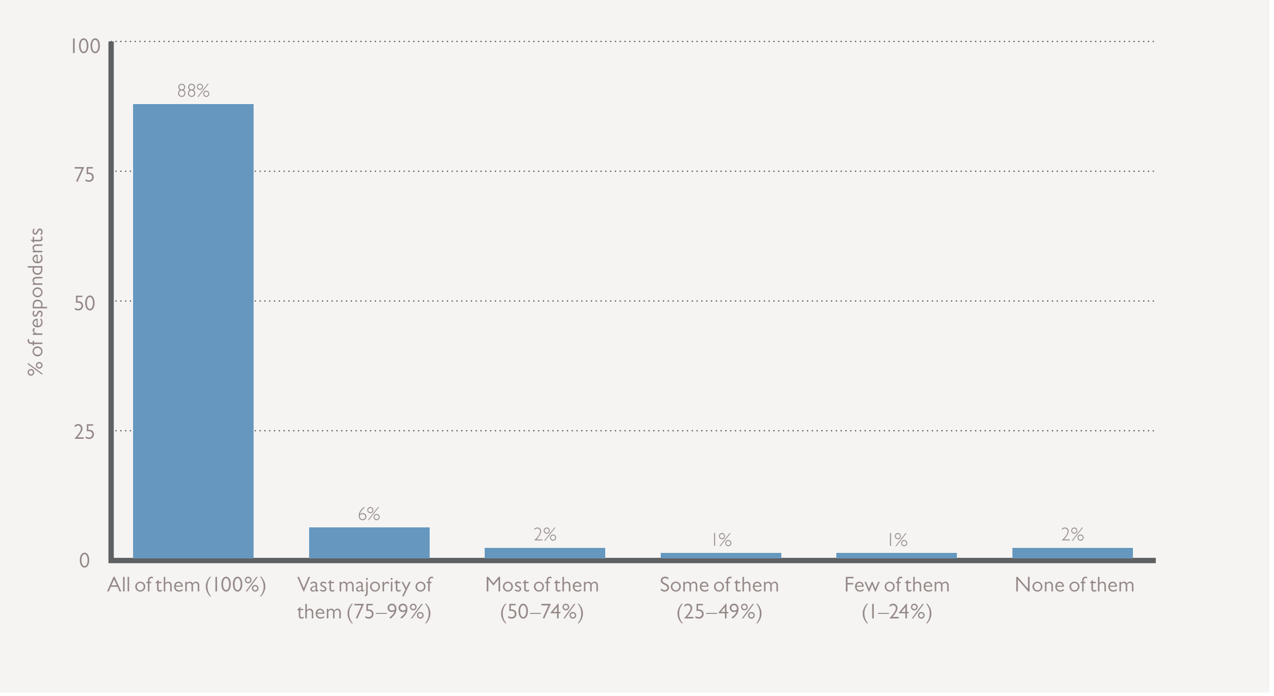
5. Biology has the lowest proportion of respondents achieving the benchmark (34% of respondents at Key Stage 4 and 18% of respondents at Post-16 level) (Figures 21 and 23). Qualitative evidence suggests it is more difficult for schools to carry out practical work in biology because they are more time-consuming than practical activities for the other sciences, and may need more preparation and particular conditions. In consequence some respondents say using apps (for example showing a 3D 'map' of the body) is an easier and faster way to teach biology rather than using practical work.

> "[To do a particular biology practical activity] I would need to set up a piece of equipment that needs to be left out for two weeks and in the same conditions. You find me somewhere in school where you can leave the lighting and temperature consistent for two weeks. It's a completely impractical practical."
>
> Academy, London (depth interviewee)

> "Some of the (biology) practicals are very difficult for us to do. We would need to carry out the experiment with every child over a period of several days. We have over 200 children in a year group – so more than 50 experiments even to do them in groups of four. The numbers are unworkable and yet this is supposed to be a core practical."
>
> Academy, East of England (depth interviewee)

6. The vast majority of respondents say their science lessons are at least 50 minutes long (Figure 25). This does not vary substantially across different institution types generally, however a lower proportion of independent schools say all their science lessons are at least 50 minutes long[18] (Figure 26).

Figure 25: How many of your science lessons are at least 50 minutes long?[19]

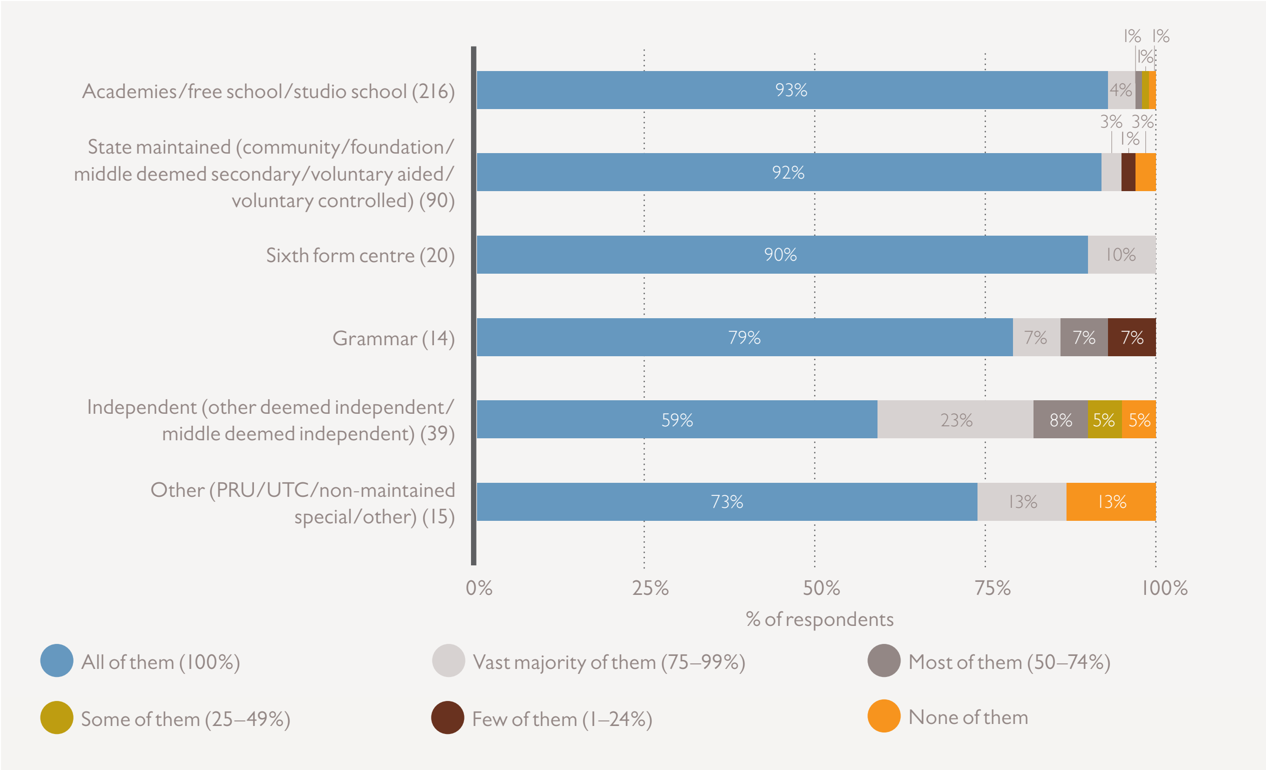


Base 395

[18] This is not statistically significant.

[19] The benchmark refers to 'enough' science lessons of at least 50 minutes in length.

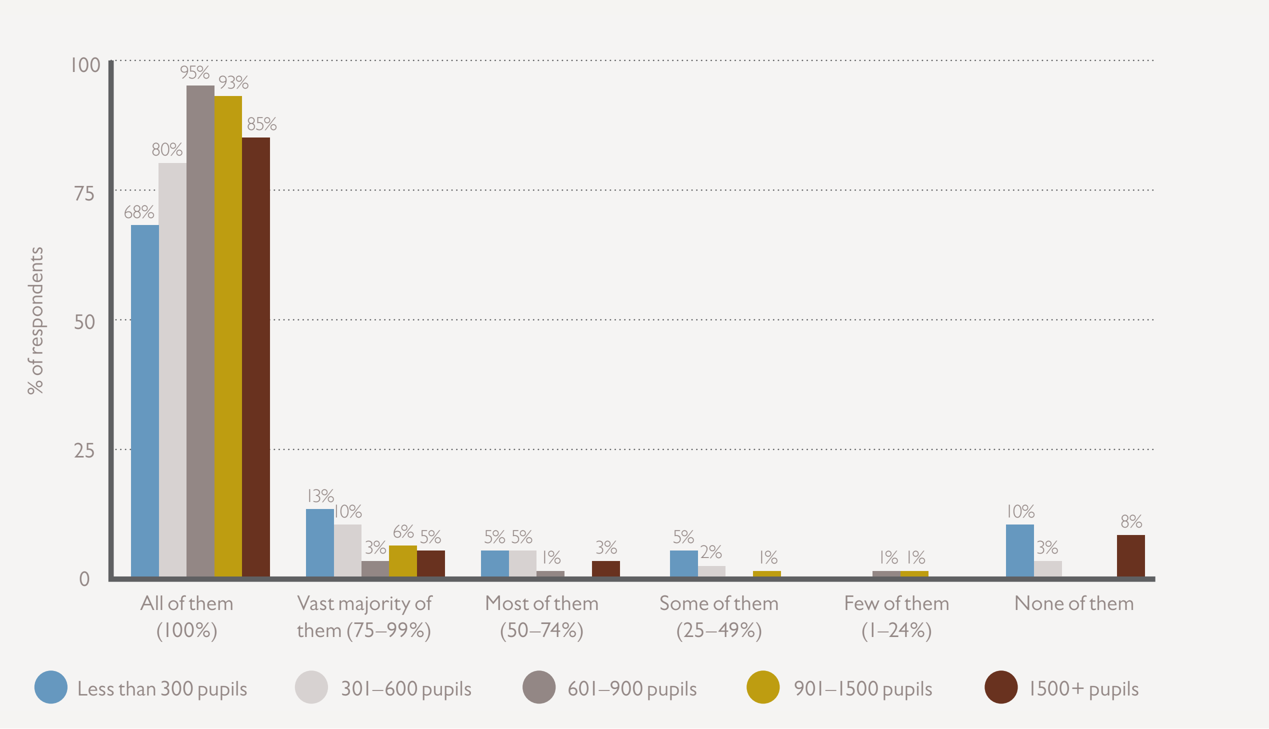
Figure 26: How many of your science lessons are at least 50 minutes long? (Institution types)



Base numbers are shown in brackets

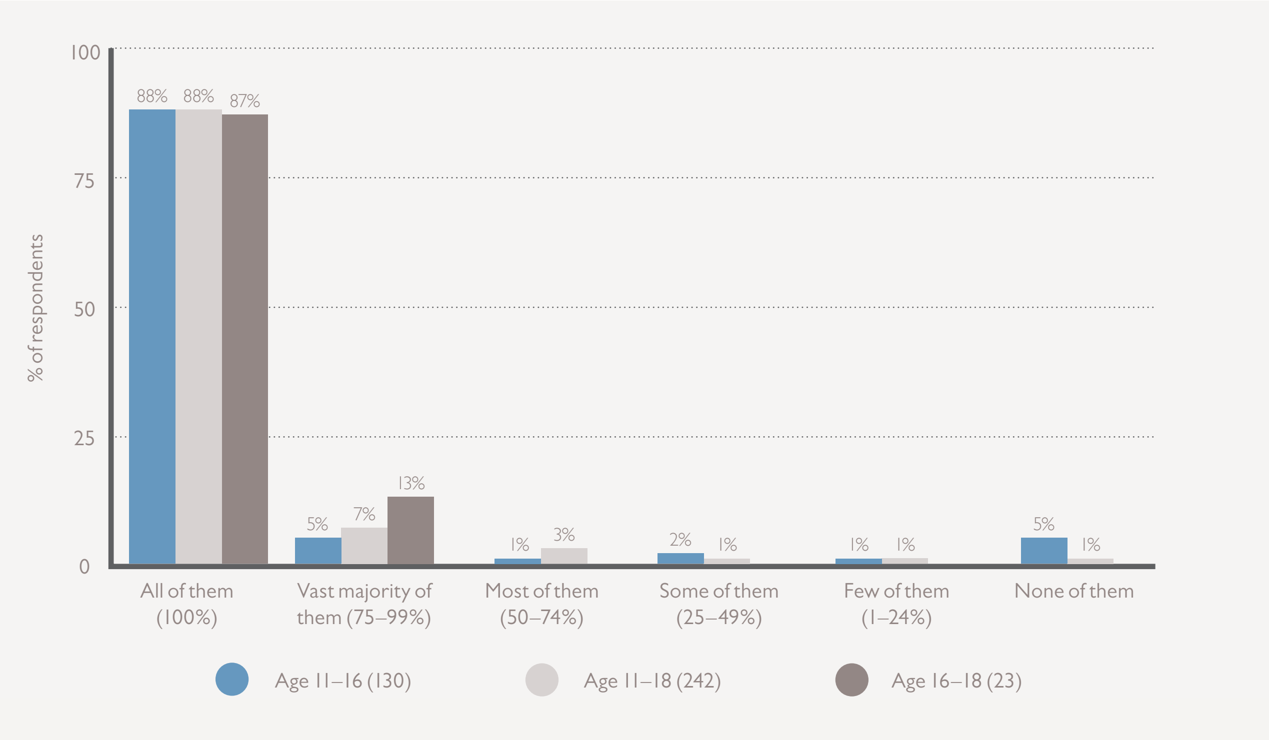
7. There are some differences between institutions of different sizes – for example 68% of respondents from schools with fewer than 300 pupils say all their science lessons are at least 50 minutes long, compared with over 90% of respondents saying the same in schools with between 601 and 1500 pupils (Figure 27). This is statistically significant.
8. There are only very minor differences between schools with or without a sixth form, or teaching years 12 and 13 only (Figure 28).

Figure 27: How many of your science lessons are at least 50 minutes long? (Institution sizes)



Base numbers are shown in brackets

Figure 28: How many of your science lessons are at least 50 minutes long? (Institution age bands)



Base numbers are shown in brackets

9. Qualitative evidence has flagged that the number of science lessons, rather than just their length, is a concern where the number of timetabled hours for science has been reduced. Respondents say this makes it much harder to teach to new "content-heavy curriculum". As with other factors, the stance that the SMT adopts is a critical influencer – either enabling or preventing sufficient hours on the timetable.

> "The SMT don't give us enough hours to teach science – we get as much as the Maths department, but we have much more content to cover. They [Maths] have got one subject, we've got four. The guided learning hours on triple science are for nine or ten lessons a week. We get six or seven if we're lucky."
>
> Academy, East of England (depth interviewee)

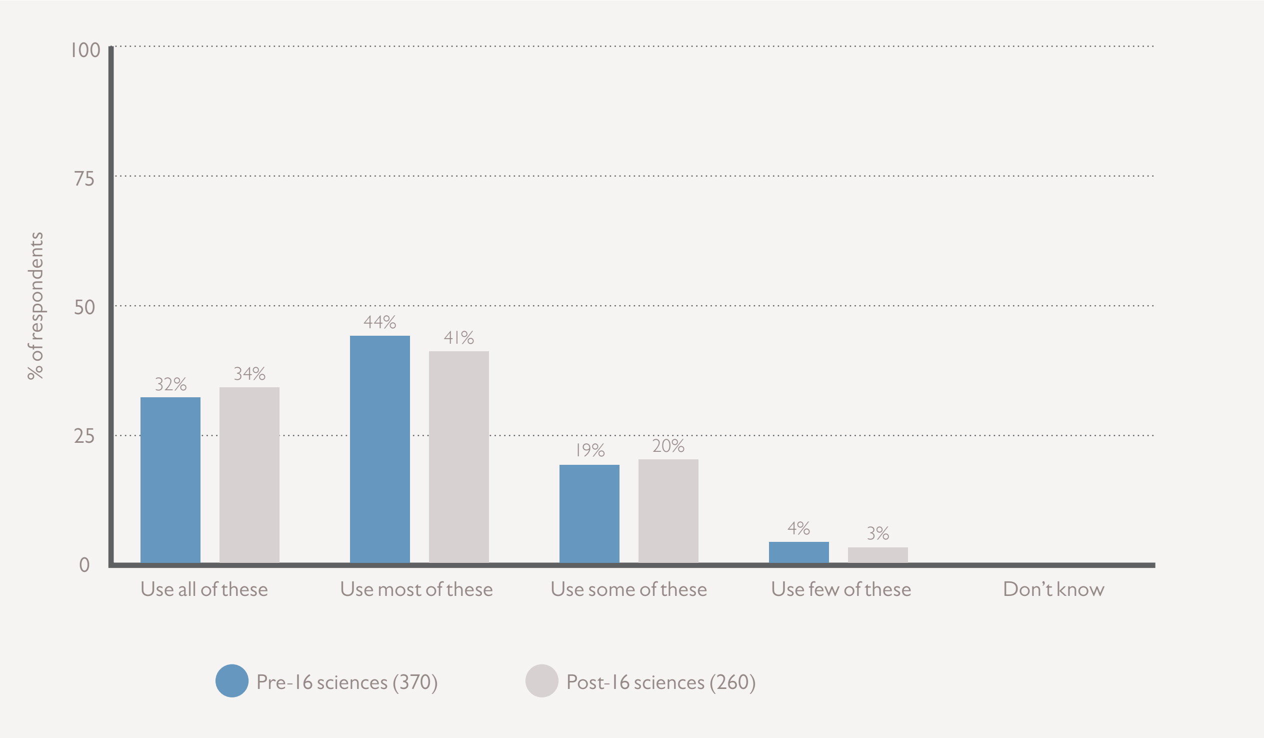
10. Respondents were asked to what extent over the course of an average school year[20] the following types of practical science activity are included (at each stage and across all science subjects):

    A. Investigations
    B. Projects
    C. Collaborative research
    D. Experiments to confirm theories
    E. Experiments to show phenomena
    F. Putting techniques into practice

11. Just under a third of all respondents say they use all of these for pre-16 sciences, and just over a third of respondents say the same for post-16 sciences (Figure 29).

[20] Over the course of an average school year' was added to the description following the survey pilot.

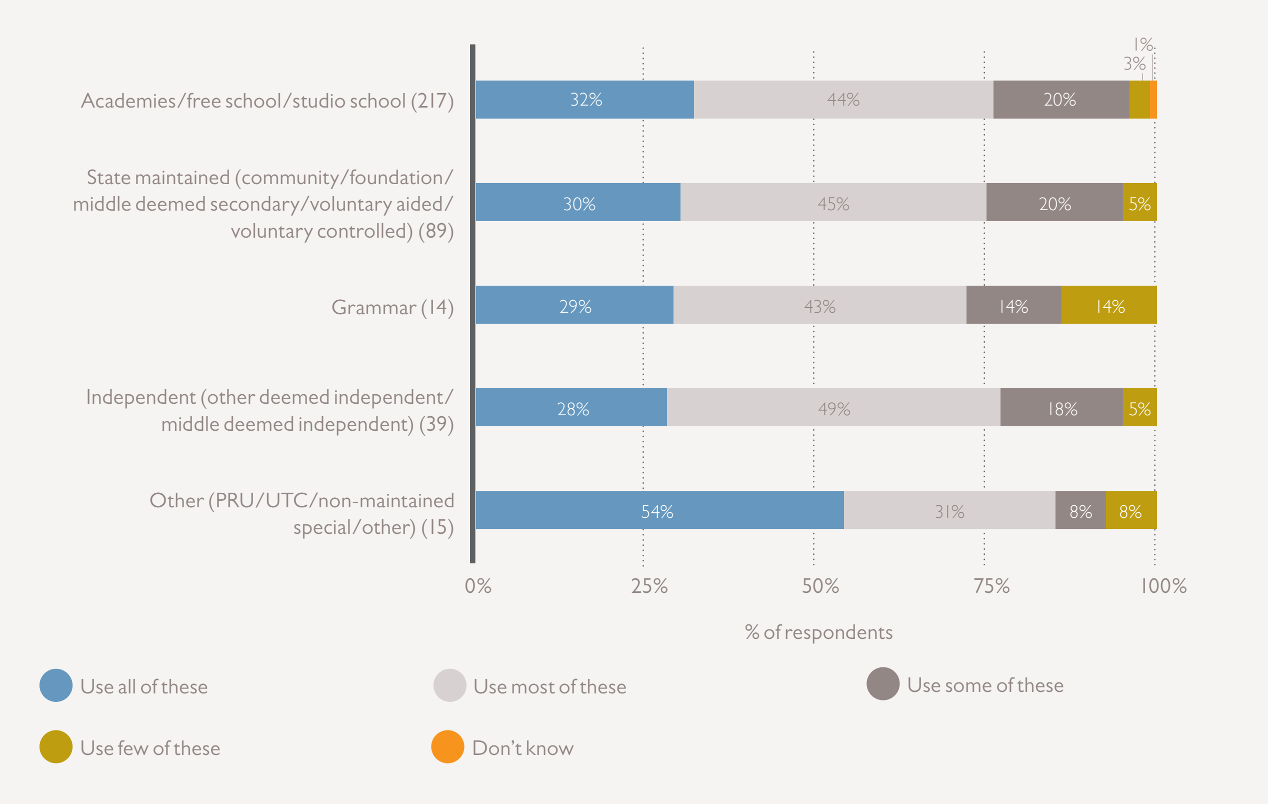
Figure 29: Extent to which different types of practical science activity are used, pre and post-16 sciences



Base numbers are shown in brackets

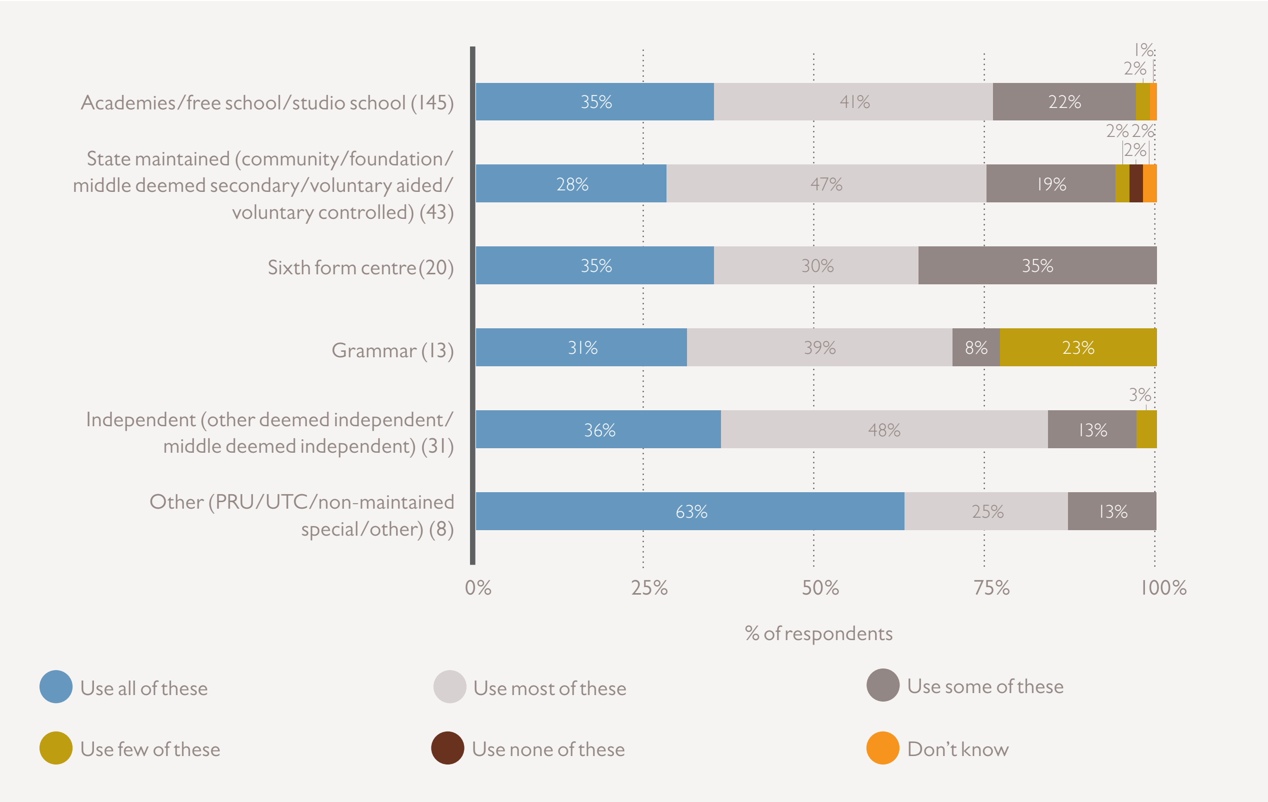
12. There are few differences between institution size for pre-16 sciences (Figure 32). For post-16 sciences, a higher proportion of respondents from schools with fewer than 300 pupils use all these types of activity (47%) compared with schools with between 301 and 600 pupils (Figure 33). This difference is not statistically significant.

Figure 30: Extent to which different types of practical science activity are used – pre-16 sciences (Institution types)



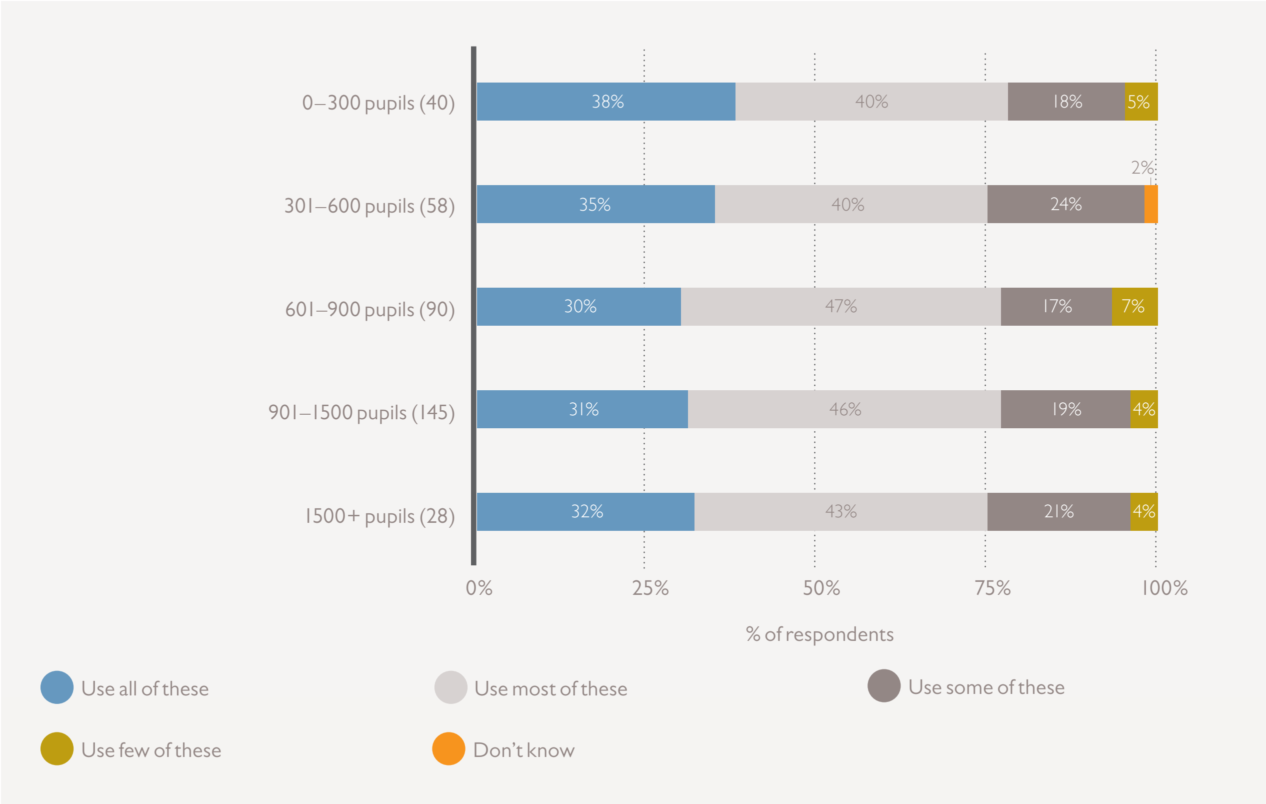
Base numbers are shown in brackets

Figure 31: Extent to which different types of practical science activity are used – post-16 sciences (Institution types)



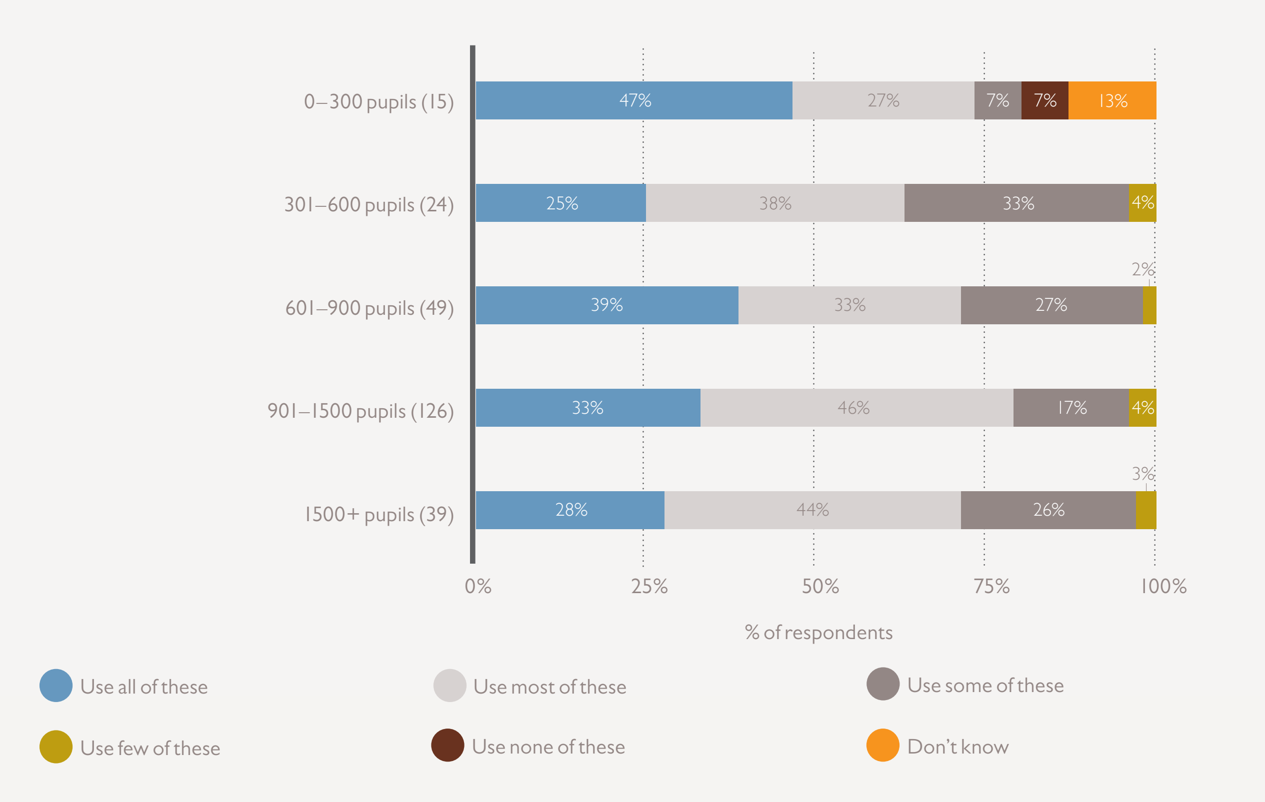
Base numbers are shown in brackets

Figure 32: Extent to which different types of practical science activity are used – pre-16 sciences (Institution sizes)



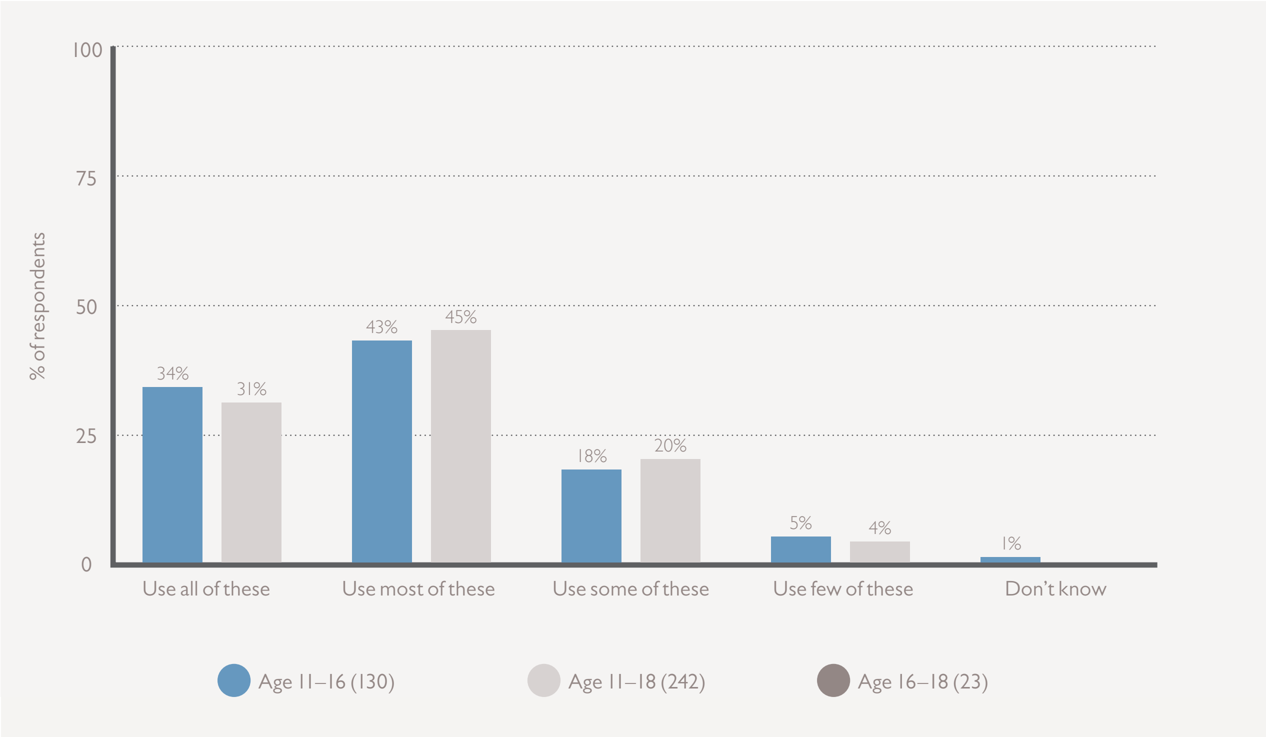
Base numbers are shown in brackets

Figure 33: Extent to which different types of practical science activity are used – post-16 sciences (Institution sizes)



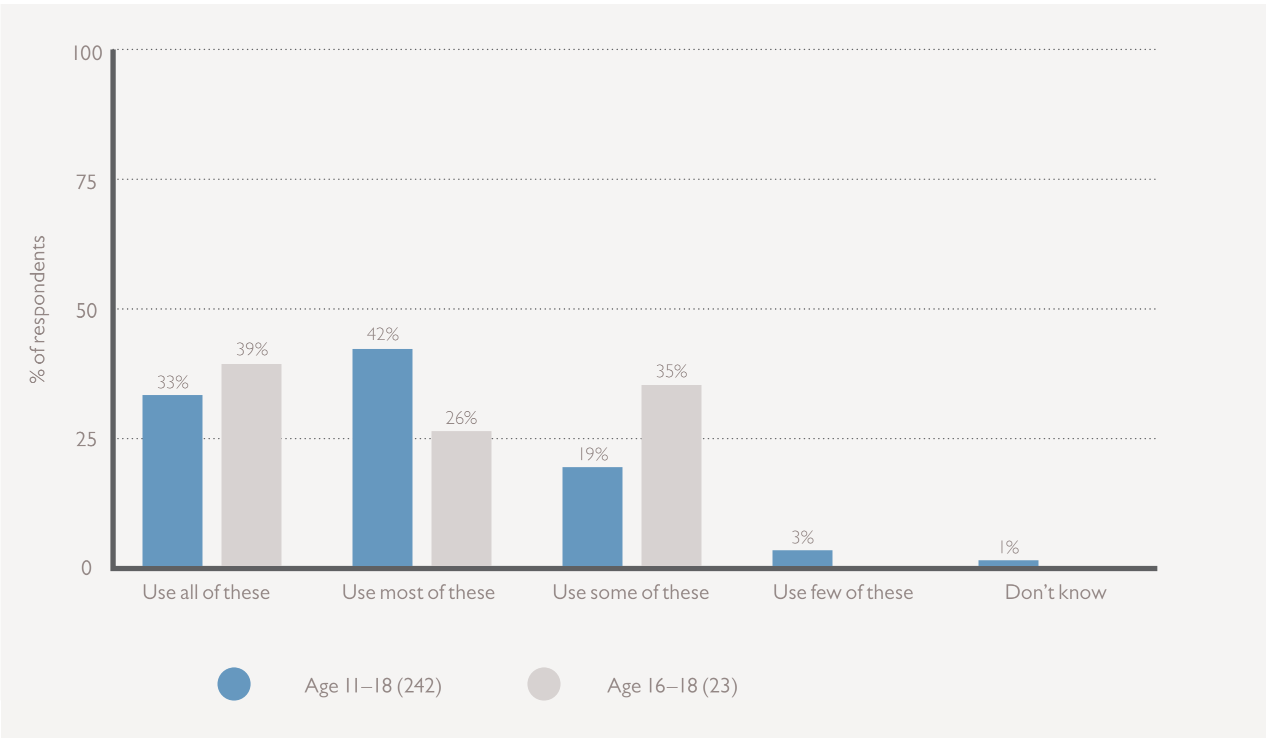
Base numbers are shown in brackets

Figure 34: Extent to which different types of practical science activity are used – pre-16 sciences (Institution age bands)



Base numbers are shown in brackets

Figure 35: Extent to which different types of practical science activity are used – post-16 sciences (Institution age bands)



Base numbers are shown in brackets

13. There are only very slight differences between schools with and without a sixth form (Figure 34).

14. Qualitative evidence identifies funding constraints, insufficient time for planning and a content heavy science curriculum (although opinions are divided on the latter as discussed below) as the main barriers to the provision of frequent and varied practical science.

> "It will be more difficult in the future to do practical science – our budgets are being cut. Schools are run like businesses now. The curriculum is jam packed. With the new curriculum, we need new textbooks and equipment for compulsory practicals. Where is the money for this?"
>
> Community school, Yorkshire & the Humber (depth interviewee respondent)

> "There is more practical now built in to the Key Stage 3 curriculum but as the content has increased massively, this can mean that doing a practical has to be sacrificed in order to be able to cover all the content in each lesson. We try to include as many of the experiments as possible but the longer ones can be very difficult to fit in. This is also a problem for Key Stage 4 as the content is now so much that investigative practicals no longer happen as we do not have lesson time."
>
> Academy, South-East (survey respondent)

> "Funding is a huge issue, we simply do not have enough money to complete practicals as much as we would like or in small enough groups."
>
> Academy, South-West (survey respondent)

> "I am really concerned that this is a dying area of science caused by general lack of funding in schools."
>
> Academy, East of England (survey respondent)

15. Opinions are mixed among respondents as to whether the new curriculum will enable or obstruct more frequent and varied practical science. One school of thought states the content-rich curriculum leaves less time for practical work, while the alternate view is that new practical assessments in GCSEs and A-levels will lead to more practical work in schools and colleges.

16. One respondent comments: *"If the SMT gave us more time for planning and discussion, we could research more inspiring techniques…working together is the key, and then working with other schools."*

8. BENCHMARK 5 – LABORATORY FACILITIES AND EQUIPMENT

Schools should have enough laboratories to make it possible for every teacher to do frequent practical science safely. Each laboratory should have sufficient equipment for students to work in small groups.

There should be enough laboratories so that the availability of labs 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 students 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.

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

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

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

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

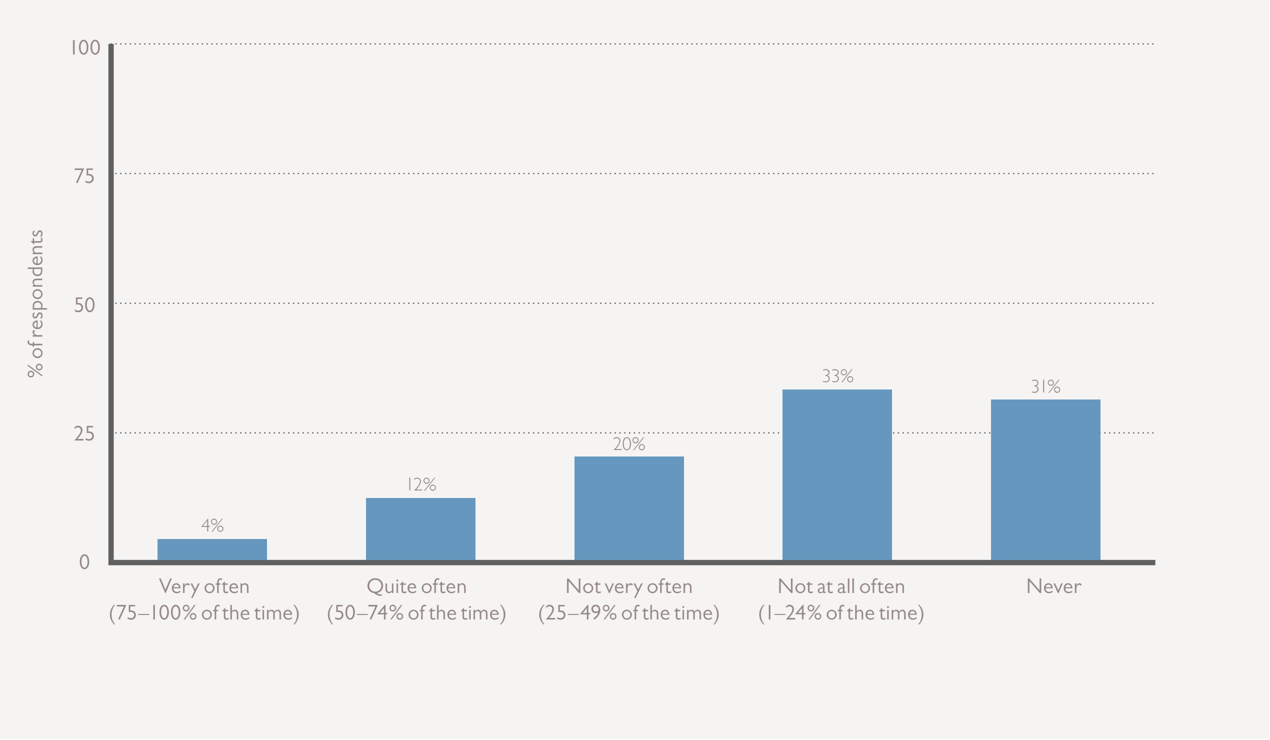
1. On average there are eight laboratories per respondent.
2. On average, survey data show respondents have a higher number of general purpose laboratories than subject-specific ones. The average number of laboratories for biology (three) is more than the two for chemistry and physics – even though survey data show fewer practical activities take place in biology compared with other sciences (Table 11).

Table 11: Number of laboratories

Subject	Number of laboratories				
	Average across all respondents	Where science facilities refurbished in the last five years	Where part of a multi-academy trust	Where the availability of laboratories is never a barrier to carrying out practical science	Where the availability of laboratories is very often a barrier to carrying out practical science
Biology	3	3	2	3	2
Chemistry	2	3	2	2	2
Physics	2	3	2	2	2
All-purpose (including applied science)	5	5	7	6	4

3. Nearly a third of respondents say the availability of laboratories has never been a barrier to carrying out practical science activities in the last academic year (Figure 36).

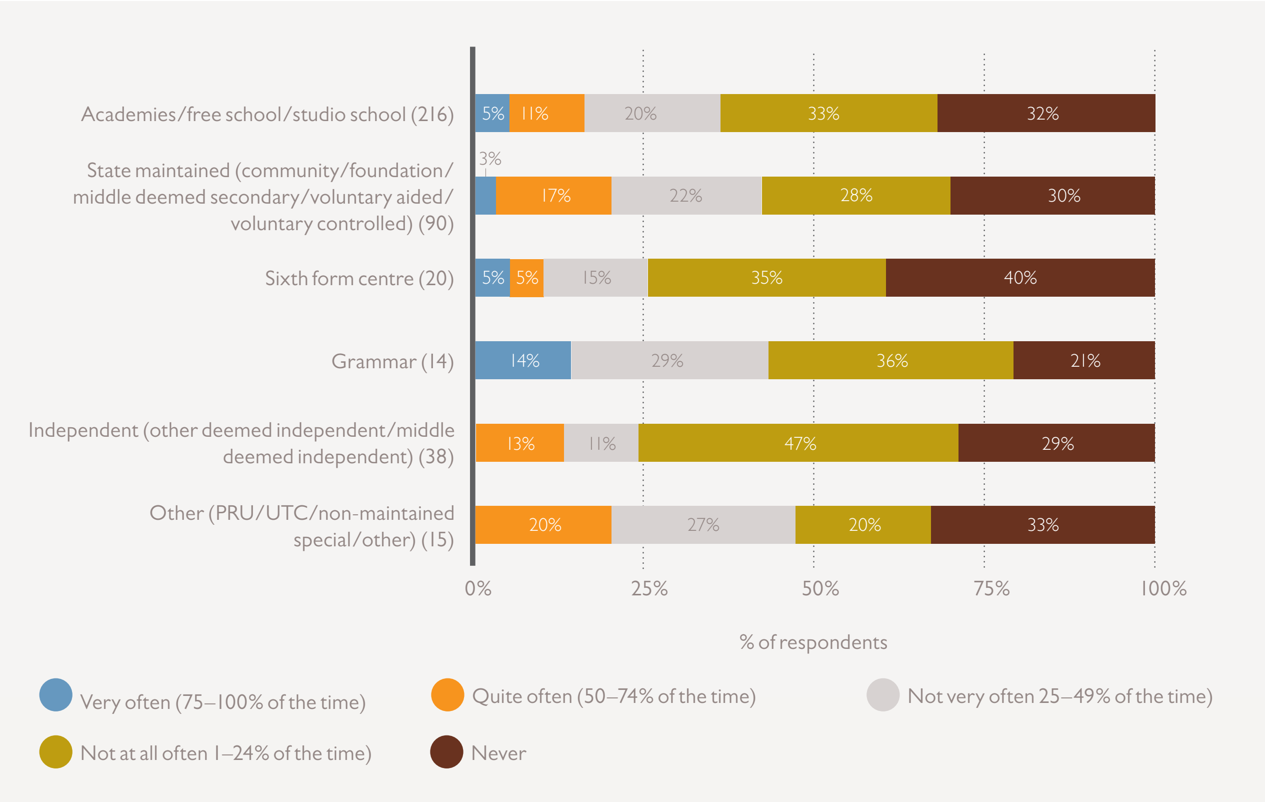
Figure 36: Over the last academic year, how often has the availability of laboratories been a barrier to carrying out practical science activities (in any science subject)?



Base 394

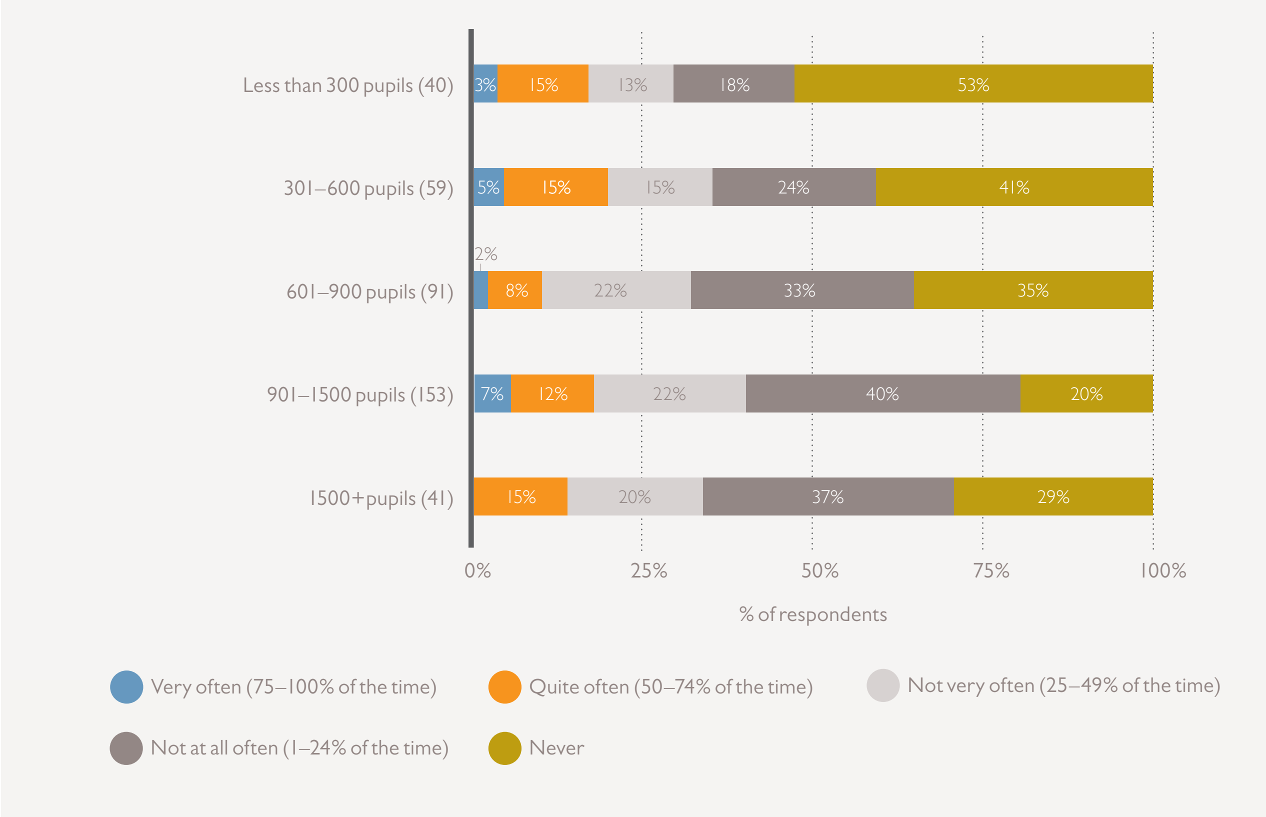
4. There are few differences between institution types although a slightly higher proportion of sixth form centres (40% of respondents) say the availability of laboratories has never been a barrier (Figure 37).
5. There are more noticeable differences however between small and large institutions. Just over half of respondents from schools with fewer than 300 pupils say this has never been a barrier, compared with 29% of respondents from schools with more than 1500 pupils (Figure 38). This is statistically significant.
6. A lower proportion of schools with sixth forms say the availability of laboratories has never been a barrier (25% of respondents) compared with schools without sixth forms (42% of respondents) (Figure 39). This is not statistically significant.

Figure 37: Over the last academic year, how often has the availability of laboratories been a barrier to carrying out practical science activities (in any science subject)? (Institution types)



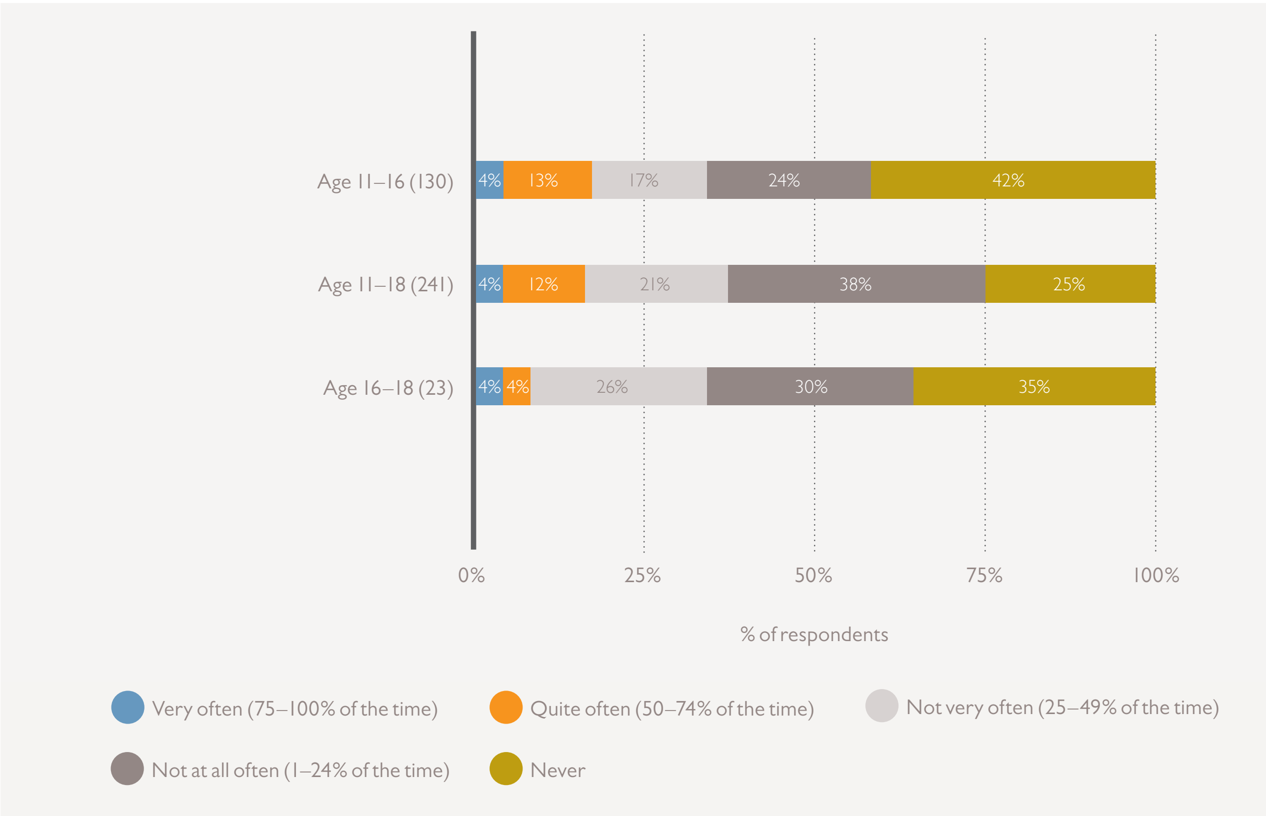
Base numbers are shown in brackets

Figure 38: Over the last academic year, how often has the availability of laboratories been a barrier to carrying out practical science activities (in any science subject)? (Institution sizes)



Base numbers are shown in brackets

Figure 39: Over the last academic year, how often has the availability of laboratories been a barrier to carrying out practical science activities (in any science subject)? (Institution age bands)

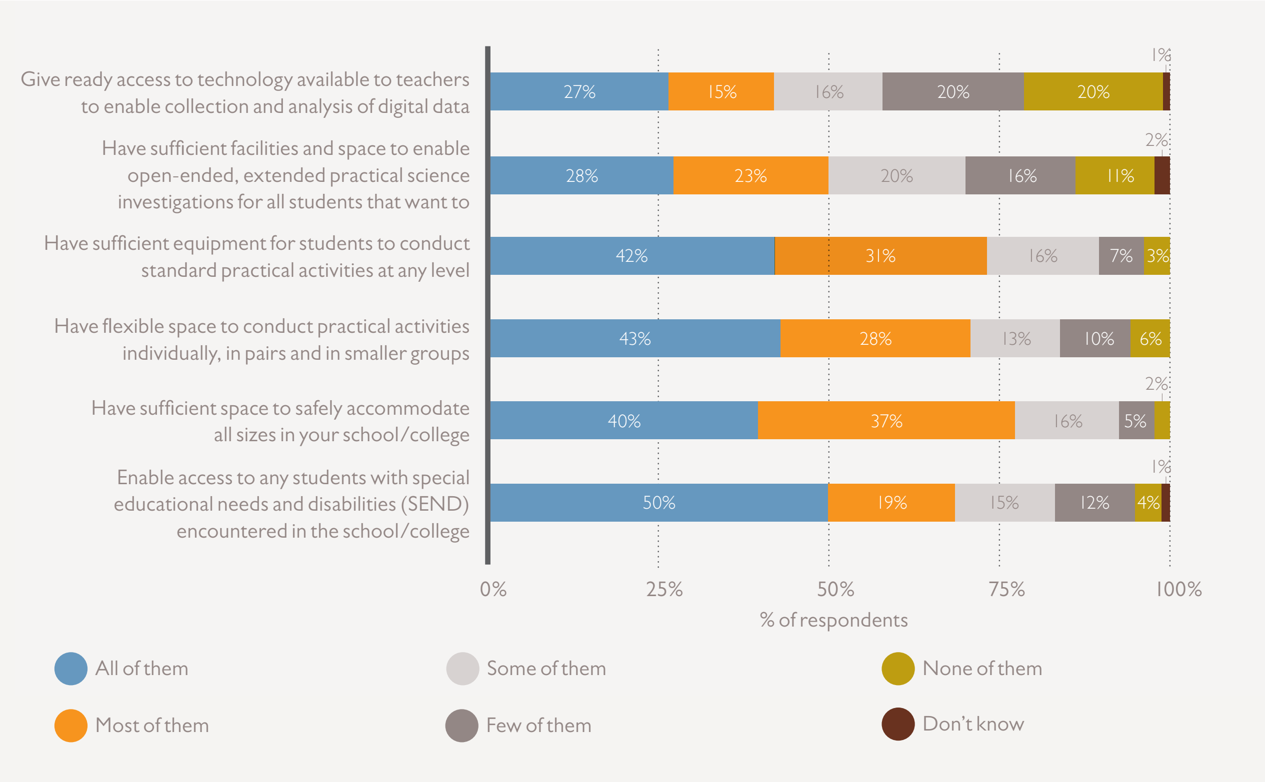


Base numbers are shown in brackets

7. It is clear from survey data that schools without sixth forms and smaller schools (fewer than 300 pupils) are the closest to meeting most components of the benchmark.
8. Approximately 40% of all respondents say all their laboratories have sufficient space to safely accommodate all class sizes (Figure 40). This rises to 80% among respondents from schools with fewer than 300 pupils, compared with 29% among respondents from schools with more than 1500 pupils (Figure 42). This is statistically significant.
9. There are differences between schools with and without a sixth form; 55% of respondents from schools without a sixth form say all their laboratories have sufficient space, compared with 32% of respondents from schools with a sixth form (Figure 43). This is not statistically significant.
10. Around 43% of all respondents say all their laboratories have flexible space to conduct practical work individually, in pairs and in small groups (Figure 40). This figure rises to 70% among respondents from schools with fewer than 300 pupils (Figure 42).
11. Again there are differences depending on the year groups taught – 49% of respondents from schools without sixth forms say all their laboratories have flexible space, compared with 39% of respondents saying the same among schools with sixth forms (Figure 43). This is statistically significant.
12. Around 42% of all respondents say all their laboratories have sufficient equipment for conducting practical activities (Figure 40). This increases to 60% among sixth form centres and 82% among independent schools (Figure 41). This is statistically significant.
13. A higher proportion of schools with sixth forms (57% of respondents) say all their laboratories have sufficient equipment, compared with 36% of respondents from schools without sixth forms saying the same (Figure 43). This is not statistically significant.
14. Around 27% of all respondents say all their laboratories give ready access to technology enabling collection and analysis of digital data (Figure 40). This rises to 56% among independent schools (Figure 41)[21]. A much lower proportion of medium-sized schools (601–900 pupils) say all their laboratories give ready access to technology – 17% of respondents say this, compared with 45% of respondents from small schools (fewer than 300 pupils) saying the same (Figure 42). This is statistically significant.
15. Half of all respondents say all of their laboratories enable access to students with special educational needs (Figure 40). This rises to 83% among respondents from schools with fewer than 300 pupils, compared with 39% among respondents from schools with more than 1500 pupils (Figure 42). This difference is marginally statistically significant.

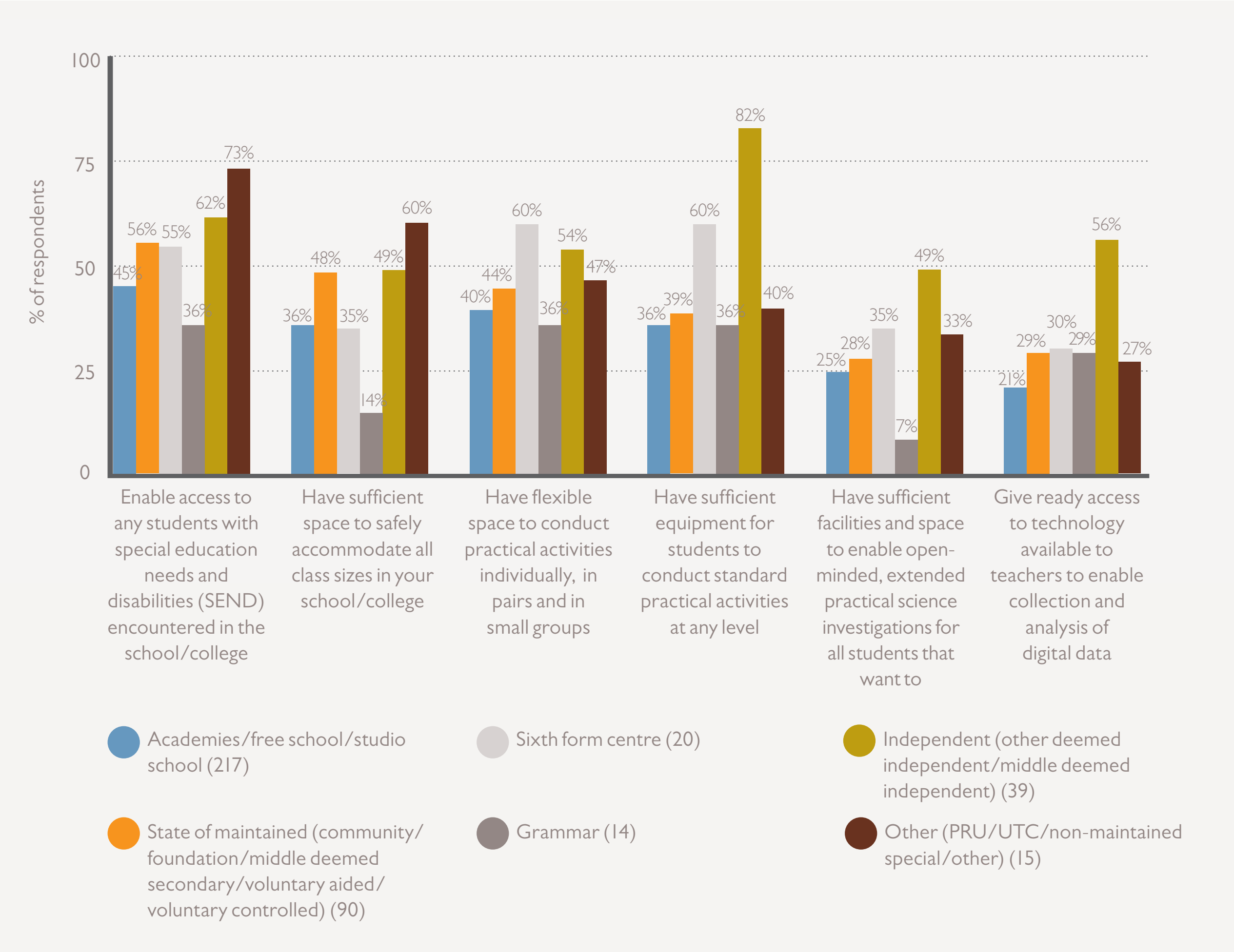
[21] There is evidence of a relationship, significant at the 1% level; 38.9% of cells have an expected value of less than 5.

Figure 40: How many of your laboratories…?



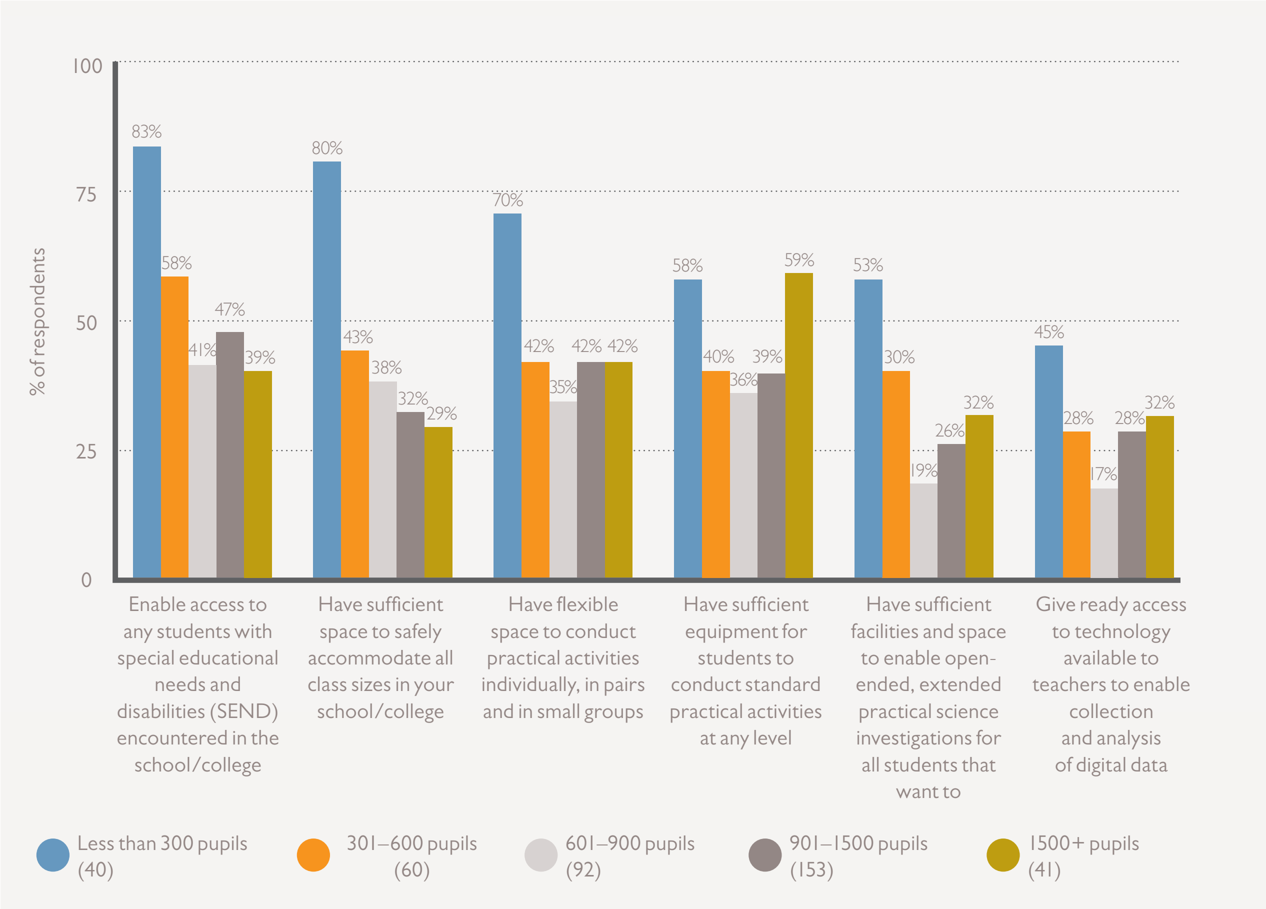
Bases 394–396

Figure 41: % of respondents saying that *all* their laboratories…? (Institution types)



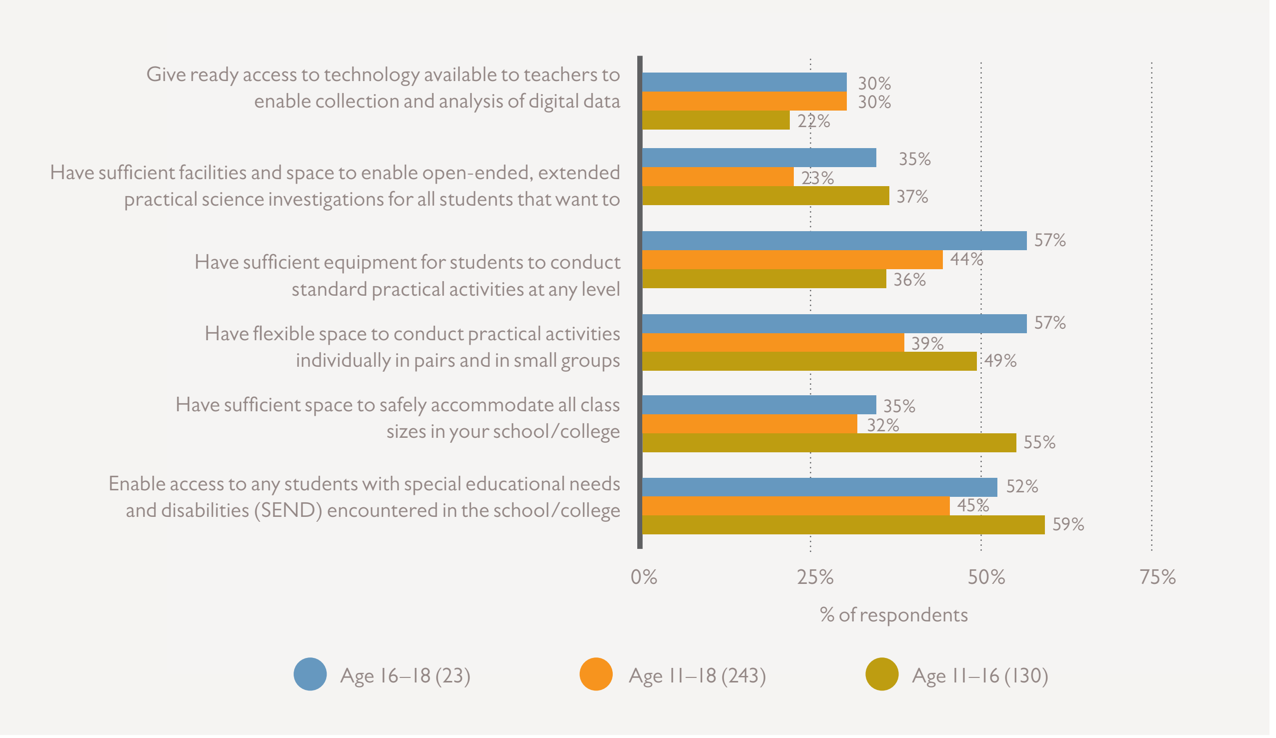
Base numbers are shown in brackets. Data show proportion of respondents that say 'all their laboratories' in relation to the options, therefore should not total 100%

Figure 42: % of respondents saying that *all* their laboratories…? (Institution sizes)



Base numbers are shown in brackets. Data show proportion of respondents that say 'all their laboratories' in relation to the options, therefore should not total 100%

Figure 43: % of respondents saying that *all* their laboratories…? (Institution age bands)



Base numbers are shown in brackets. Data show proportion of respondents that say ‘all their laboratories’ in relation to the options, therefore should not total 100%

16. Qualitative evidence states that the main barriers to effective laboratory facilities are insufficient or poorly designed space, insufficient resources and lack of funding to update or purchase new equipment. Seven of the twenty depth interviewees say the views of the science department were not taken into consideration when laboratories were being designed or refurbished, and are not fully fit for purpose as a consequence.

> "The refurbishment [of the science facilities] reduced practical capacity by removing gas taps and extractor fans so teachers are required to move laboratories for practical work to be carried out."
>
> Middle school, London (survey respondent)

> "Although our facilities were improved in the last ten years, the quality of the facilities is poor. Staff were consulted about positions of gas taps etc., but cost meant that this consultation was ignored. As a result, although our facilities look good, they are actually quite unsafe due to gas tap positions."
>
> Academy, North-West

17. Three of the depth interviewees point out that experience of science teachers and technicians can make a difference where the school has insufficient or inadequate equipment. For example an experienced technician may be able to make a piece of equipment, or may know of a way to carry out the practical activity using another piece of existing equipment – rather than feel compelled to buy new equipment. As stated in section 6 however, some respondents are finding it difficult to recruit those specialist teachers (and technicians – discussed in more detail in section 9) that could help to achieve the benchmark.

18. Although it is not clear from survey data how experienced technicians are from respondent schools, 31% that say they have sufficient technical expertise to support all sciences also state that all their laboratories have sufficient equipment, compared with 10% of respondents who say the same, where they do not have sufficient technical expertise. This difference is not statistically significant.

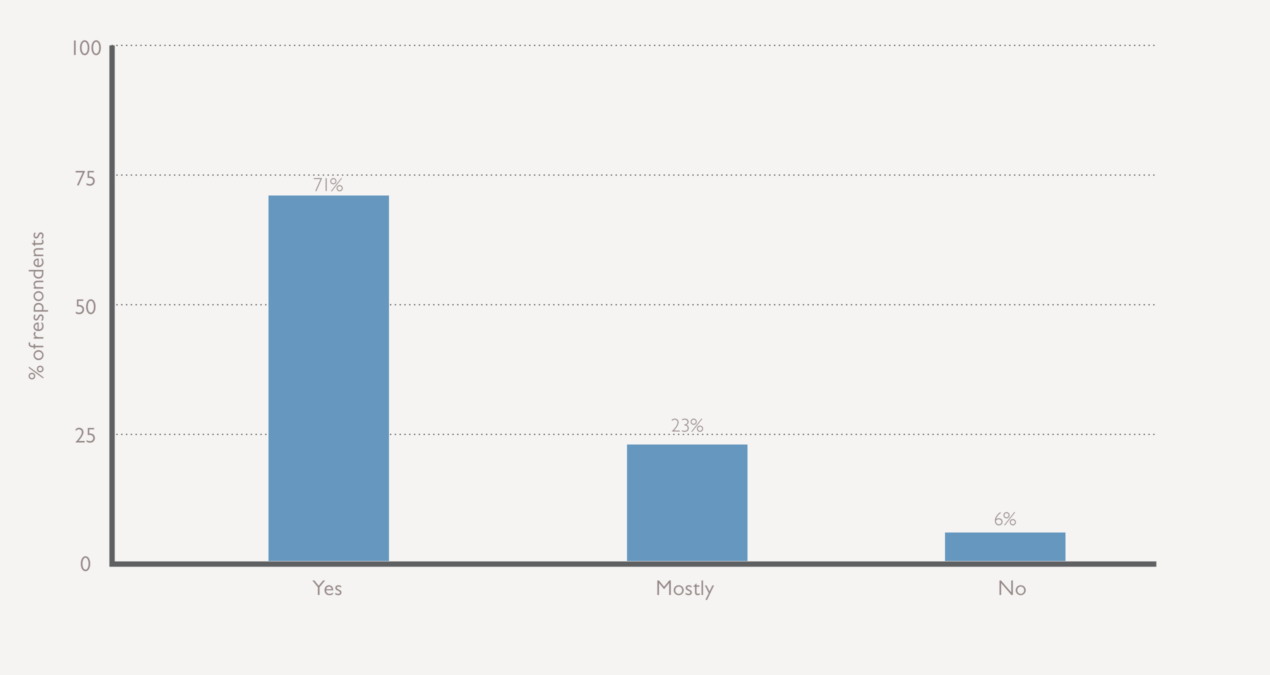
19. The majority of survey respondents (71%) say their school or college has dedicated, well-organised preparation areas that enable easy access to the laboratories (Figure 44). This rises to 78% among respondents that say there is sufficient technical expertise to support science.[22] The figure also increases among independent schools (90% of respondents) and sixth form centres (80% of respondents) (Figure 45).

20. The lowest proportion of respondents that say their school or college has dedicated and well-organised preparation areas come from schools with fewer than 300 pupils (58% of respondents – compared with 79% of respondents from schools with 901–1500 pupils) (Figure 46). This difference is statistically significant.

21. There are few differences between schools with and without sixth forms (Figure 47).

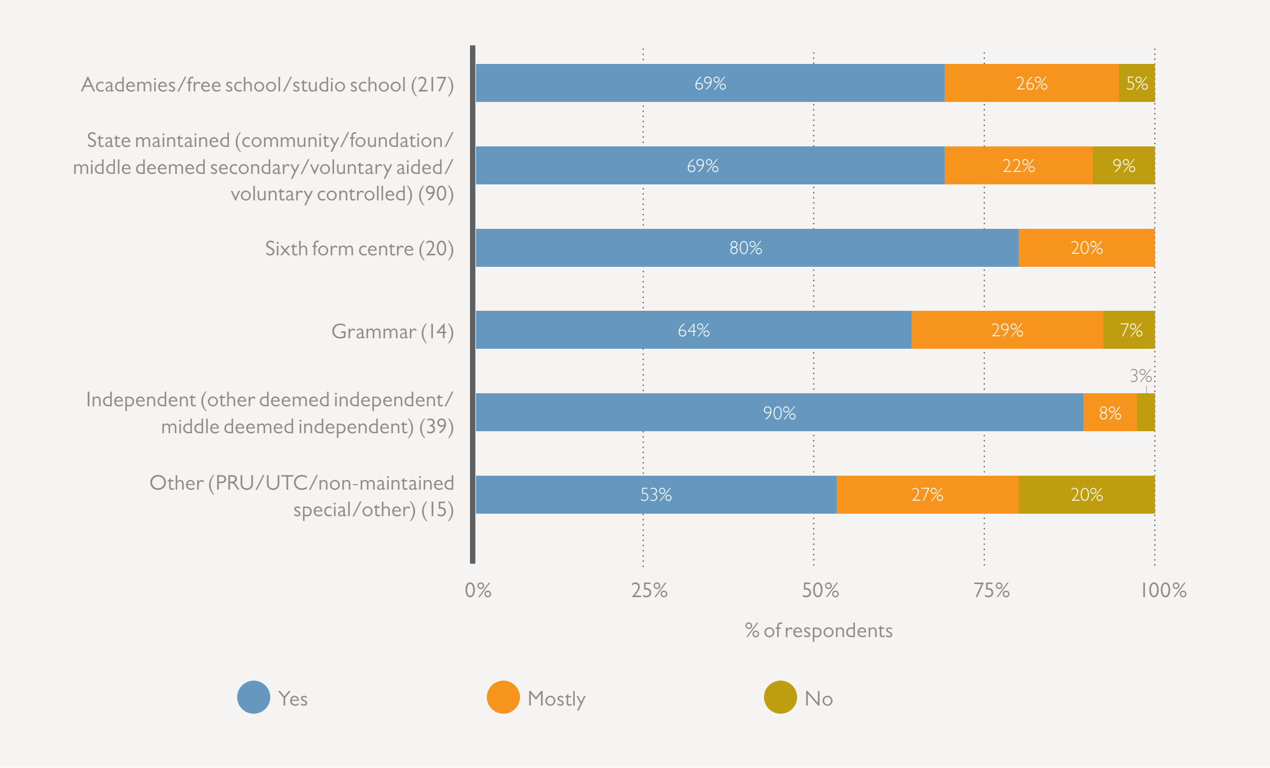
[22] Technical support is discussed in detail in section 9.

Figure 44: Does your school or college have dedicated, well-organised preparation areas with easy access to the science laboratories?



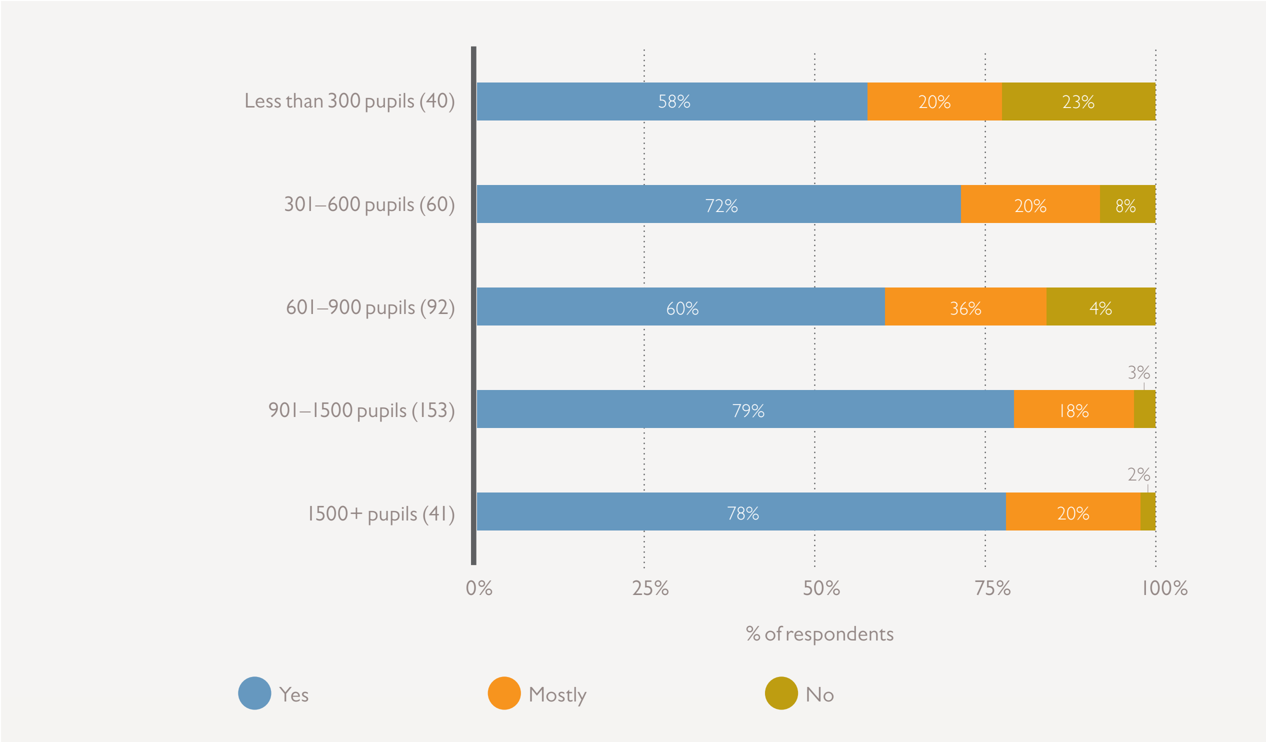
Base 396

Figure 45: Does your school or college have dedicated, well-organised preparation areas with easy access to the science laboratories? (Institution types)



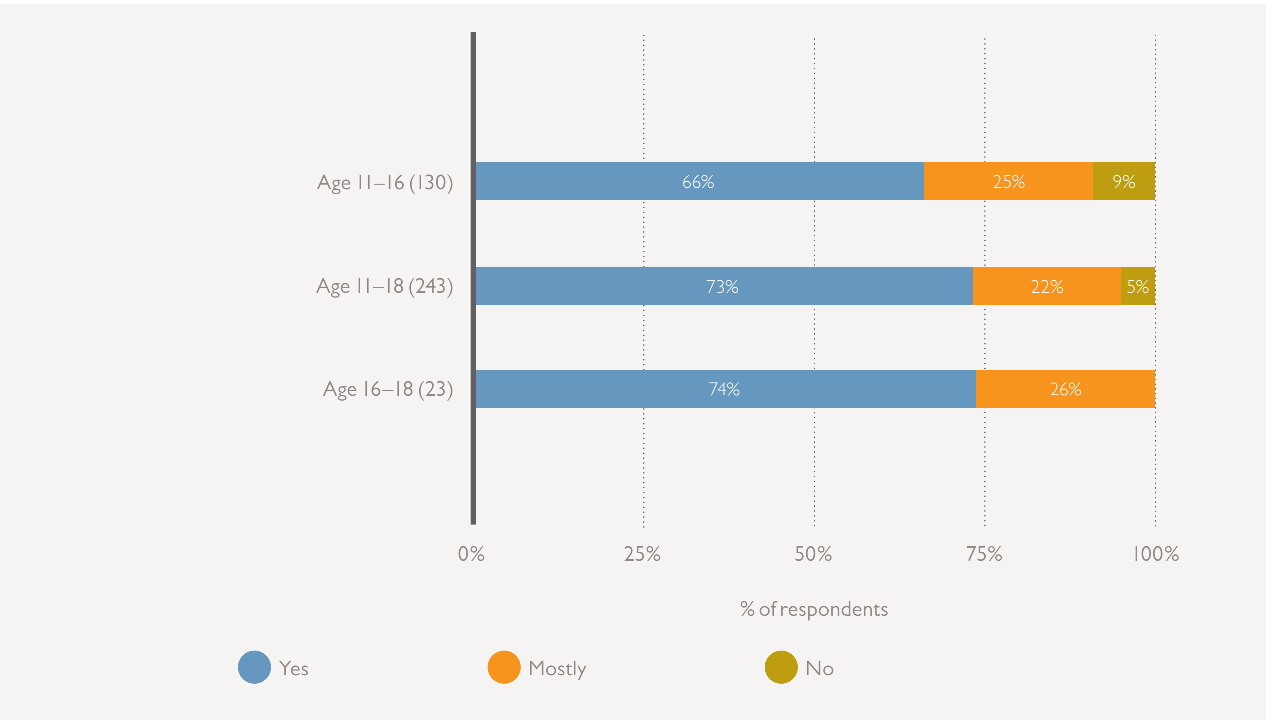
Base numbers are shown in brackets

Figure 46: Does your school or college have dedicated, well-organised preparation areas with easy access to the science laboratories? (Institution sizes)



Base numbers are shown in brackets

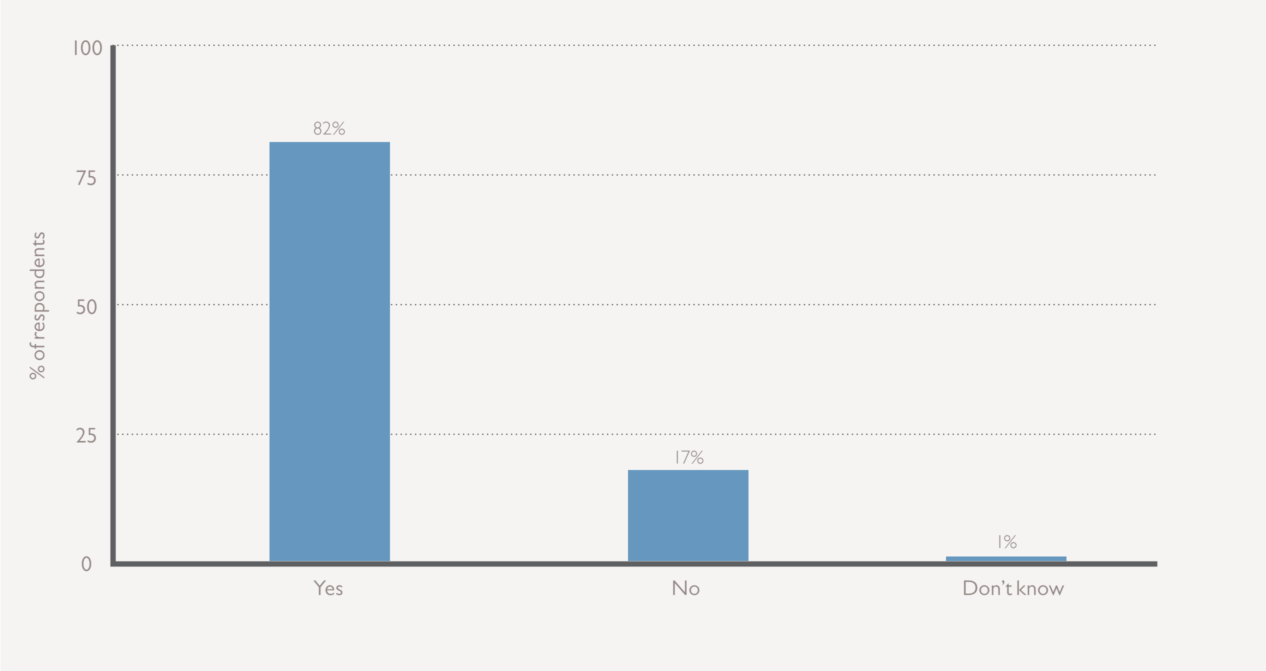
Figure 47: Does your school or college have dedicated, well-organised preparation areas with easy access to the science laboratories? (Institution age bands)



Base numbers are shown in brackets

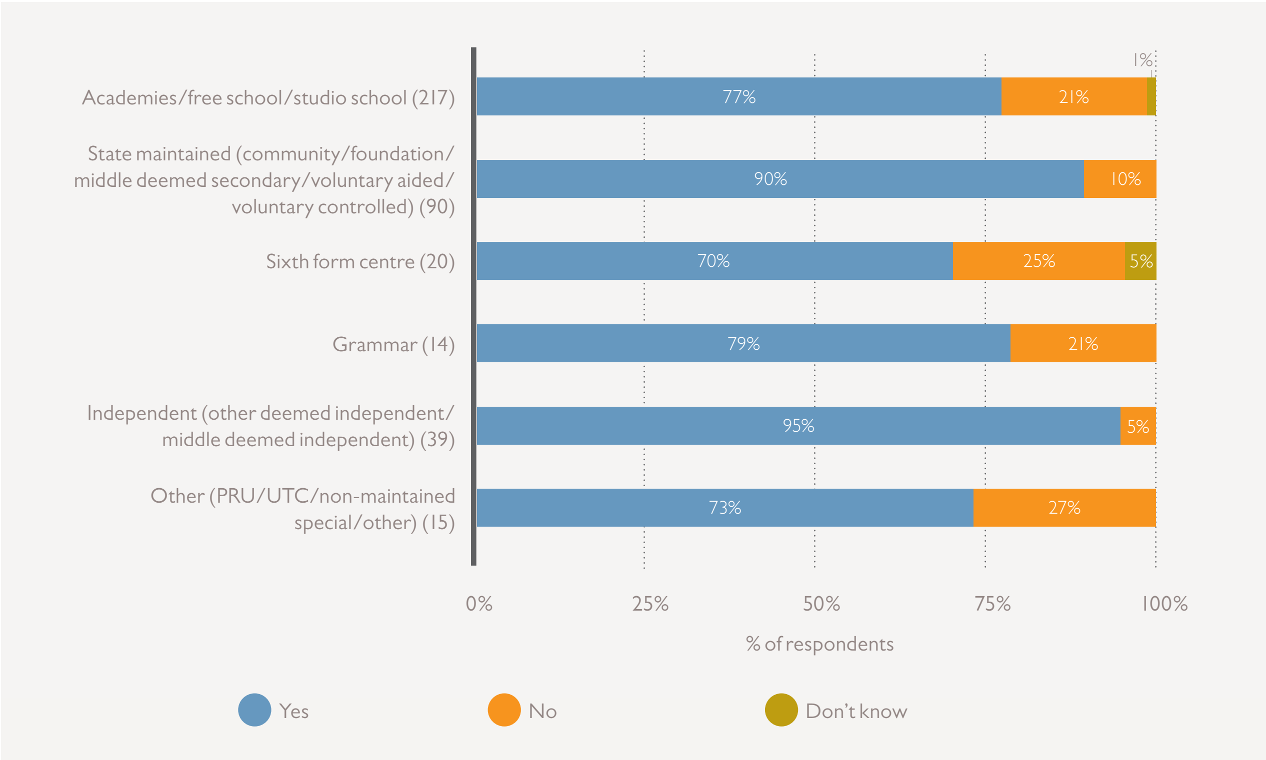
22. The majority of survey respondents (82%) say their school or college has an accessible outdoor space where practical science can take place (Figure 48). This rises to 95% among respondents from independent schools (Figure 49). There are no strong differences between schools by size (Figure 50), schools with a sixth form and those without (Figure 51).

Figure 48: Does your school or college have an accessible outdoor space where practical science activities can take place?



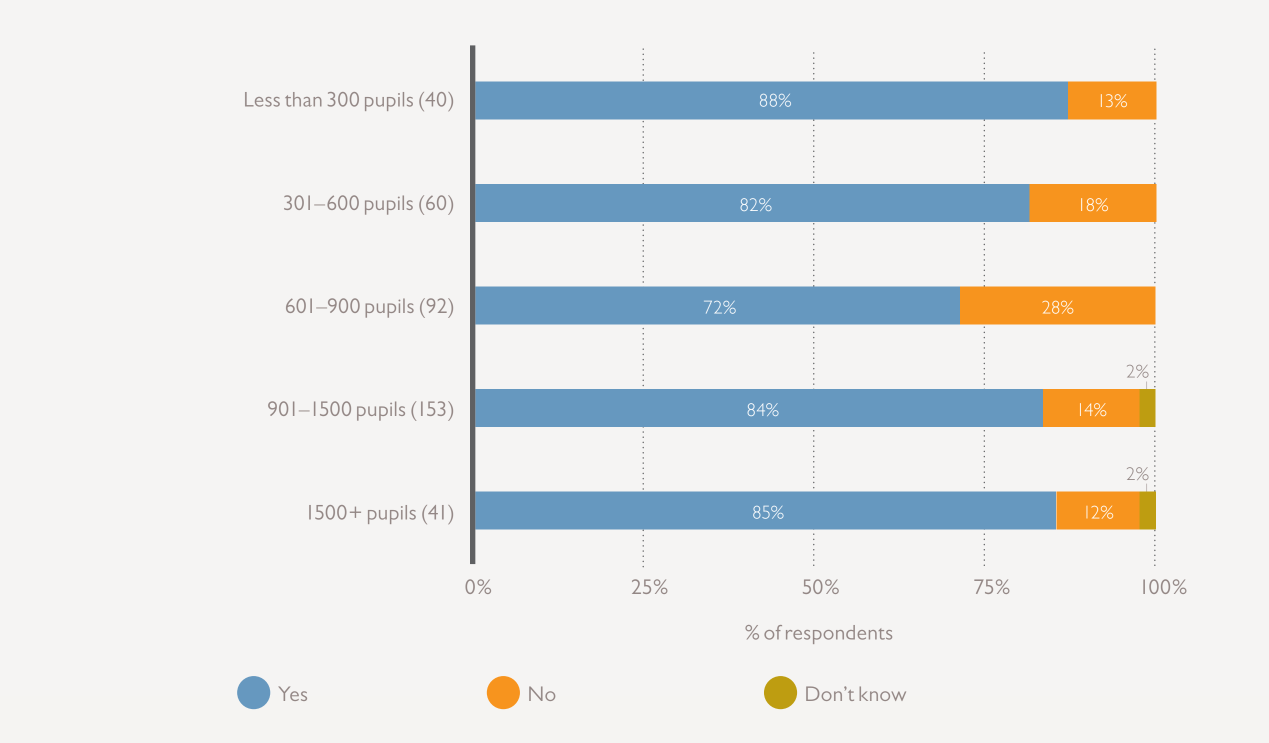
Base 396

Figure 49: Does your school or college have an accessible outdoor space where practical science activities can take place? (Institution types)



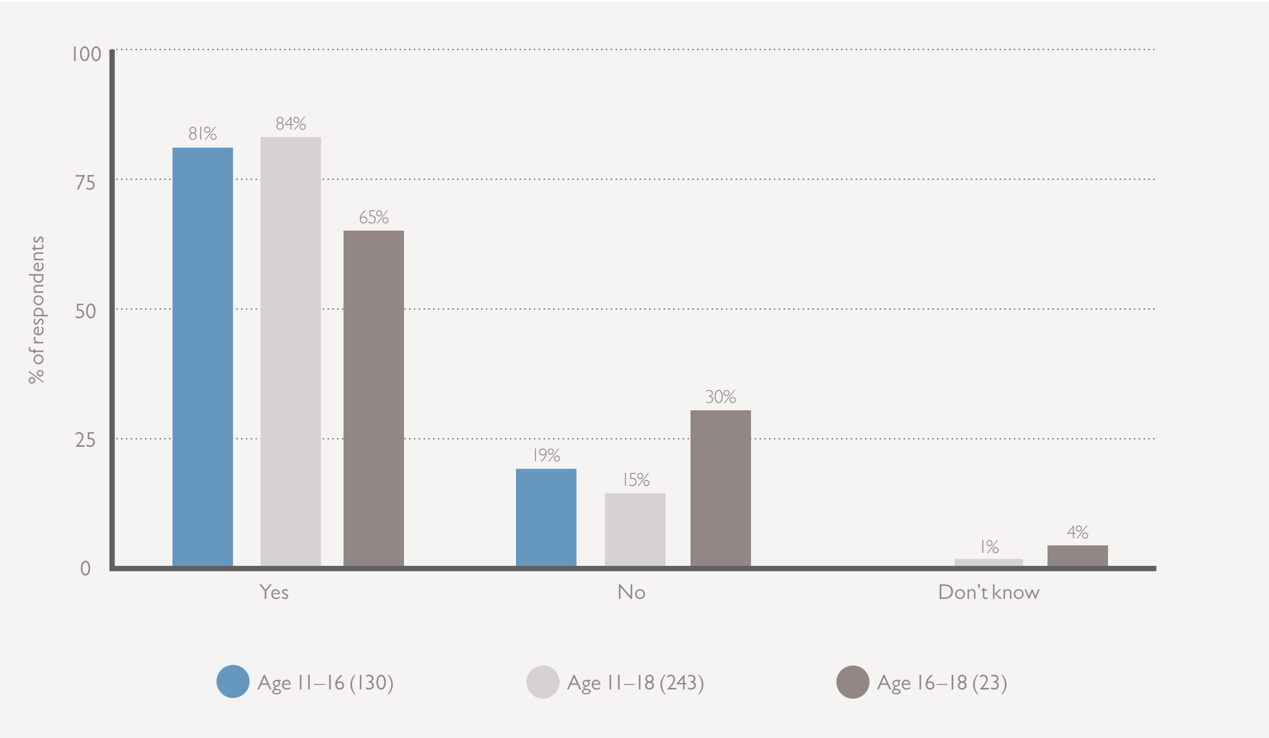
Base numbers are shown in brackets

Figure 50: Does your school or college have an accessible outdoor space where practical science activities can take place? (Institution sizes)



Base numbers are shown in brackets

Figure 51: Does your school or college have an accessible outdoor space where practical science activities can take place? (Institution age bands)

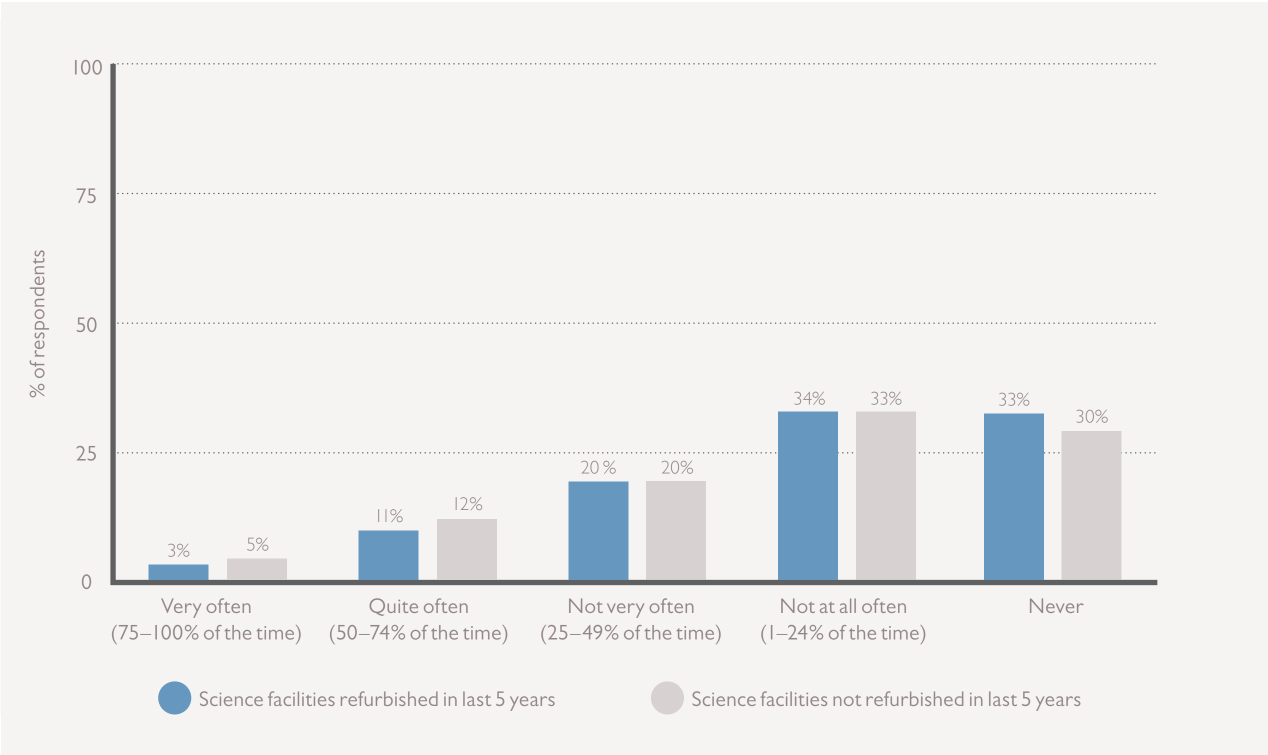


Base numbers are shown in brackets

23. Given a lower proportion of respondents meet the benchmark for 50% of all lessons involving direct practical activities in biology, compared with other sciences, survey data were analysed to see if the provision of outdoor space is likely to be an enabler for doing more practical work in biology. The results show 23% of respondents with accessible outdoor space achieve the benchmark for Key Stage 4 biology, compared with 4% achieving it where they do not have outdoor space. For post-16 biology, 14% of respondents with accessible outdoor space achieve the benchmark of 50% of lessons with direct practical activities, compared with 3% achieving it where they do not have outdoor space. These results are statistically significant.

24. Survey data were analysed to understand any differences in laboratory facilities and availability between schools that have had their science facilities refurbished in the past 5 years, and those that have not. Figure 52 shows few differences between the availability of laboratories between these two groups.

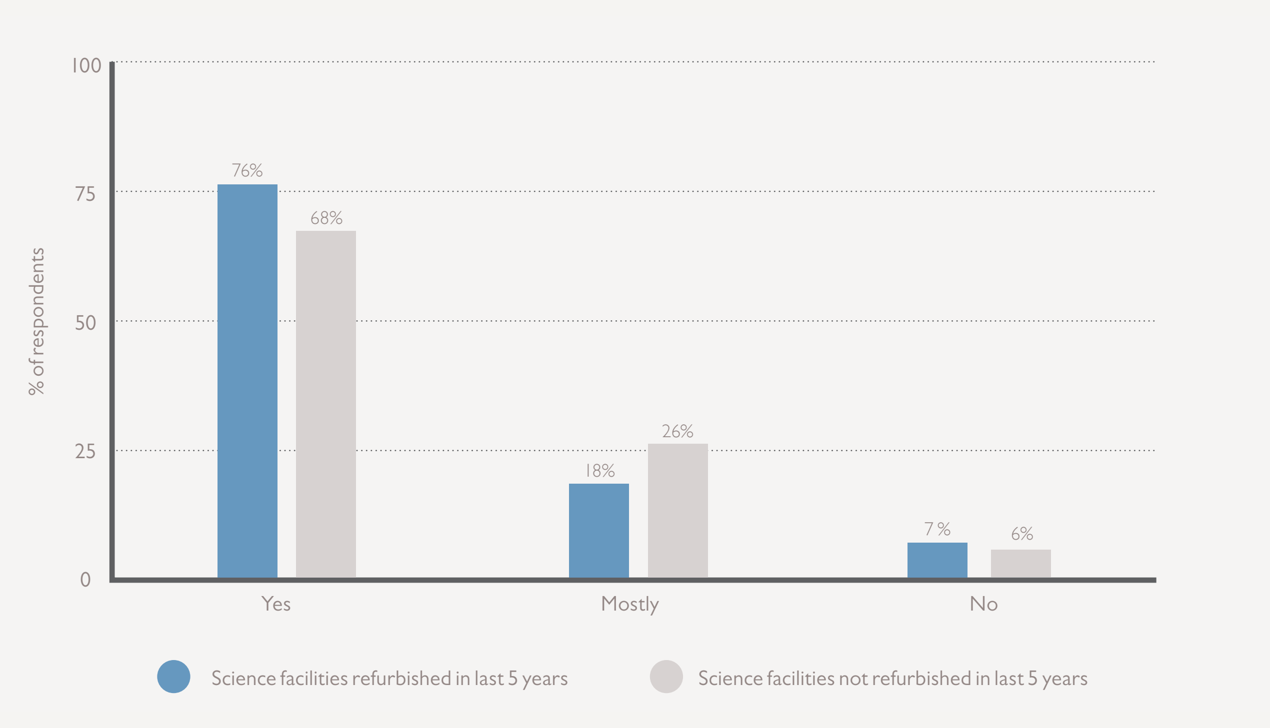
Figure 52: Over the last academic year, how often has the availability of laboratories been a barrier to carrying out practical science activities (in any science subject)? (Where science facilities refurbished, and not refurbished in last 5 years)



Base 390

25. A slightly higher proportion of schools that have had their science facilities refurbished in the last 5 years say they have dedicated, well organised and accessible preparation areas (76% of respondents) compared with those that have not had their science facilities refurbished in the last 5 years (68%) (Figure 53).

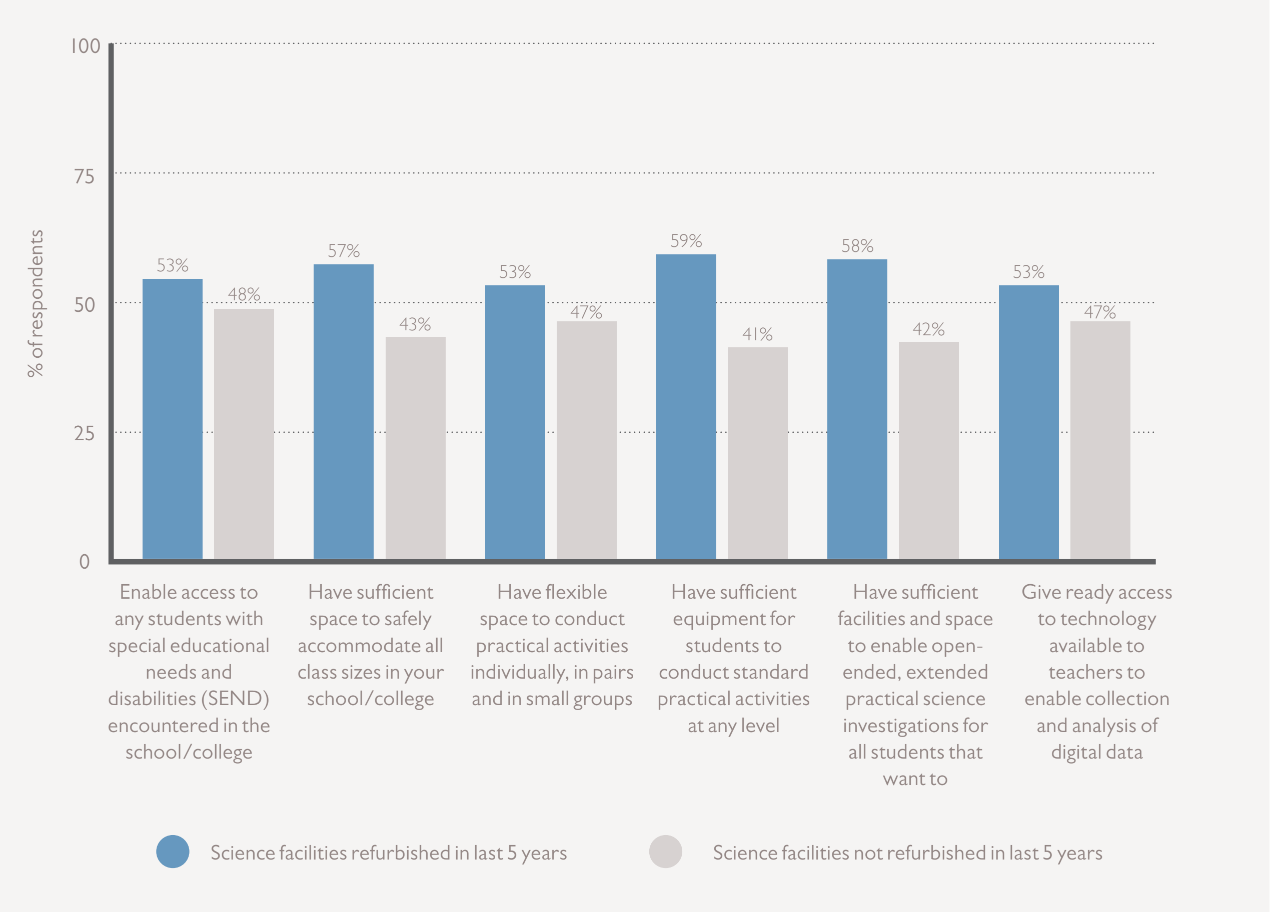
Figure 53: Does your school or college have dedicated, well-organised preparation areas with easy access to the science laboratories? (Where science facilities refurbished, and not refurbished in last 5 years)



Base 390

26. A higher proportion of schools that have had their science facilities refurbished in the last 5 years say all their laboratories meet the benchmark compared with those that have not had their science facilities refurbished in the last 5 years (Figure 54). This difference is statistically significant in respect of having sufficient equipment, and sufficient facilities and space to enable open-ended extended investigations.

Figure 54: How many of your laboratories…? (Where science facilities refurbished, and not refurbished in last 5 years)



Base 390

9. BENCHMARK 6 – TECHNICAL SUPPORT

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

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.

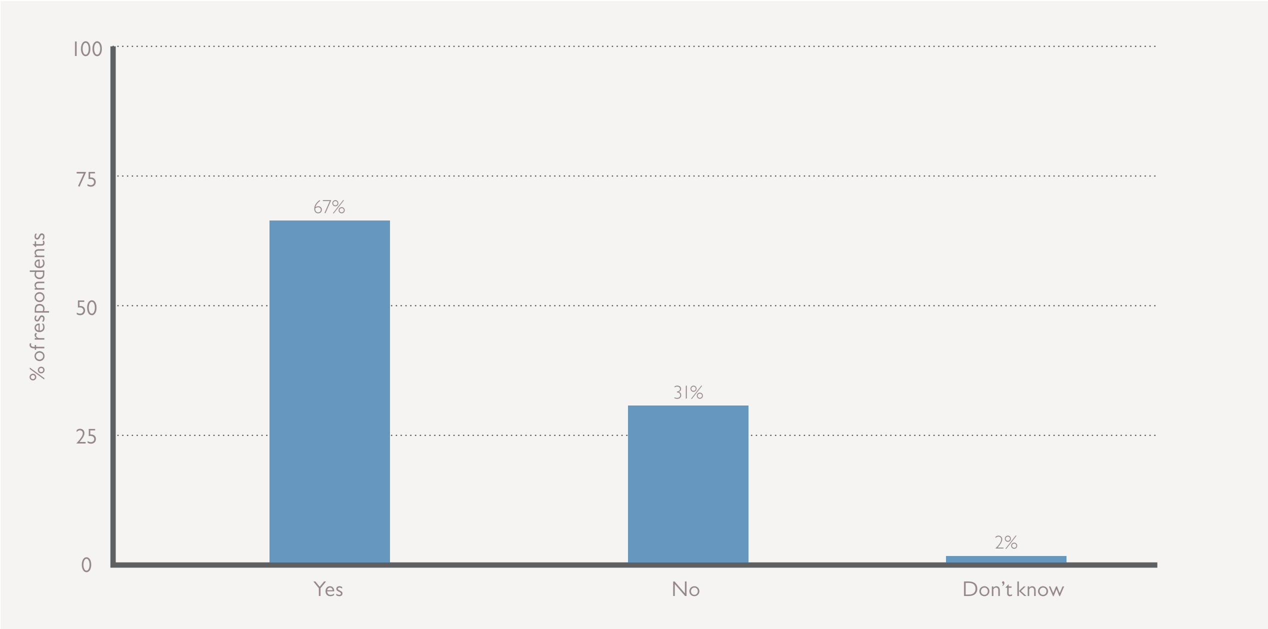
1. On average each respondent has 2.6 technicians.
2. On average, schools and colleges have 1.2 technicians that are full-time for the whole year. This rises slightly to 1.5 among respondents who say they have sufficient technical expertise, and falls to 0.8 among respondents that say they do not have sufficient technical expertise. All the average ratings rise slightly where respondents say they have sufficient technical expertise, but other factors such as Ofsted rating do not appear to make a substantial difference to resourcing levels (Table 12).

Table 12: How many science technicians does your school or college have?

	Average across all respondents	Where respondents rated outstanding by Ofsted	Where respondents rated as inadequate or requiring improvement by Ofsted	Where respondents say they have sufficient technical expertise	Where respondents say they do not have sufficient technical expertise	Where respondents have an SMT sponsor for practical science
Full-time, entire year	1.2	1.3	1.2	1.4	0.7	1.2
Full-time, term-time only	1.8	1.9	1.7	2	1.4	1.9
Part-time, entire year	0.8	1	0.4	1	0.5	0.8
Part-time, term-time only	1.6	2	1.2	1.7	1	1.4

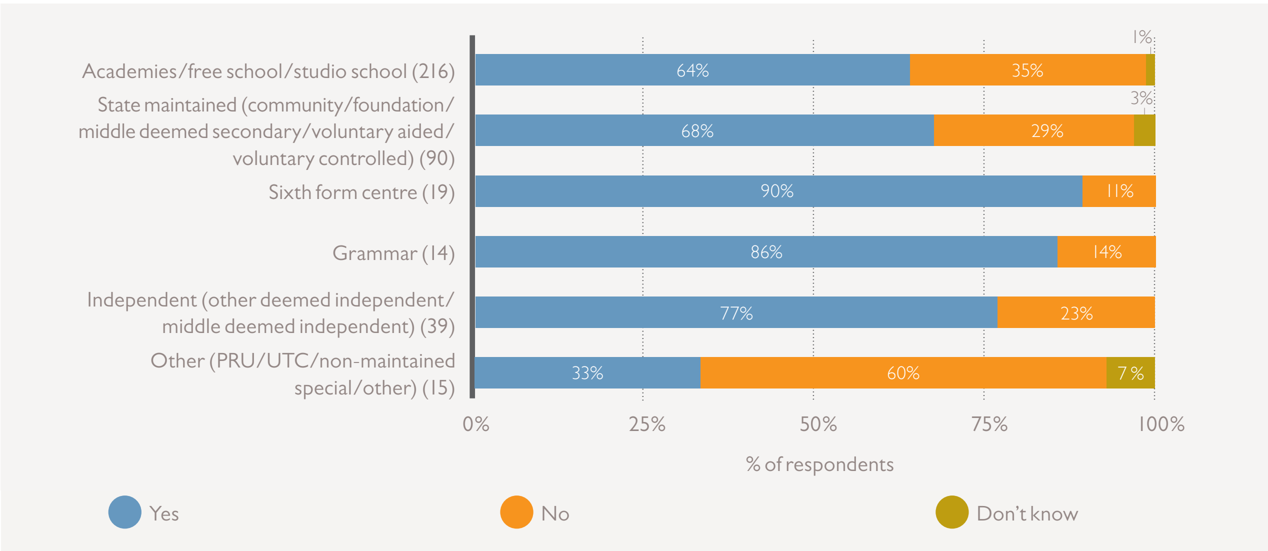
3. Just over two-thirds of respondents say they have sufficient technical expertise in the school or college to support all sciences at all levels (Figure 55). This figure increases to:
    A. 74% among respondents that have a written policy on the use of practical science;
    B. 77% among respondent schools/colleges rated outstanding by Ofsted;
    C. 81% among respondent schools/colleges with fewer than 10% of pupils eligible for Free School Meals (FSM);
    D. 77% among independent schools (Figure 56); and
    E. 90% among sixth-form centres (Figure 56)

Figure 55: Does your school or college have technical expertise among your technicians to support specialist practical science teaching in biology, chemistry and physics at all levels?



Base 394

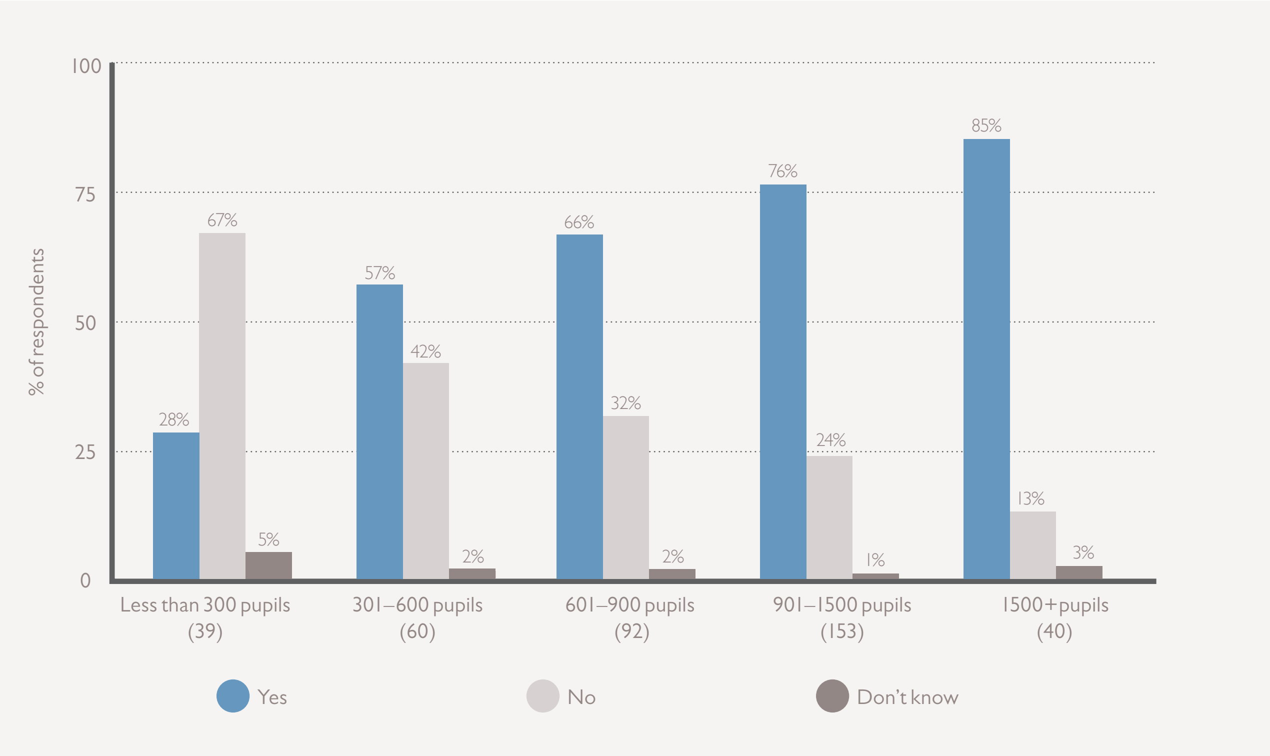
Figure 56: Does your school or college have technical expertise among your technicians to support specialist practical science teaching in biology, chemistry and physics at all levels? (Institution types)



Base numbers are shown in brackets

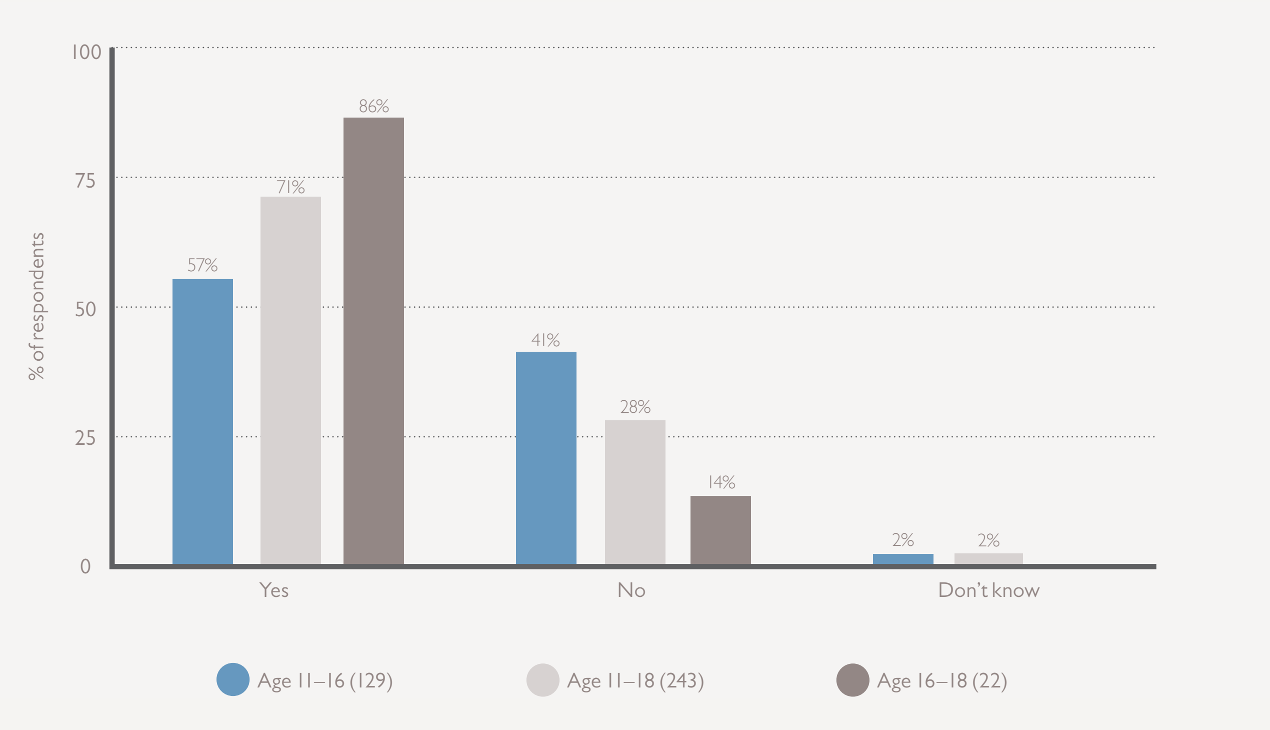
4. A considerably higher proportion of respondents within larger schools (901 pupils +) say they have sufficient technical expertise compared with smaller schools. For example 28% of respondents in schools with fewer than 300 pupils say they have sufficient technical expertise, compared with 76% of respondents in schools with 901–1500 pupils, and 85% of respondents in schools with over 1500 pupils (Figure 57). This difference is statistically significant.
5. A higher proportion of schools with sixth forms say they have sufficient technical expertise (71% of respondents) compared with schools without sixth forms saying the same (57% of respondents) (Figure 58). This difference is statistically significant.

Figure 57: Does your school or college have technical expertise among your technicians to support specialist practical science teaching in biology, chemistry and physics at all levels? (Institution sizes)



Base numbers are shown in brackets

Figure 58: Does your school or college have technical expertise among your technicians to support specialist practical science teaching in biology, chemistry and physics at all levels? (Institution age bands)



Base numbers are shown in brackets

6. Qualitative evidence finds respondents are experiencing difficulties in recruiting experienced technicians. The main barrier is the salary offered, which nearly all respondents that spoke on this subject agree is not typically high enough to reflect the skilled work that they undertake.

> "Their [technicians] pay makes a huge difference. They are paid the lowest of the low. They don't just do the washing up. All our technicians have degrees – they are highly qualified and experienced people. It's vital to raise their profile."
>
> Academy, London (depth interviewee)

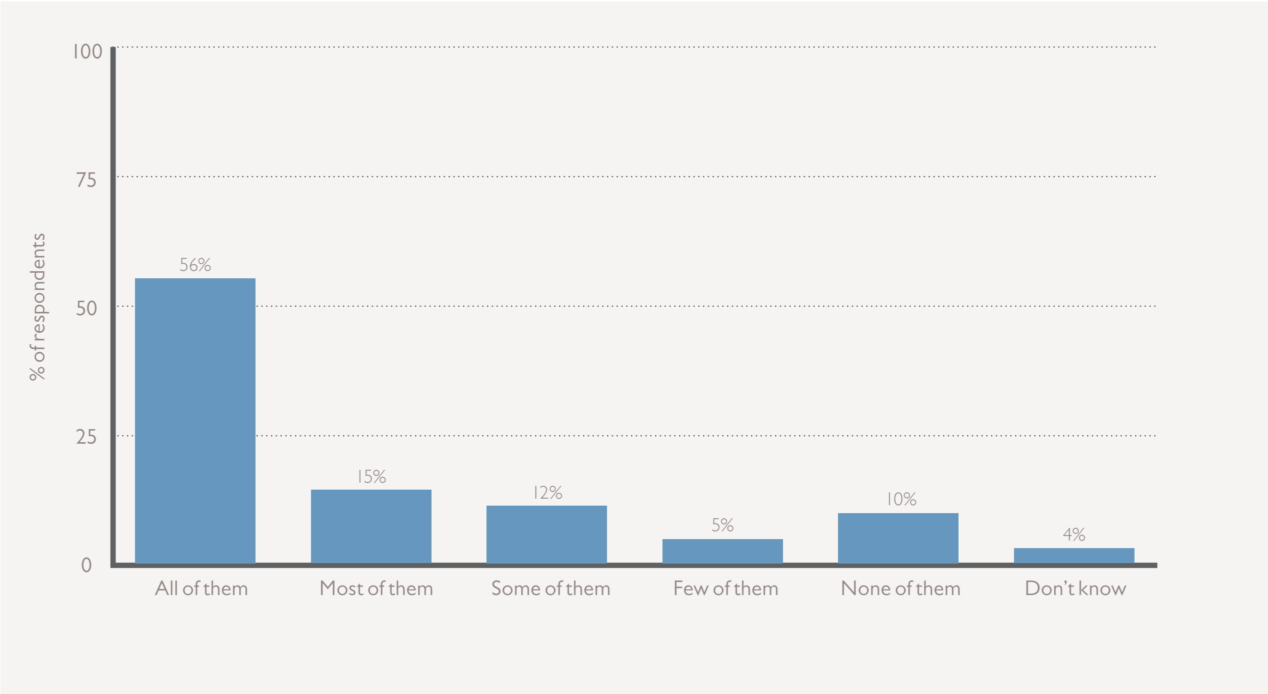
> "We pay technicians abysmally, so no experienced technicians ever apply for our jobs. The last time we recruited we advertised three times, and got no experienced applicants. We ended up employing a recent graduate. He has to work elsewhere part-time in order to boost his income as his salary here is so poor."
>
> Community school, South-West

7. This can link back to Benchmark 1 – having an SMT sponsor. Respondents agree that where the SMT understands and values the role of the science technician, they are more likely to be given an adequate budget to pay for sufficient technical resource. However respondents that do not have an SMT sponsor say they are finding it increasingly difficult to make the case to have enough technicians employed (in some capacity) to support them.

> "We don't have a trained technician at our school. The SMT doesn't want to pay for trained technicians and say the work should be given to Teaching Assistants (TAs) with spare hours. You argue and argue [with the SMT] but they continue trying to cut technician hours."
>
> Academy, North-West (depth interviewee)

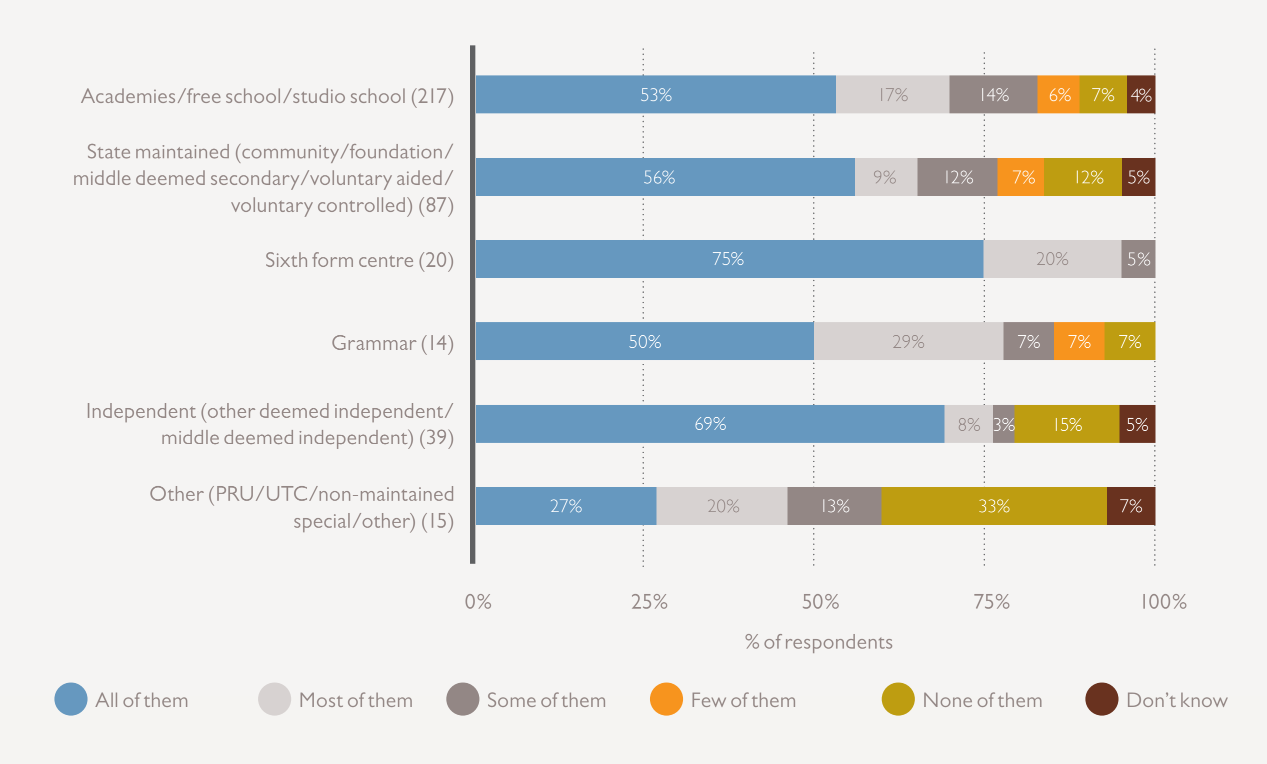
8. Around 56% of respondents say all of their science technicians have regular opportunities for training and development (Figure 59). This figure rises to 64% among respondents that say they have sufficient technical expertise in their school or college. It also rises to 69% among independent schools and to 75% among sixth form centres (Figure 60).
9. Only 32% of respondents from small schools (fewer than 300 pupils) say all of their technicians are given regular training and development opportunities, compared with 59% of respondents from schools with over 1500 pupils (Figure 61). This difference is not statistically significant.
10. A slightly higher proportion of schools with sixth forms say all their technicians receive regular training and development opportunities (56% of respondents compared with 50% of respondents from schools without sixth forms saying the same) (Figure 62).

Figure 59: How many of your science technicians have regular opportunities for training and development?



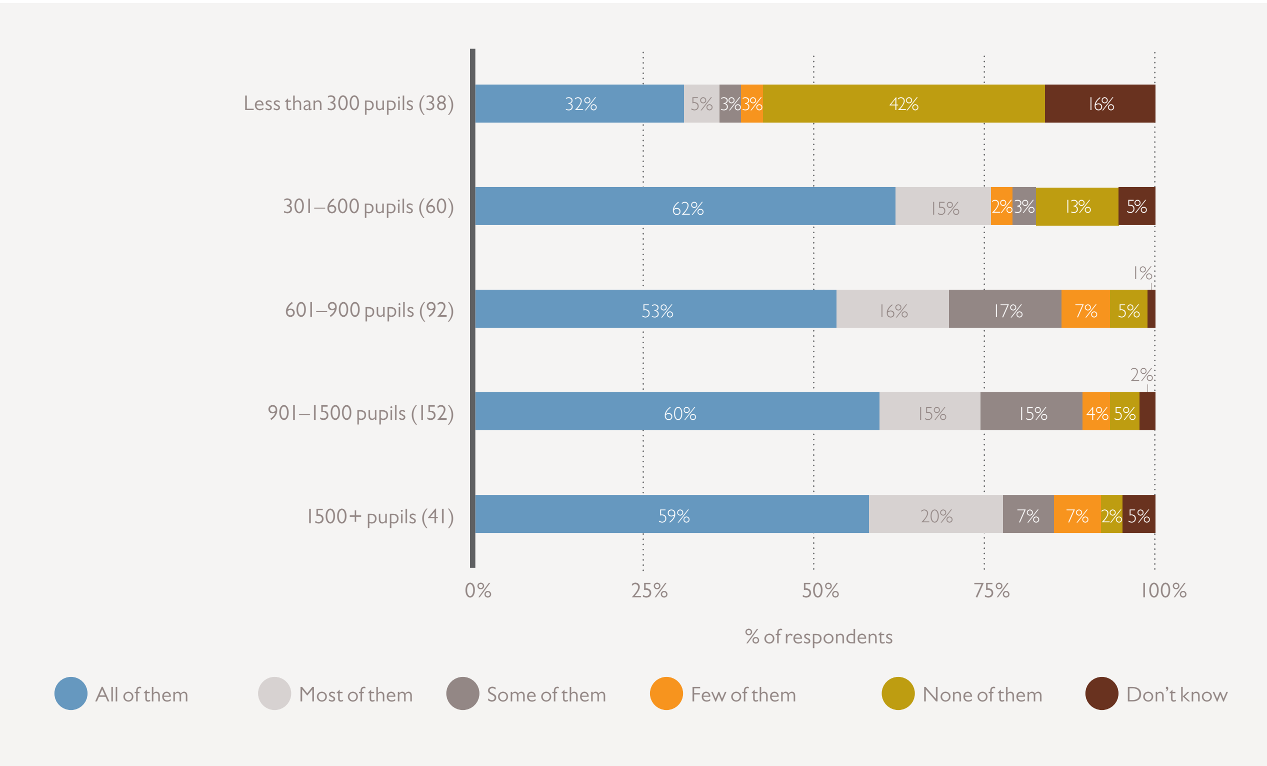
Base 393

Figure 60: How many of your science technicians have regular opportunities for training and development? (Institution types)



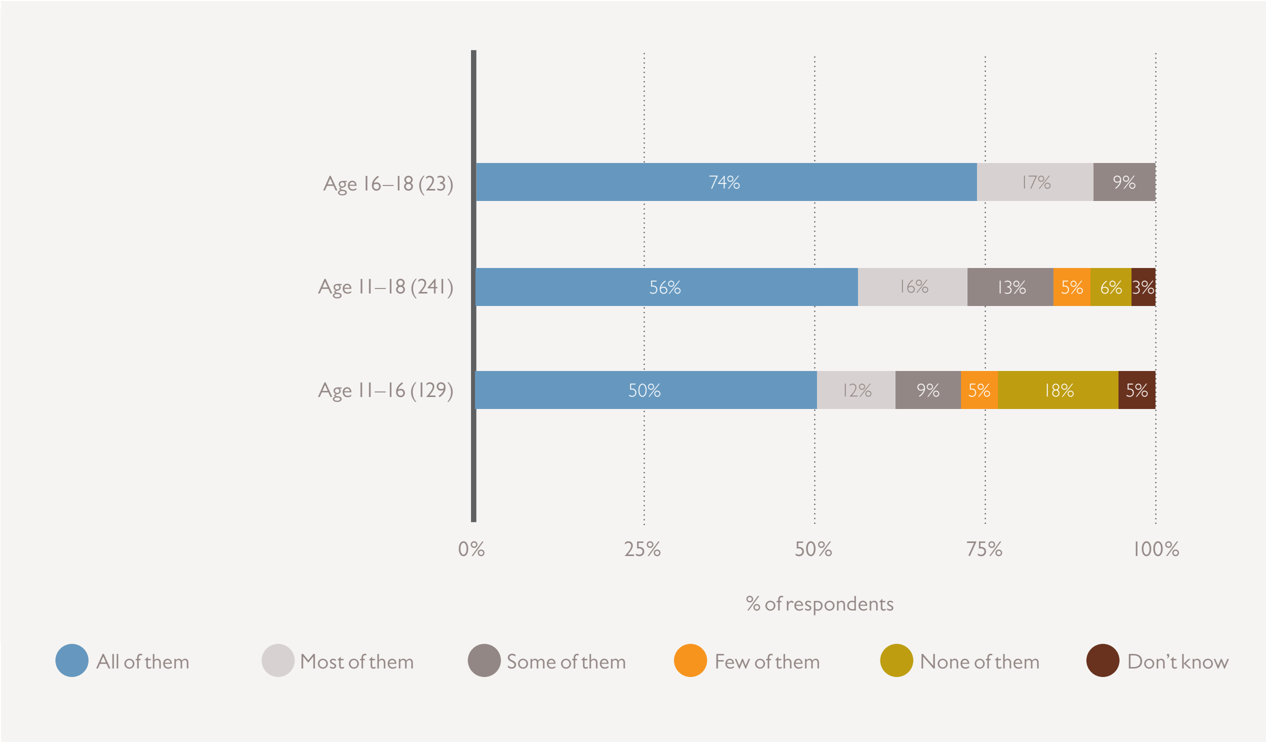
Base numbers are shown in brackets

Figure 61: How many of your science technicians have regular opportunities for training and development? (Institution sizes)



Base numbers are shown in brackets

Figure 62: How many of your science technicians have regular opportunities for training and development? (Institution age bands)



Base numbers are shown in brackets

11. Respondents emphasise the positive knock on effects they feel would come about by having sufficient technical expertise in the school or college. For example:
    A. Freeing up the teachers' time by taking on part of their workload in preparing for practical activities;
    B. Supporting/training less experienced teachers;
    C. Making the best of resources and equipment (including drawing upon established relationships with local schools to borrow items); and
    D. Providing support in the laboratories to students during lesson time.
12. One respondent states: *"If we had the full complement of technicians it [achieving the benchmarks] would be doable."* Another says: *"These enablers [employing more technicians to undertake the types of activities outlined above in A-D] will only enable if you have experienced people."*

10. BENCHMARK 7 – REAL EXPERIMENTS, VIRTUAL ENHANCEMENTS

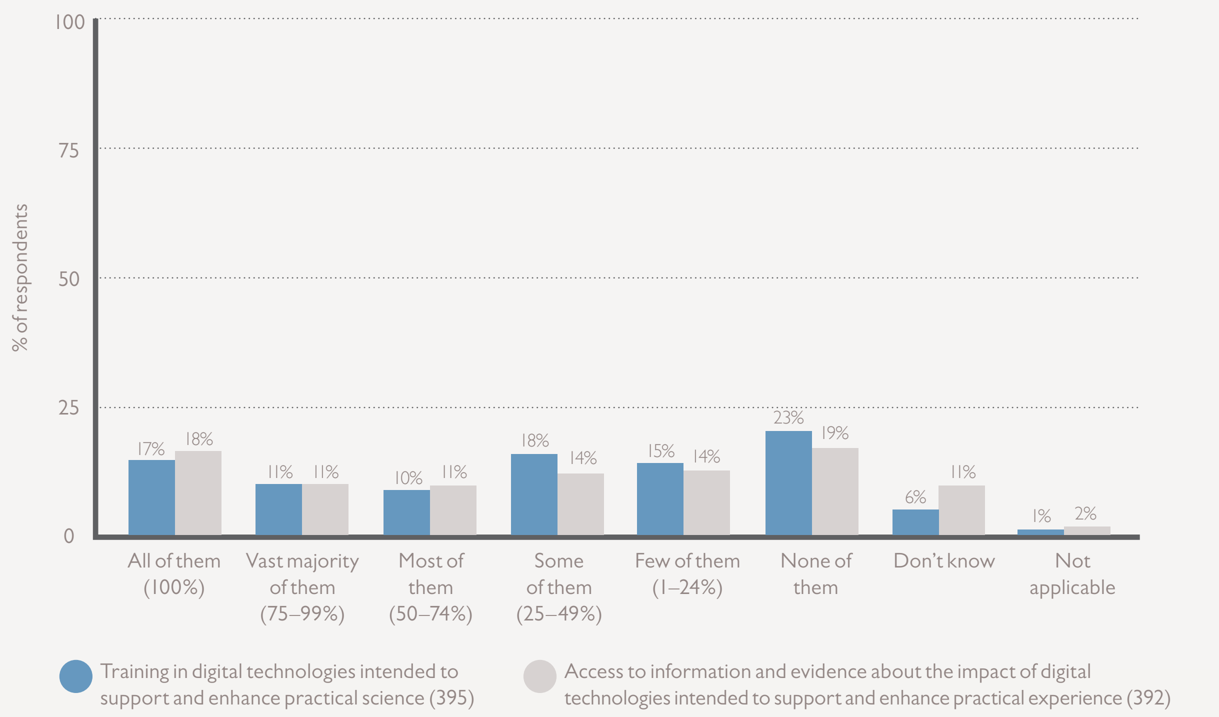
Teachers should use digital technologies to support and enhance practical experience, but not to replace it.

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.

1. A relatively small proportion of all respondents say all their science teachers have training in digital technologies (17%) and access to information and evidence about the use of digital technologies for practical science (18%) (Figure 63).
2. Having an SMT sponsor makes a notable difference – 55% of respondents that have an SMT sponsor for practical science say all their science teachers have training in digital technologies and 49% say all their teachers have access to information and evidence about the use of digital technologies for practical science. This difference is statistically significant.

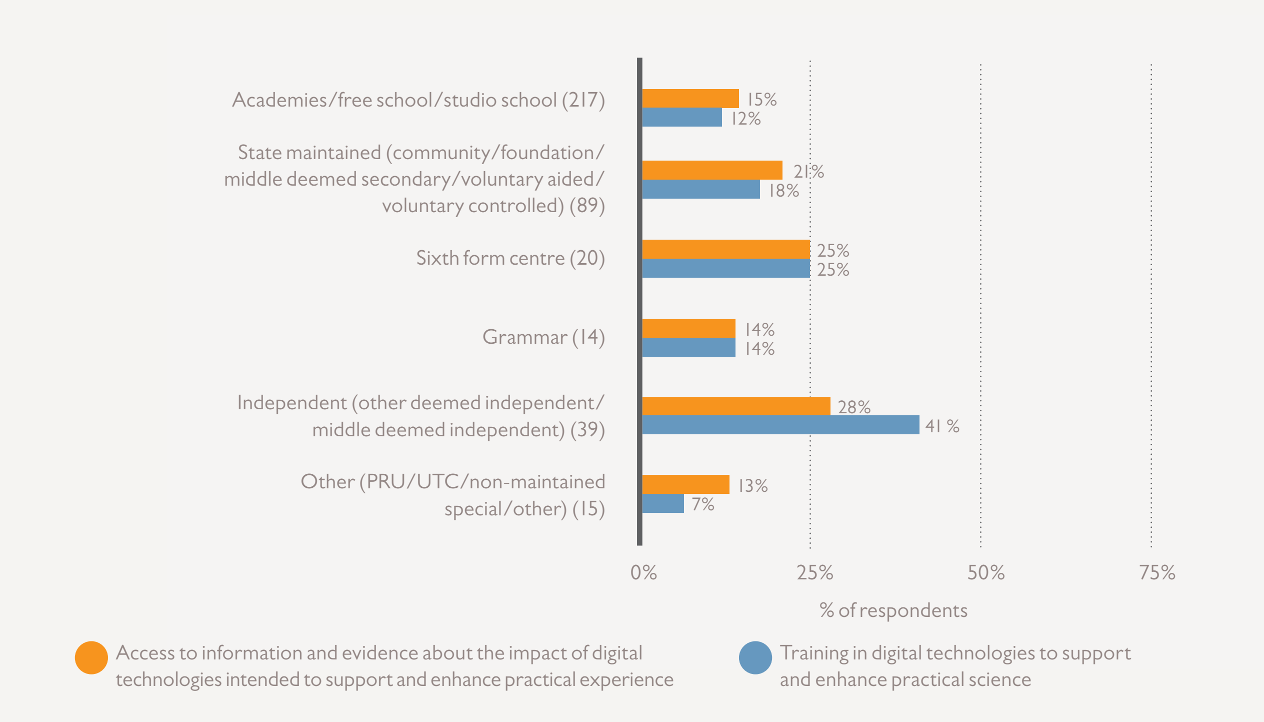
Figure 63: In relation to digital technologies, how many of your science teachers have…?



Base numbers are shown in brackets

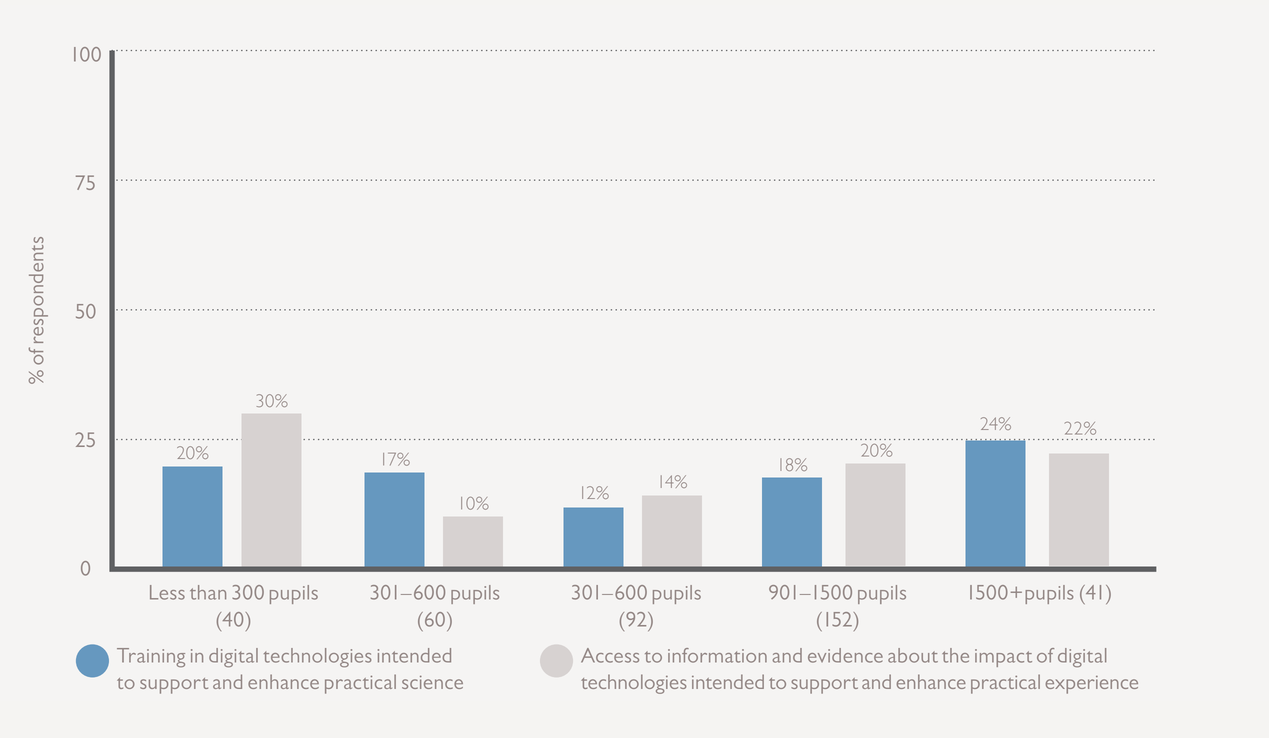
3. A slightly higher proportion of independent schools say all their science teachers have relevant training and information about digital technologies compared with the average across all respondents (Figure 64).
4. There are no major differences between institutions by size or by age bands taught (Figures 65 and 66).

Figure 64: % of respondents saying that in relation to digital technologies, *all* their science teachers have…? (Institution types)



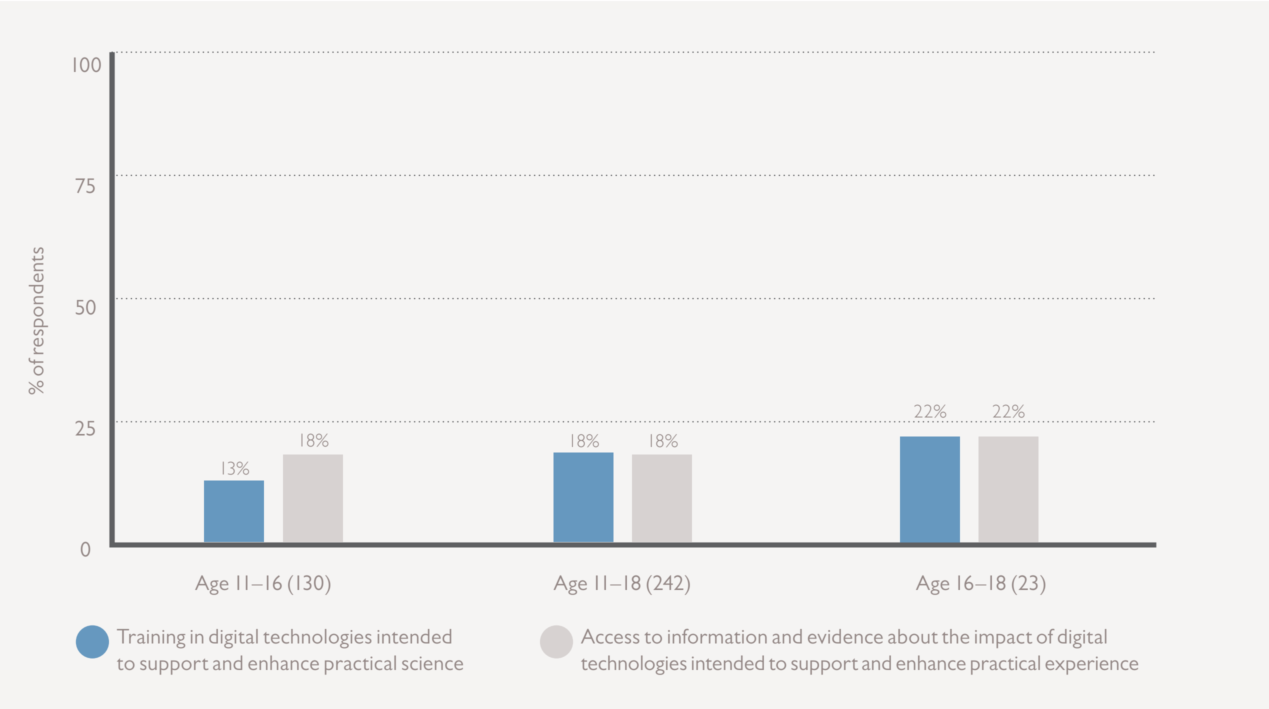
Base numbers are shown in brackets. Data show proportion of respondents saying 'all their science teachers' therefore should not total 100%

Figure 65: % of respondents saying that in relation to digital technologies, *all* their science teachers have…? (Institution sizes)



Base numbers are shown in brackets. Data show proportion of respondents saying 'all their science teachers' therefore should not total 100%

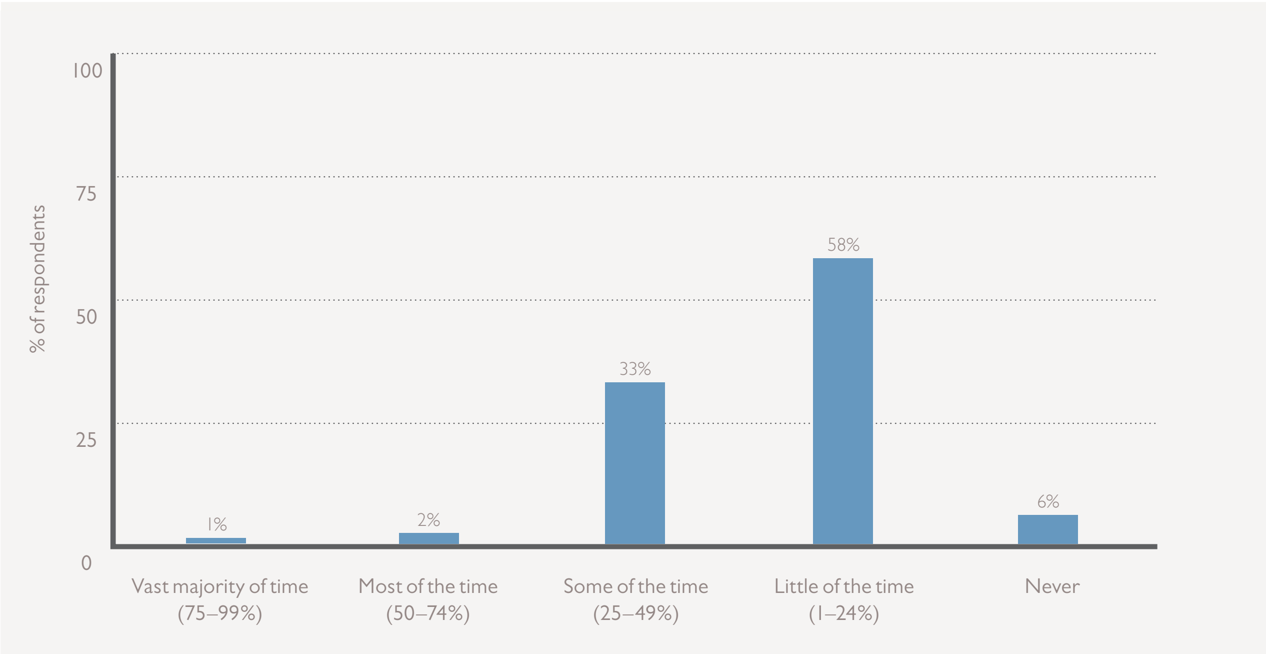
Figure 66: % of respondents saying that in relation to digital technologies, *all* their science teachers have…? (Institution age bands)



Base numbers are shown in brackets. Data show proportion of respondents saying 'all their science teachers' therefore should not total 100%

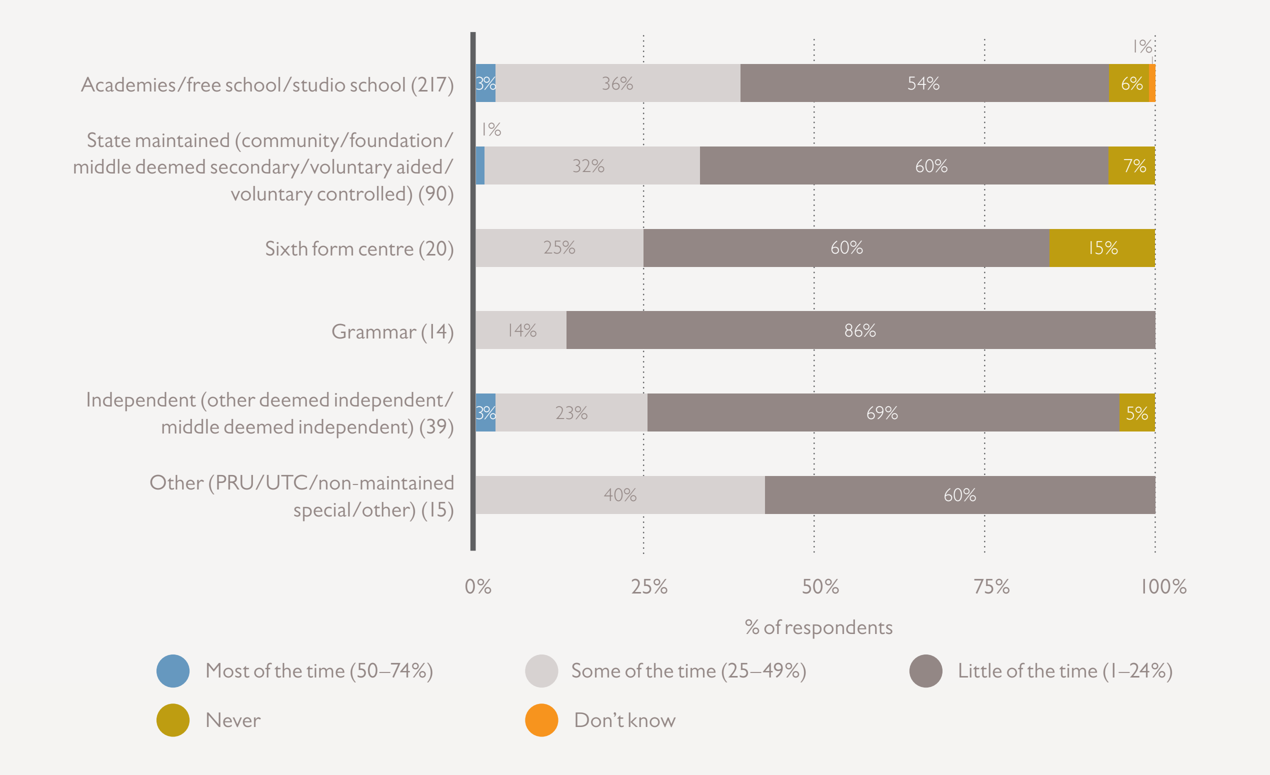
5. Nearly two-thirds of respondents say that virtual environments and/or simulated experiments are either never used, or are used little of the time (Figure 67). None of the respondents say these are used all of the time. A slightly higher proportion of sixth form centres (15%) never used these, compared with all respondents (6%) (Figures 67 and 68).
6. There is a broadly similar approach taken by institutions regardless of size and year group (Figures 69 and 70).

Figure 67: To what extent are virtual environments and/or simulated experiments used to replace practical science experiences?



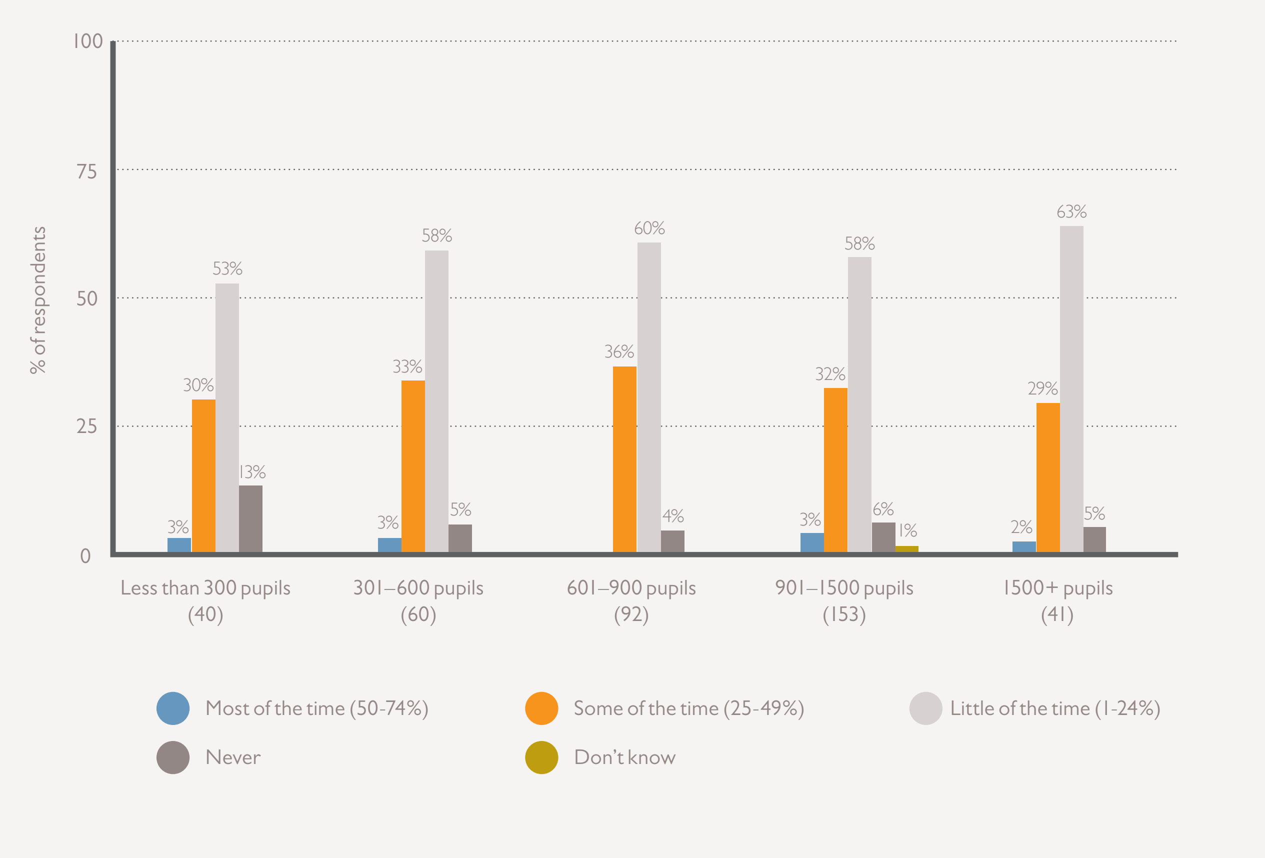
Base 396

Figure 68: To what extent are virtual environments and/or simulated experiments used to replace practical science experiences? (Institution types)



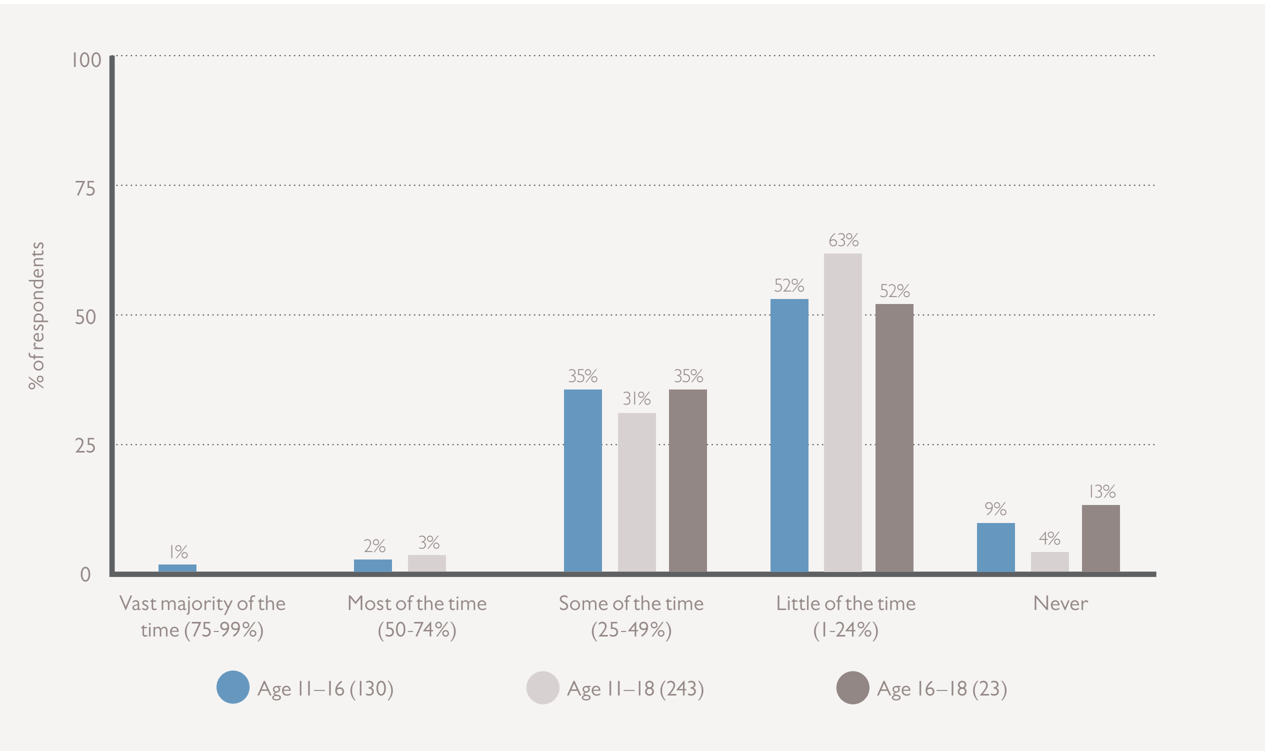
Base numbers are shown in brackets

Figure 69: To what extent are virtual environments and/or simulated experiments used to replace practical science experiences? (Institution sizes)



Base numbers are shown in brackets

Figure 70: To what extent are virtual environments and/or simulated experiments used to replace practical science experiences? (Institution age bands)



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11. BENCHMARK 8 – INVESTIGATIVE PROJECTS

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

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

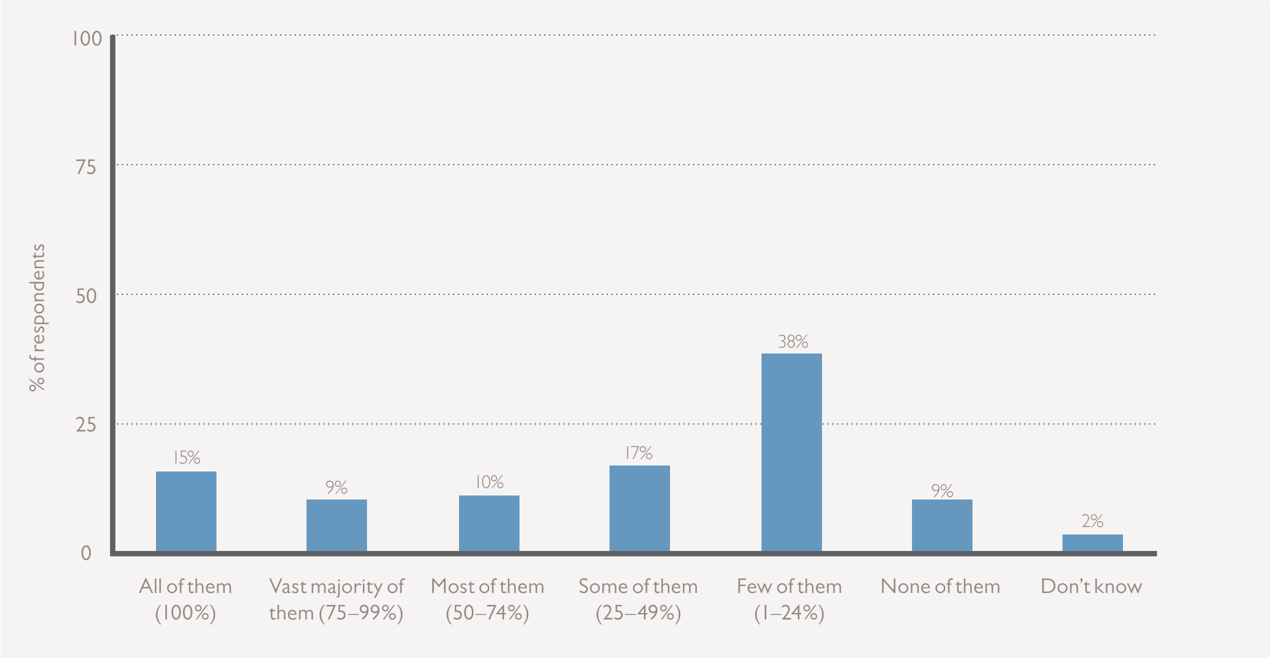
The school should have laboratory facilities such that all students who want to can carry out extended practical science investigations, particularly among post-16 year olds.

1. Only 15% of respondents say all their students have the opportunity to do open-ended extended investigative projects in science, over the course of their school career (Figure 71). As with some of the other benchmarks, this one is influenced by the presence of an SMT sponsor for science – 45% of respondents say all their students have this opportunity where there is an SMT sponsor.

2. The proportion of respondents that say all their students have this opportunity increases to 36% among grammar schools but falls to 5% for sixth form centres (Figure 72). This difference is not statistically significant.

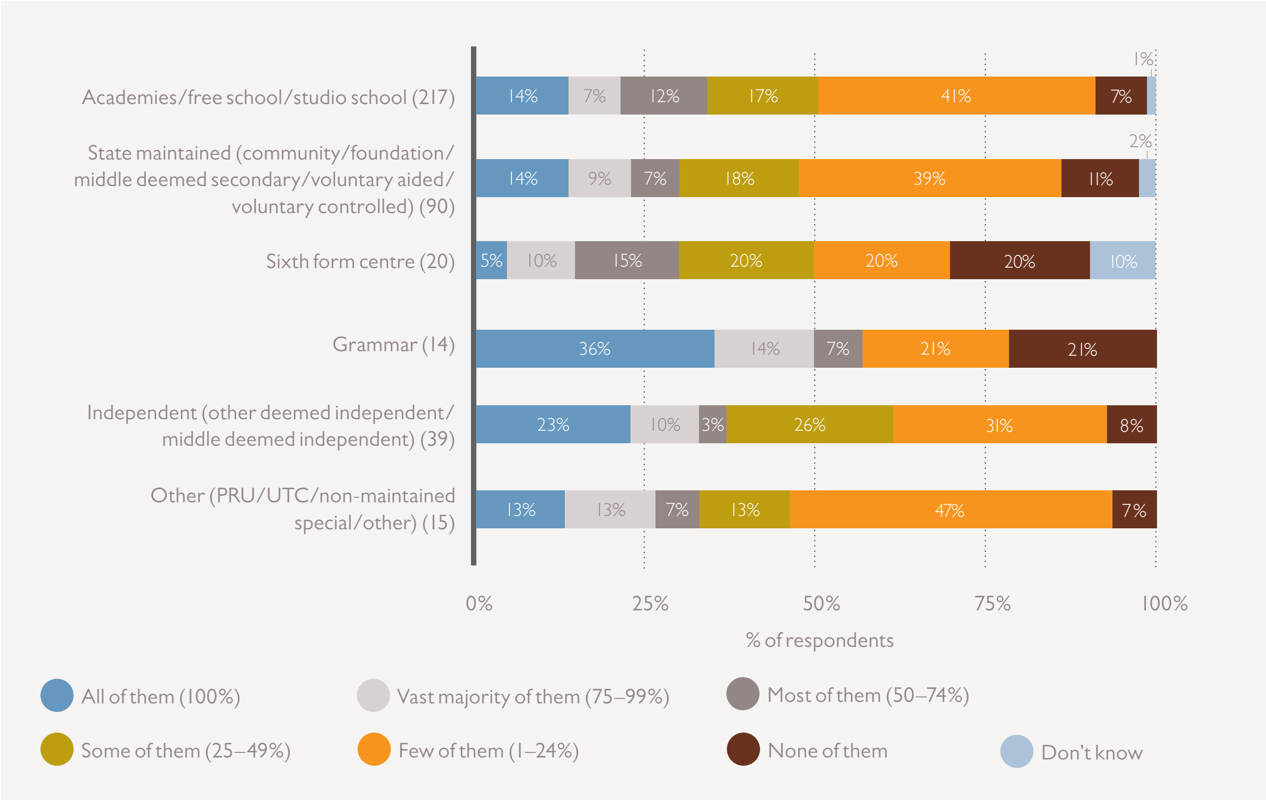
3. The proportion of respondents saying that all their students have this opportunity falls to 5% within large schools of more than 1500 pupils (Figure 73). There are no strong differences between schools with and without sixth forms (Figure 74).

Figure 71: How many of your students, over the course of their school career, have the opportunity to do open-ended extended investigative projects in science?



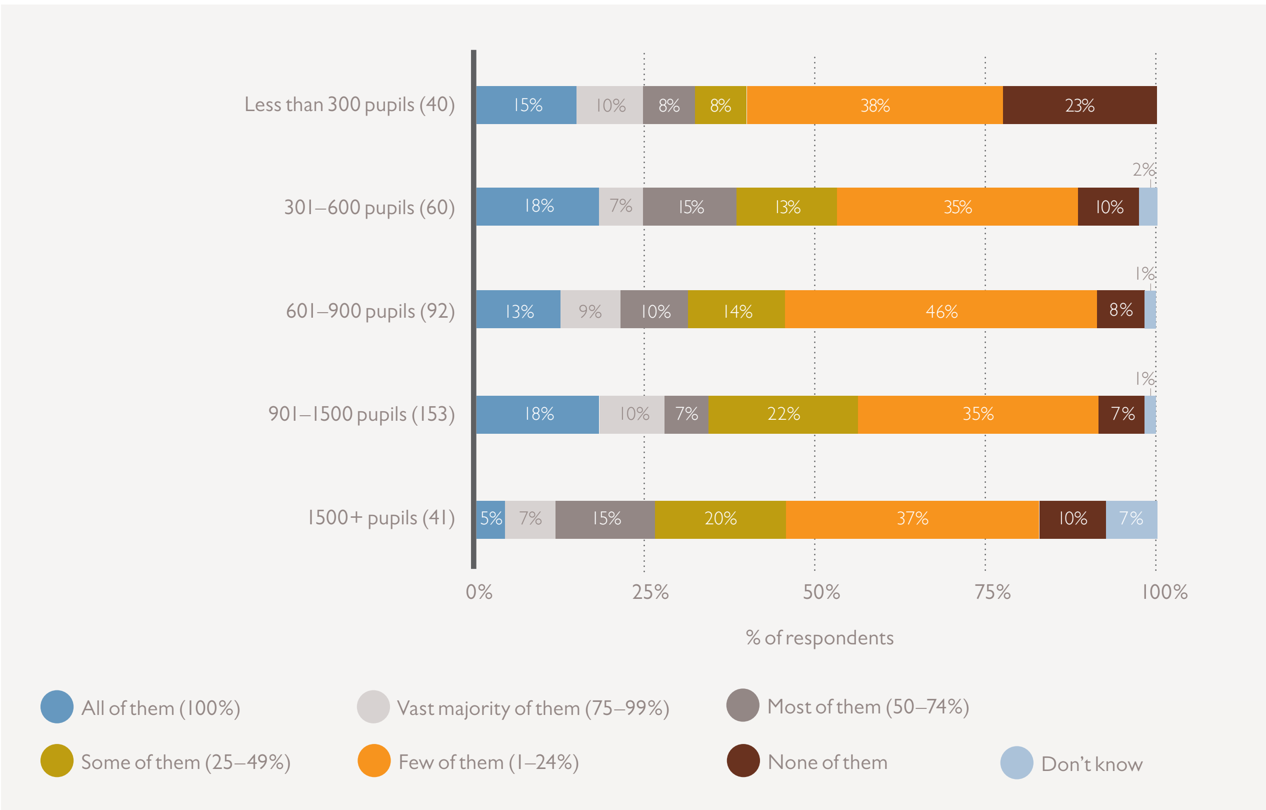
Base 396

Figure 72: How many of your students, over the course of their school career, have the opportunity to do open-ended extended investigative projects in science? (Institution types)



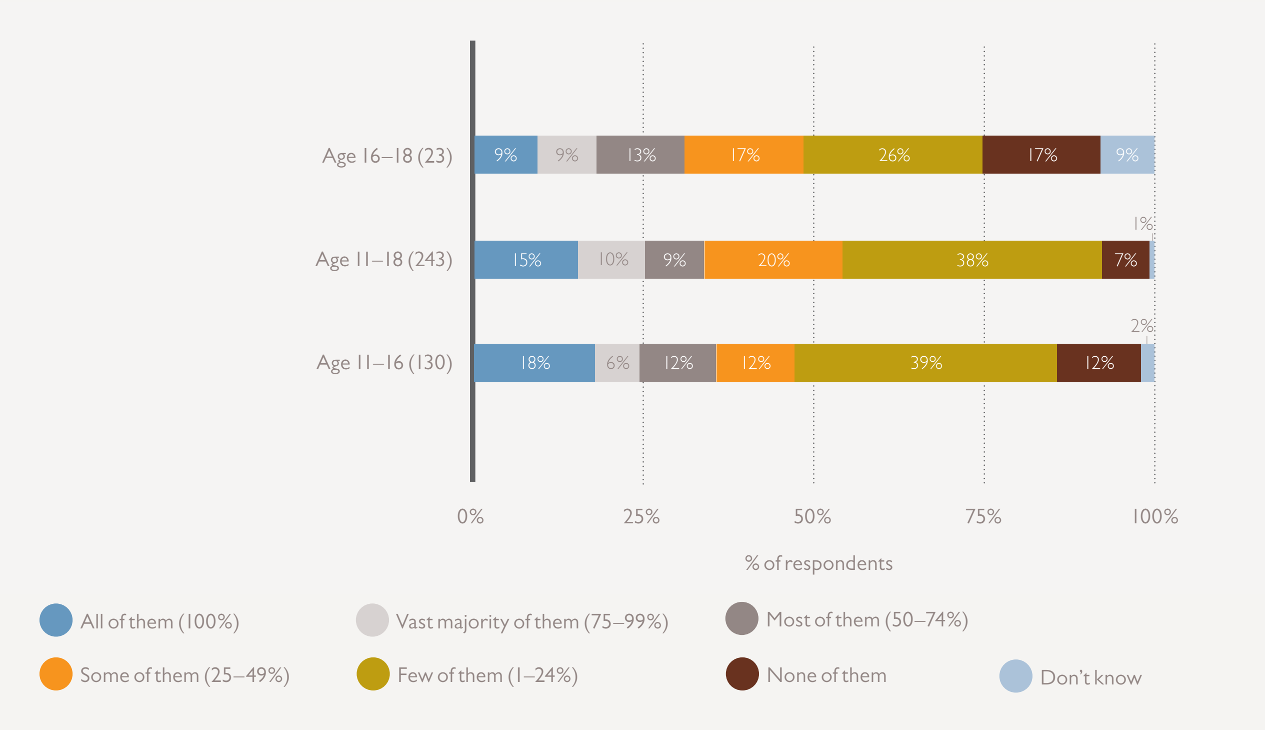
Base numbers are shown in brackets

Figure 73: How many of your students, over the course of their school career, have the opportunity to do open-ended extended investigative projects in science? (Institution sizes)



Base numbers are shown in brackets

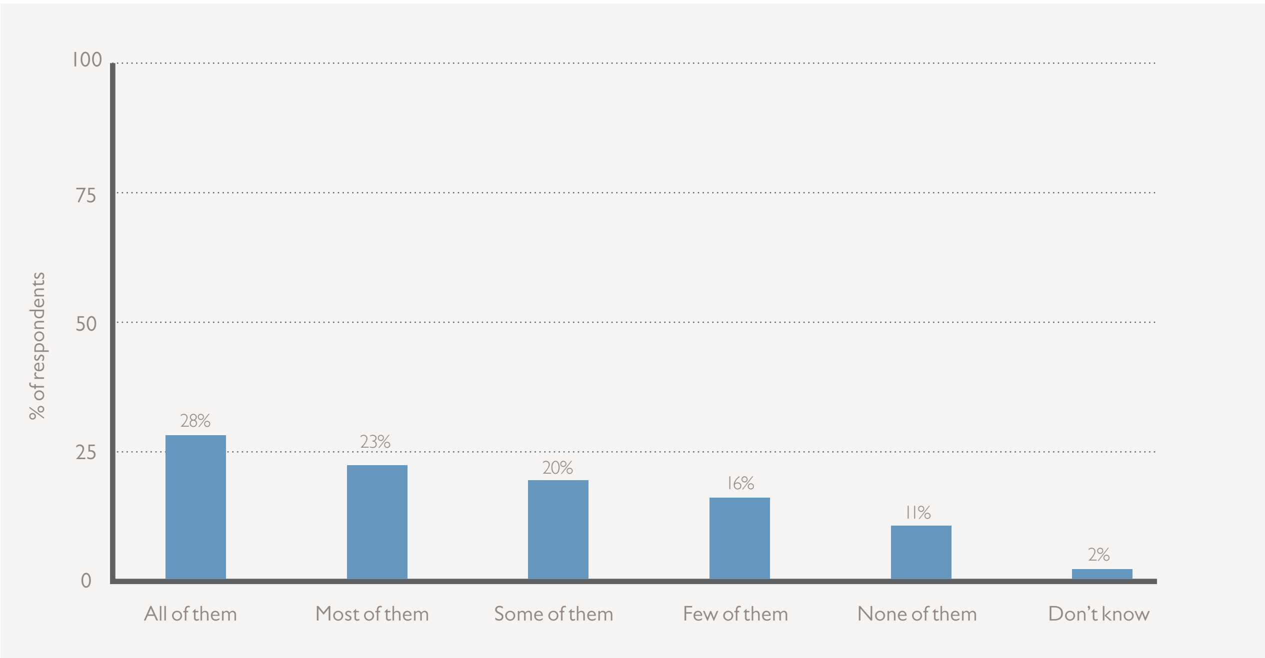
Figure 74: How many of your students, over the course of their school career, have the opportunity to do open-ended extended investigative projects in science? (Institution age bands)



Base numbers are shown in brackets

4. Approximately 28% of respondents say all of their laboratories are able to support open-ended extended investigative projects in science (Figure 75). Again, there are some differences as a result of certain enablers: this increases to 37% where respondents have an SMT sponsor for science, and to 34% where respondents have a written policy on the use of practical science.

Figure 75: How many of your laboratories can support open-ended extended investigative projects in science?



Base 396

5. The majority of respondents participating in depth interviews consider this to be an aspirational benchmark because of a perceived lack of time available to undertake extended projects. Lack of time being a barrier for teachers and technicians that may need to support projects, for example by helping to set up equipment and giving access to ICT equipment;[23] and lack of time for students who may already have a busy extra-curricular schedule. Respondents also believe the content-heavy curriculum is a barrier for this benchmark, as it takes a lot of time to cover the content, leaving limited if any "spare" time to conduct extended work of this nature.

> "The new A-levels are much more demanding with greater breadth and depth of content – we would find it difficult to bolt anything extra on. I believe open-ended projects as described should be on the curriculum – that would help students understand the real world of a scientist where you may be working on something for months and months before you see any results. The curriculum specification means we have to work at such a fast pace – we finish one topic and leap straight on to the next. I'm actually worried we won't finish in time for the first cohort sitting the new A-level."
>
> Academy, North-West (depth interviewee)

> "Open ended investigations unfortunately take more time than can be allowed when the rest of the curriculum has to fit in to the lesson time."
>
> Independent school, West Midlands (survey respondent)

6. Seven of the twenty respondents that took part in interviews say they would expect students who wanted to do an extended experiment or project, to apply for a Nuffield or CREST award.
7. Respondents consider this benchmark is most applicable to years 7, 8 and 9 (because they are not working on GCSE content) and also to primary schools, but that it would be much harder to achieve for years 10 and above.

[23] This is also because there may not be sufficient ICT equipment to use for projects of this nature which respondents consider to be "extra" rather than "core".

12. BENCHMARK 9 – A BALANCED APPROACH TO RISK

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

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.

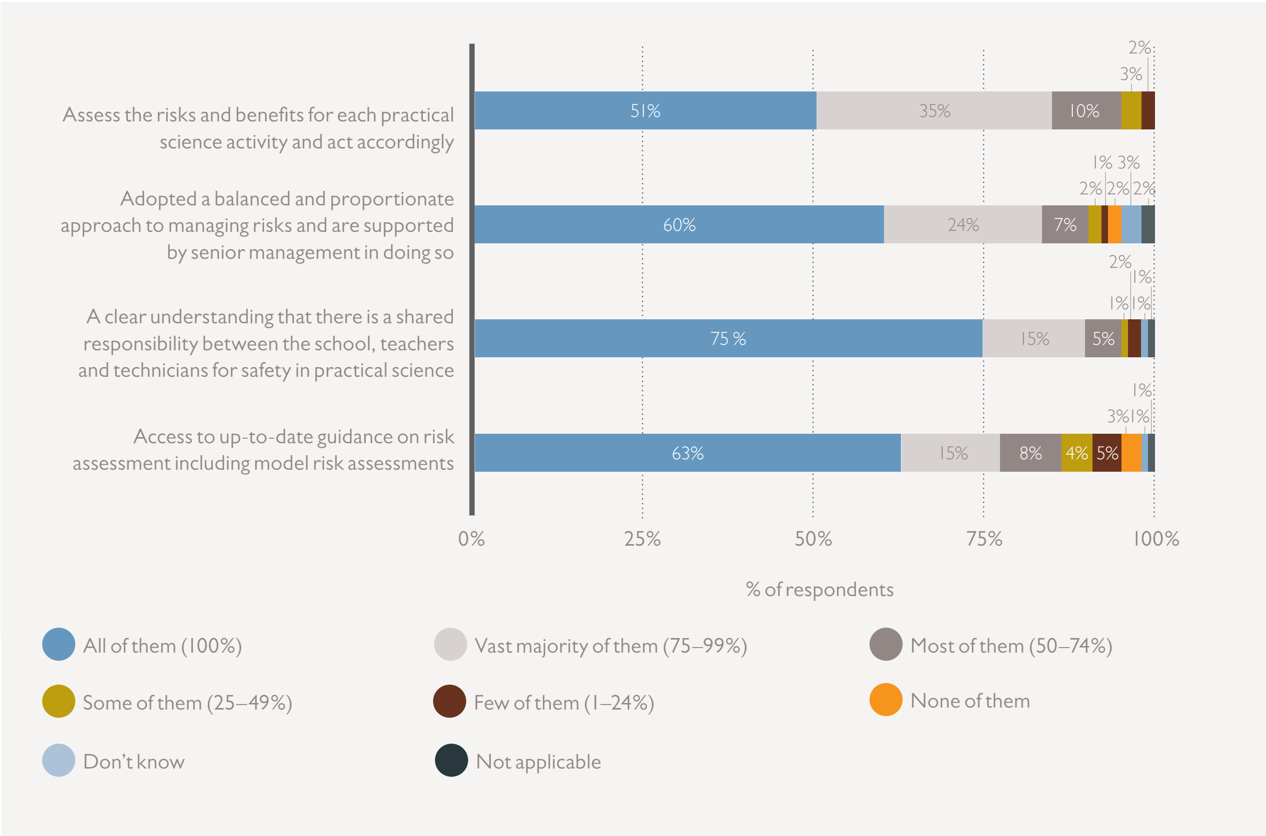
The school should ensure that teachers and technicians have access to authoritative and up-to-date guidance including model risk assessments.

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.

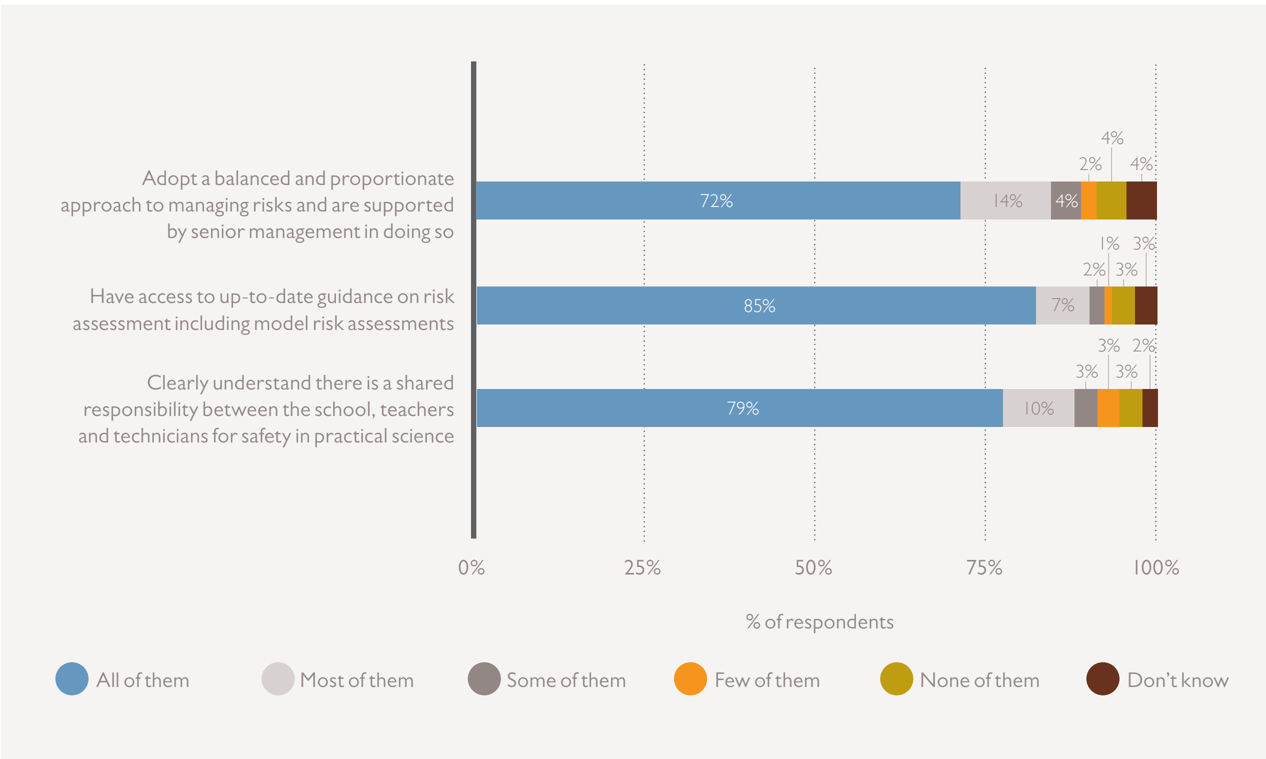
1. Three-quarters of respondents say all their teachers clearly understand shared responsibility for safety (Figure 76).
2. Nearly two-thirds of respondents (63%) say all their teachers have access to authoritative and up-to-date guidance including model risk assessments (Figure 76). This increases to 85% of respondents saying all their technicians have this access and guidance (Figure 77).
3. Only 51% of respondents say all of their teachers assess the risks and benefits for each practical science activity and act accordingly (Figure 76). This increases to 61% of respondents who say they have a written policy on the use of practical science. The proportion of respondents that say all their teachers do this is higher in schools with fewer than 300 pupils (78% of respondents) (Figure 80).
4. Around 60% of respondents say all their teachers adopt a balanced and proportionate approach to managing risks and are supported by senior management in doing so (Figure 76). Nearly three-quarters of respondents (72%) say all their technicians adopt this approach (Figure 77). However this falls to 55% of respondents saying all their technicians adopt this in small schools with fewer than 300 pupils (Figure 81). This difference is statistically significant.

Figure 76: In relation to risk, how many of your science teachers…?



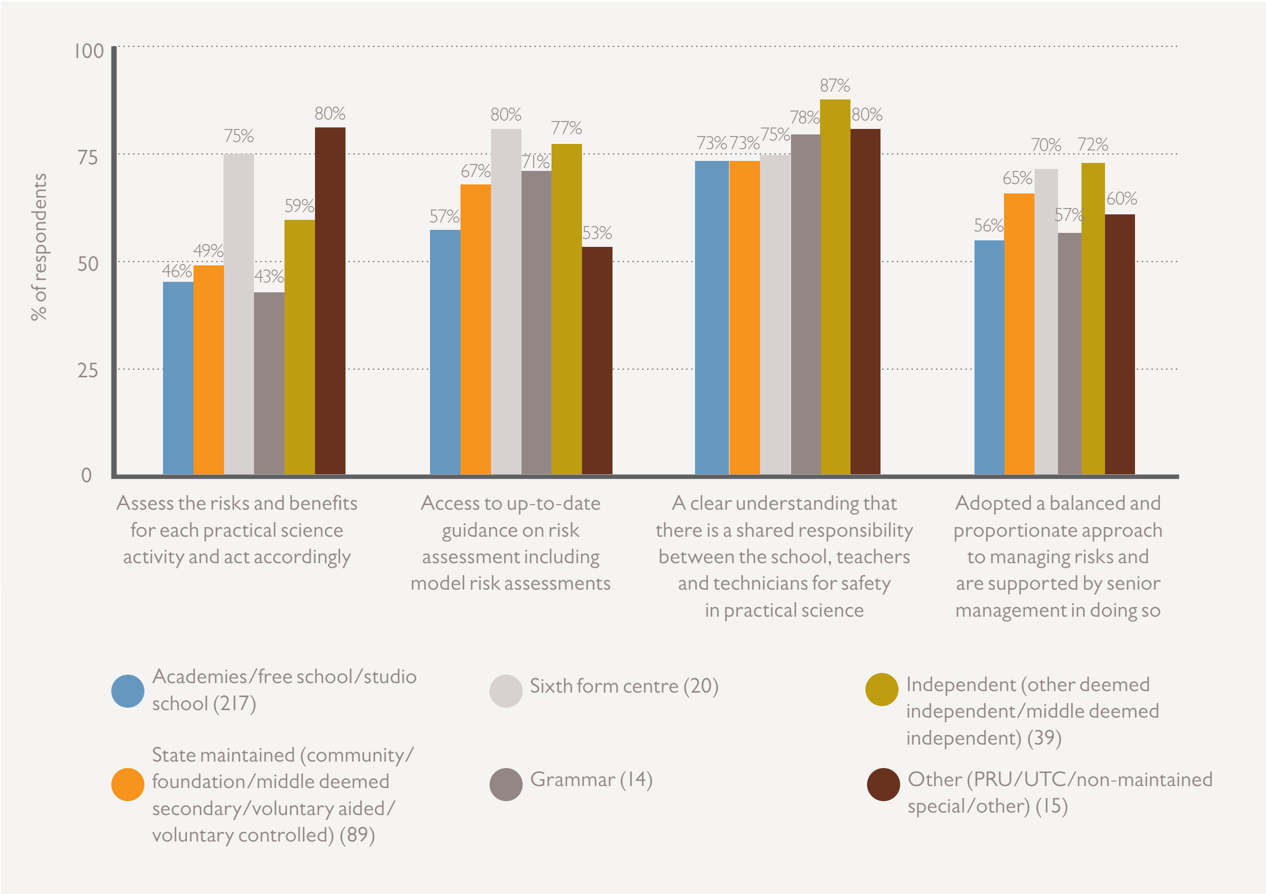
Base 395

Figure 77: In relation to risk, how many of your science technicians…?



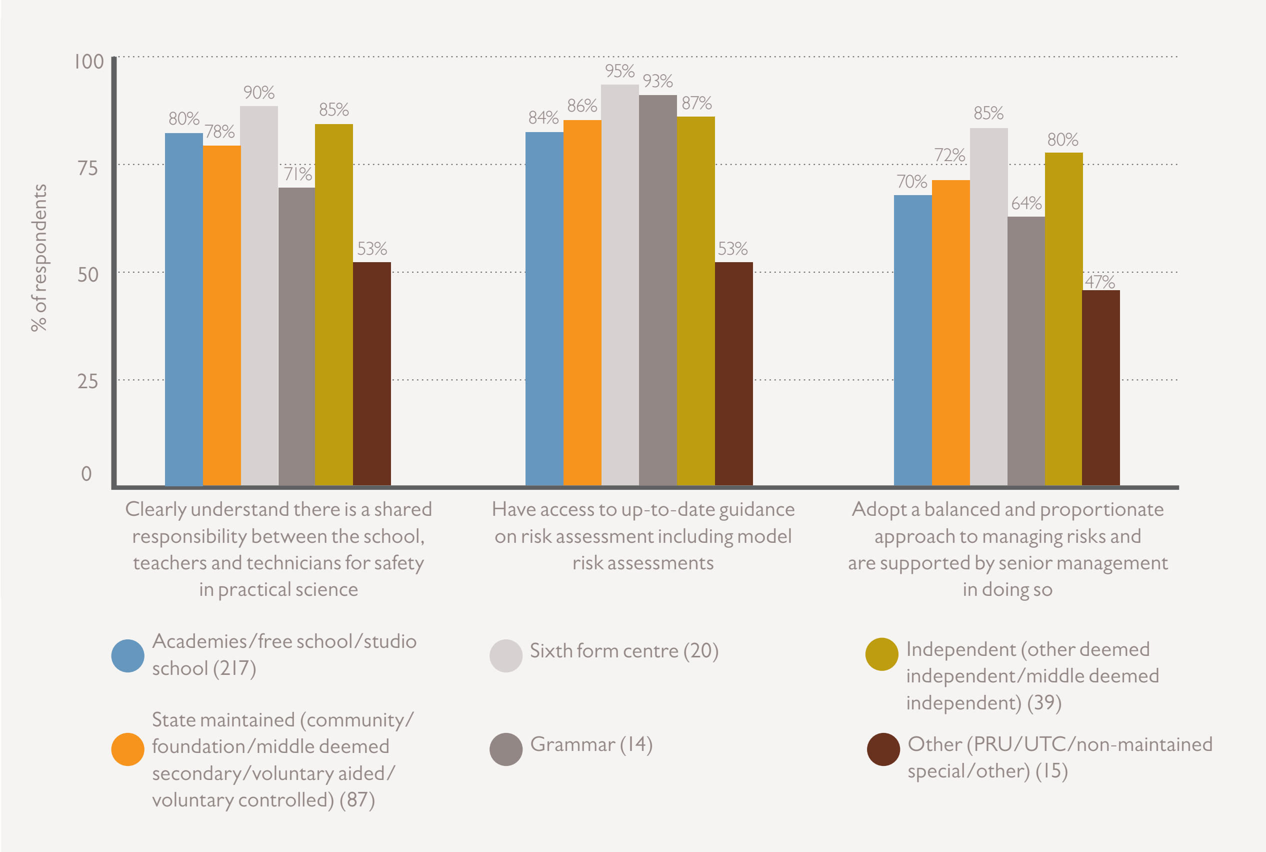
Base 391–393

Figure 78: % of respondents saying that in relation to risk, *all* their science teachers: (Institution types)



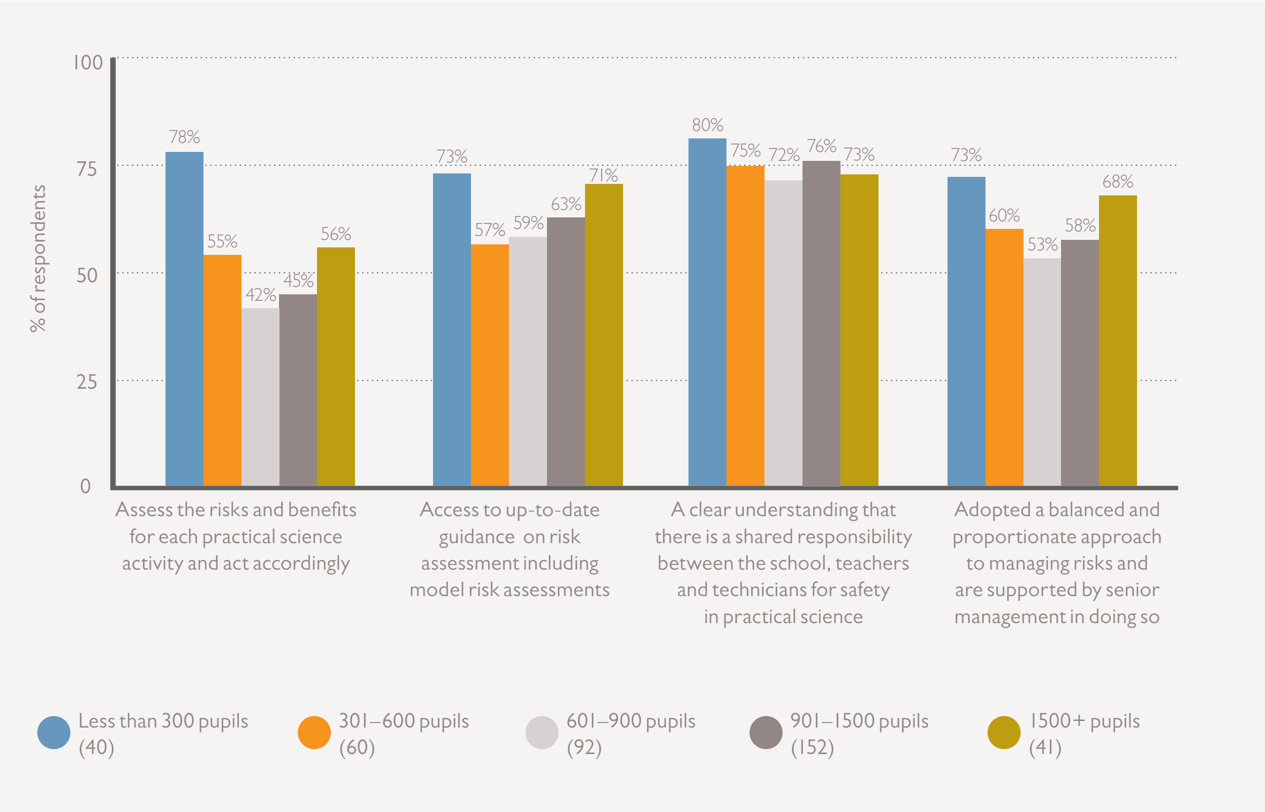
Base numbers are shown in brackets. Data show proportion of respondents saying 'all their science teachers' and therefore should not total 100%

Figure 79: % of respondents saying that in relation to risk, *all* their science technicians: (Institution types)



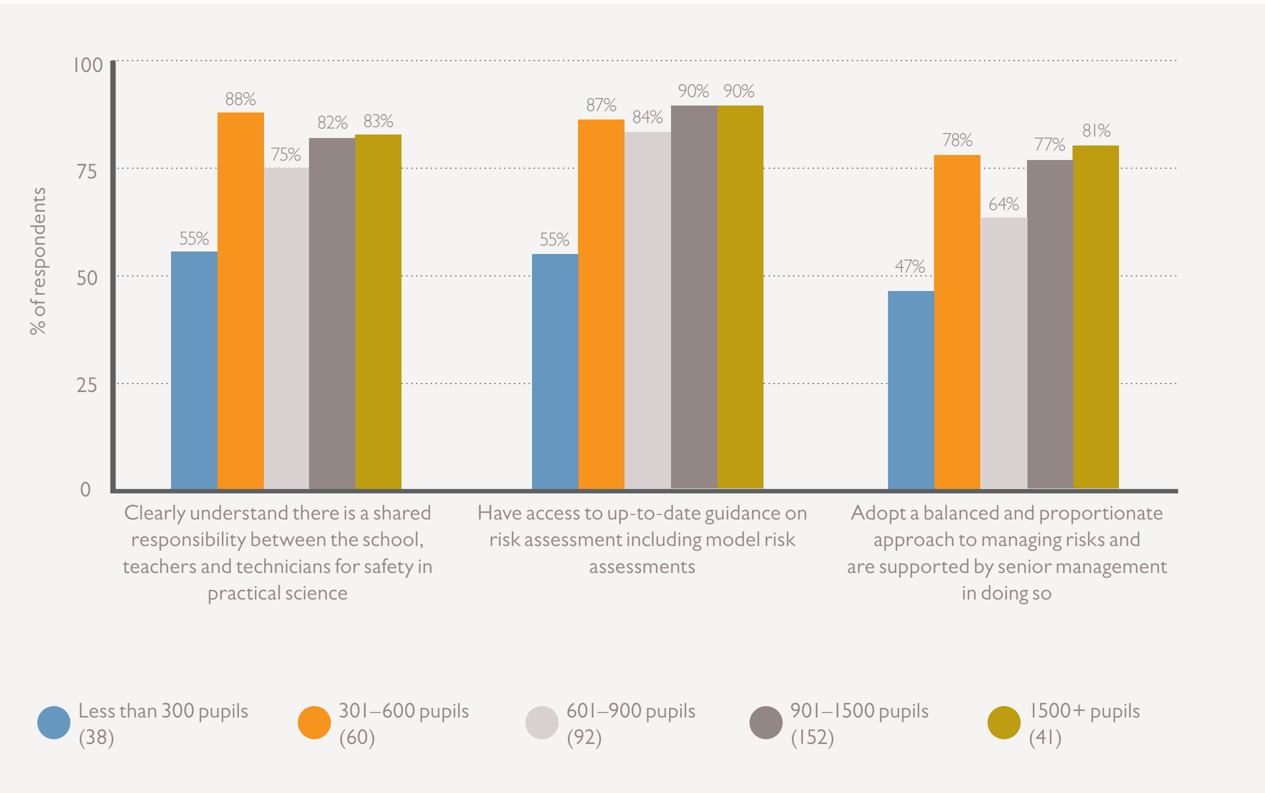
Base numbers are shown in brackets. Data show proportion of respondents saying 'all their science technicians' and therefore should not total 100%

Figure 80: % of respondents saying that in relation to risk, *all* their science teachers: (Institution sizes)



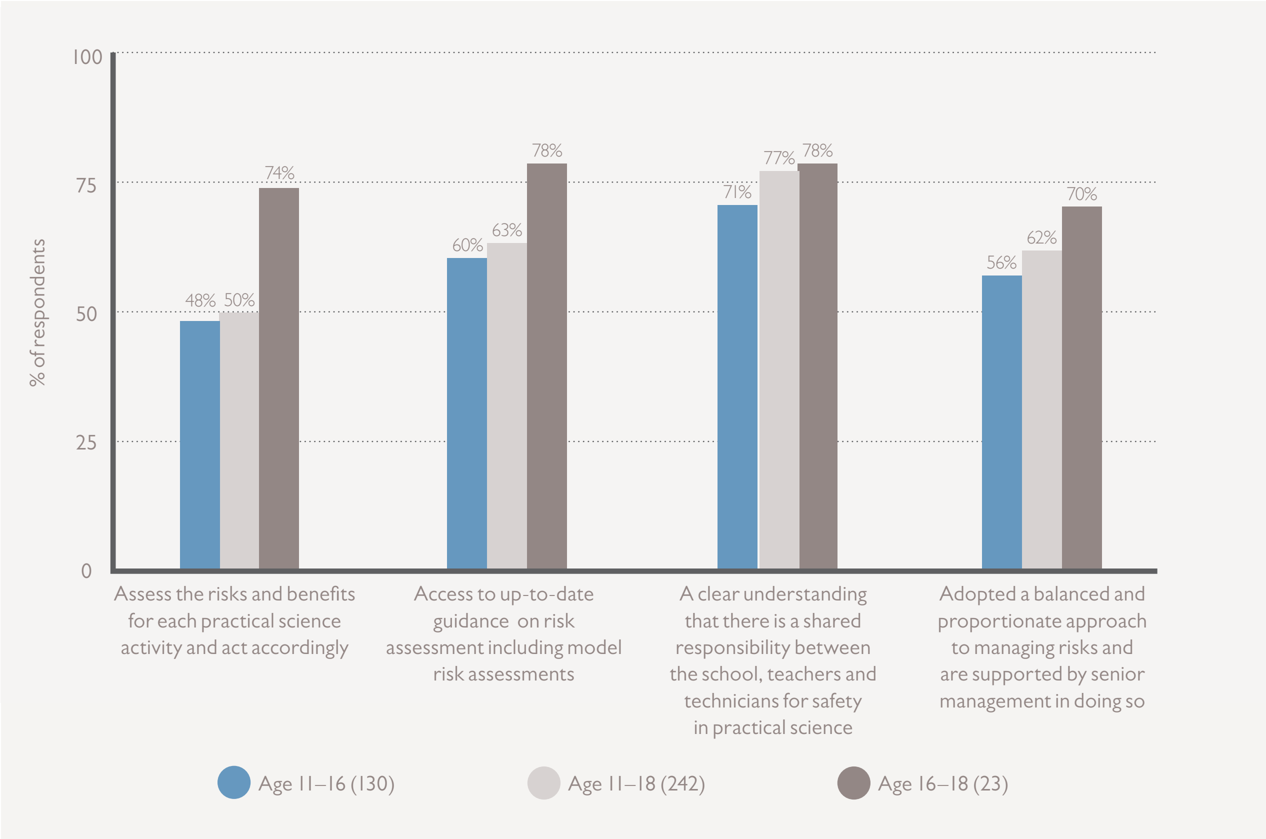
Base numbers are shown in brackets. Data show proportion of respondents saying 'all their science teachers' and therefore should not total 100%

Figure 81: % of respondents saying that in relation to risk, *all* their science technicians: (Institution sizes)



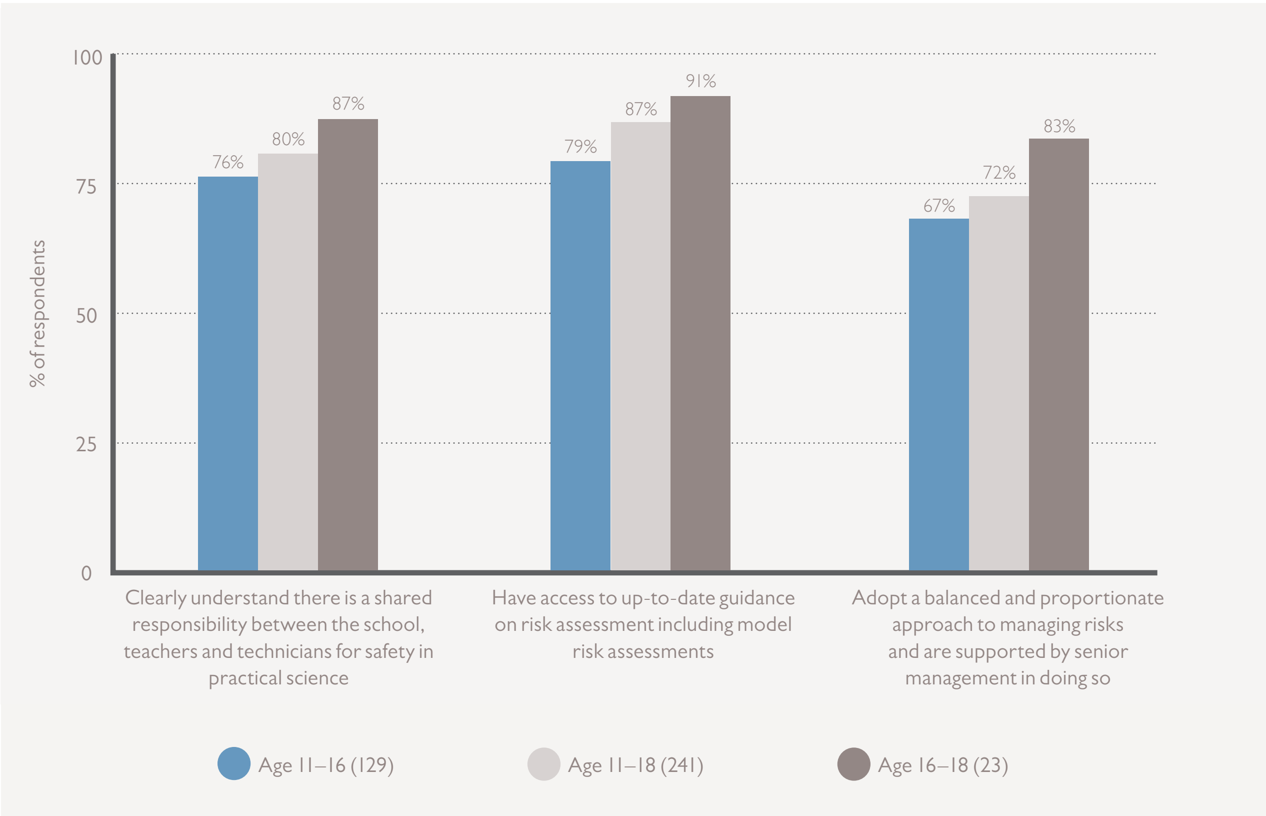
Base numbers are shown in brackets. Data show proportion of respondents saying 'all their science technicians' and therefore should not total 100%

Figure 82: % of respondents saying that in relation to risk, *all* their science teachers: (Institution age bands)



Base numbers are shown in brackets. Data show proportion of respondents saying 'all their science teachers' and therefore should not total 100%

Figure 83: % of respondents saying that in relation to risk, *all* their science technicians: (Institution age bands)



Base numbers are shown in brackets. Data show proportion of respondents saying 'all their science technicians' and therefore should not total 100%

13. BENCHMARK 10 – ASSESSMENT FIT FOR PURPOSE

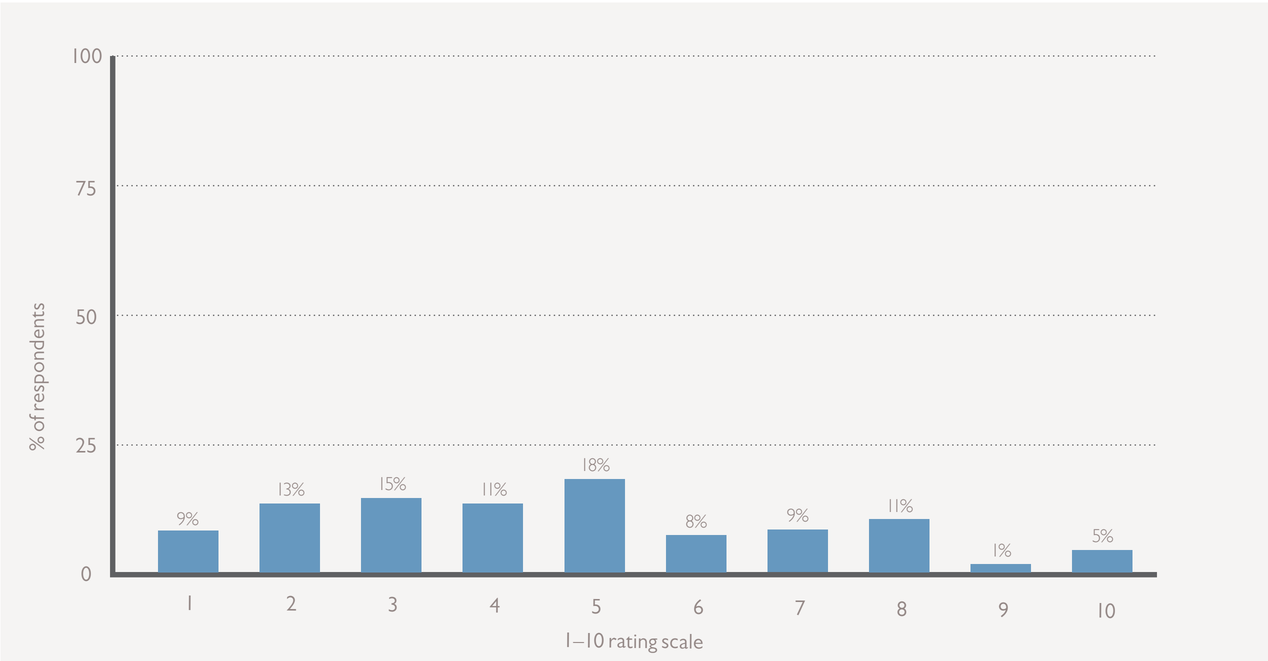
Assessment of students' work in science should include assessment of their practical knowledge, skills and behaviours. This applies to both formative and summative assessment.

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

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

1. Respondents were asked to rate the extent to which their teachers take assessment of performance in practical science activities into account when awarding students' overall grades in science.[24] Using a scale of 1–10, where 1 is not at all, and 10 is fully and completely, the average rating given is 4.7. The distribution of responses is shown in Figure 84.
2. The average rating is slightly higher where:
    - A. Respondents have a written policy on the use of practical science (5.7);
    - B. Respondents have an SMT sponsor for practical science (5); and
    - C. Respondents have sufficient technical expertise (4.9).

Figure 84: Distribution of responses – respondent ratings of the extent to which their teachers take assessment of performance in practical science activities into account when awarding students' overall grades in science

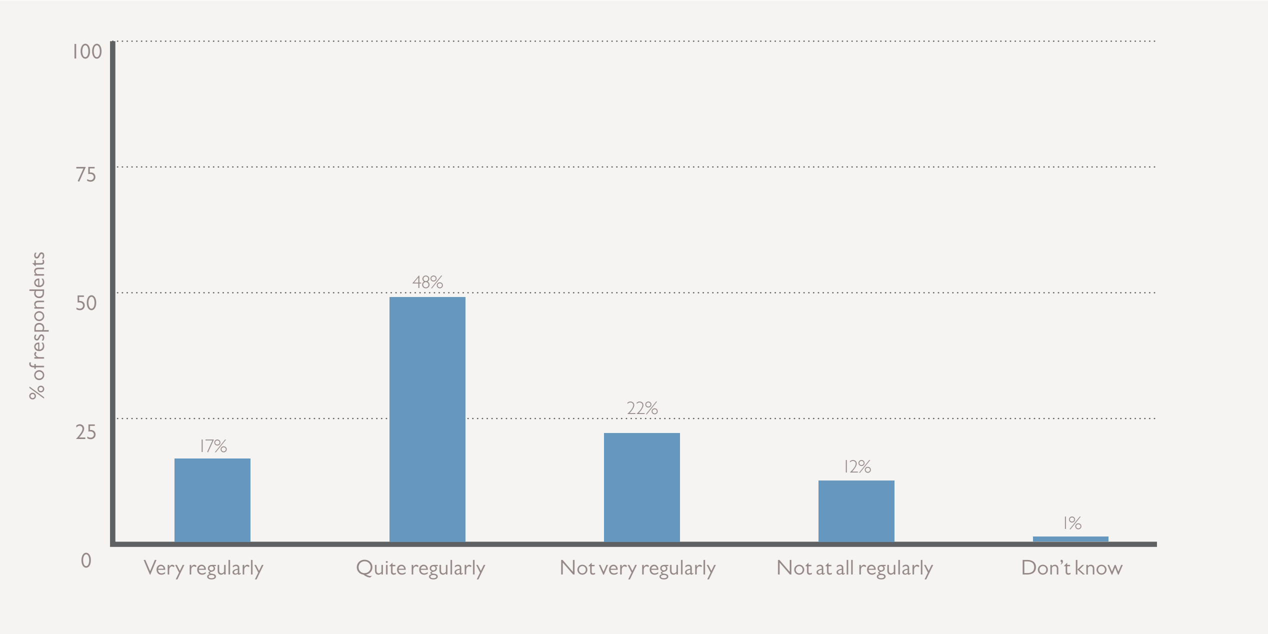


Base 379

[24] This refers to all instances where students are given grades for science as part of internal assessment.

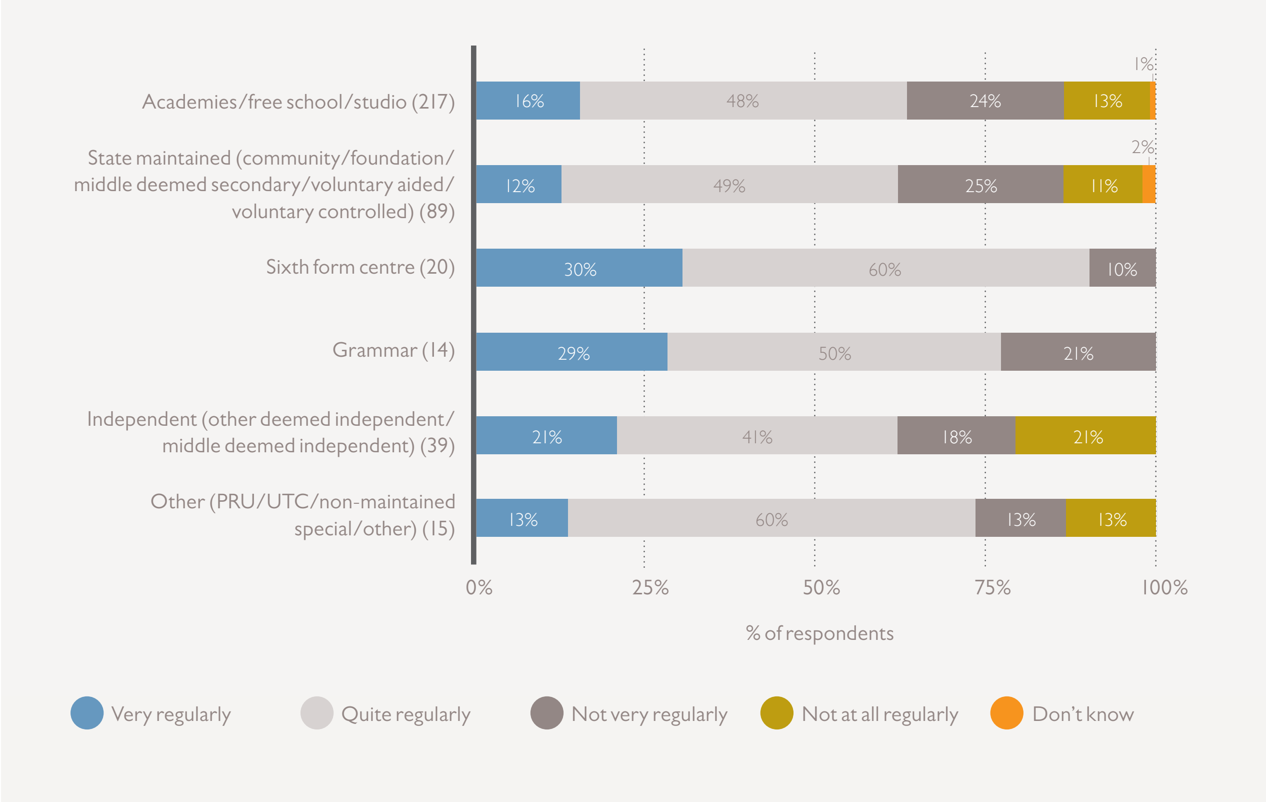
3. Nearly two-thirds of respondents very or quite regularly use practical activities as an opportunity to formatively assess students' progress in science, where it is appropriate to do so (Figure 85). This increases to 90% of respondents in sixth form centres (Figure 86); this difference is not statistically significant. There are no strong differences between schools by size (Figure 87) or age band (Figure 88).

Figure 85: How regularly do teachers use practical activities as an opportunity to formatively assess students' progress in science, where it is appropriate to do so?



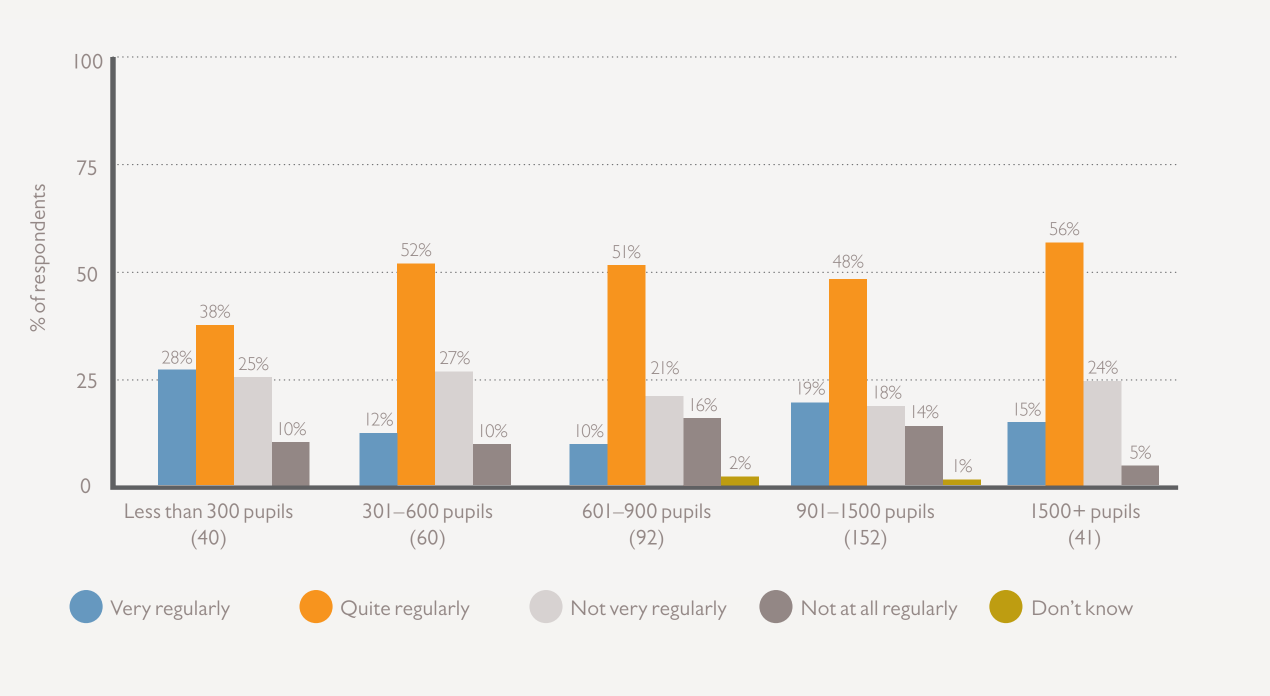
Base 395

Figure 86: How regularly do teachers use practical activities as an opportunity to formatively assess students' progress in science, where it is appropriate to do so? (Institution types)



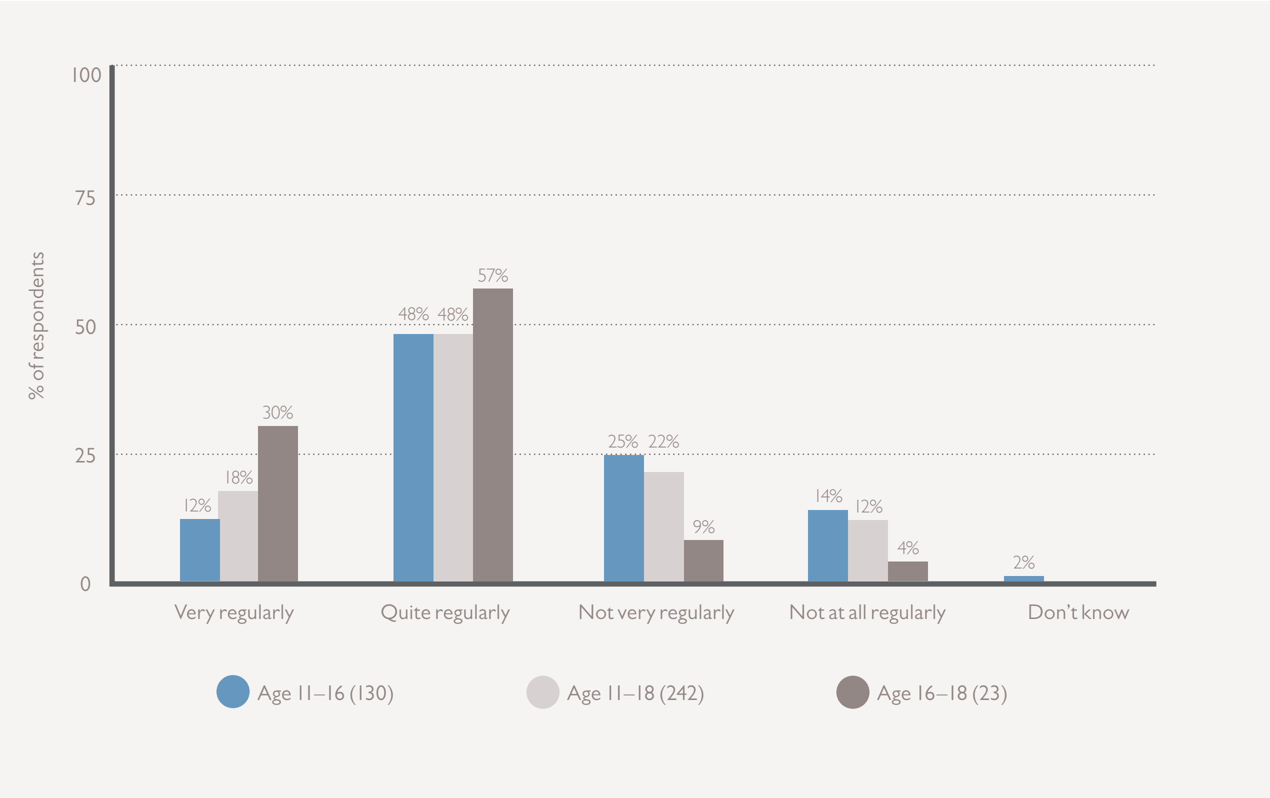
Base numbers are shown in brackets

Figure 87: How regularly do teachers use practical activities as an opportunity to formatively assess students' progress in science, where it is appropriate to do so? (Institution sizes)



Base numbers are shown in brackets

Figure 88: How regularly do teachers use practical activities as an opportunity to formatively assess students' progress in science, where it is appropriate to do so? (Institution age bands)



Base numbers are shown in brackets

4. Qualitative evidence suggests formative assessment may increase as a result of new science specifications at GCSE and A-level. Eight of the twenty respondents participating in depth interviews say they are developing systems to assess in a more formative and structured approach lower down the school, mirroring approaches developed for GCSE and A-level assessment.
5. The majority of respondents interviewed say that the introduction of lab books for students help them to understand what skills they need to develop and build upon, over time. Teachers marking practical work are then looking for specific criteria to be met and review student lab books to inform this process. However a minority say that lab books are *"a box-ticking exercise"* which do not enable students to independently design and undertake their own experiments.

> "The addition of practical requirements at both KS4 and KS5 has greatly increased the need to formalise practical activities in both planning and assessing. Practical activities at this institution are planned for at every level (schemes of work, individual lesson plans). Students have individual lab books that they now conduct all practical work in, this ensures they see the purpose of practical science as well as getting enjoyment from it."
>
> Foundation School, North-East (survey respondent)

6. Respondents say greater opportunities for professional exchange and discussion between teachers would enable better and more structured approaches to formative assessment.
7. One respondent has developed a range of laminated 'prompt cards' which set out the skills being assessed and are used to formatively assess pupil progress in science. These have been well-received (with local schools asking for copies) and have multiple purposes:
   A. They are useful in guiding less experienced teachers during lessons;
   B. They can be distributed to pupils to help them understand what skills they need to develop and which are being assessed; and
   C. They can inform lesson planning.
8. Several respondents are using virtual learning environments to support formative assessment. One respondent describes a platform that gives a certain amount of information to students before they undertake practical work.

14. LIKELY USE OF THE BENCHMARKS

1. Feedback about the likely use of the benchmarks within schools and colleges was predominantly gathered from respondents taking part in in-depth interviews. A small number of survey respondents volunteered information about the use of benchmarks.
2. Qualitative evidence finds that the benchmarks are most likely to be used for:
   A. Developing and presenting a 'business case' for changes or improvements in science;
   B. As a means of self-evaluation intended to underpin continuous improvement in quality of provision of science (including demonstrating improvement in students' achievements and understanding); and
   C. Linking to self-evaluation, as a form of tool to help identify training and development needs, particularly for less experienced science teachers and technicians.
3. In particular, respondents say if the benchmarks could help them present a strong case to evidence a need for more technicians and more training, this would be extremely valuable.

> "It's good to have a benchmark standard. Measuring progress and being able to demonstrate progress is a major priority."
>
> Sixth form college, Yorkshire & the Humber (depth interviewee)

> "It would be very helpful if we have some evidence to do with technicians – they are grossly undervalued in our school. The more evidence we can take to the head teacher the better."
>
> Academy, East Midlands (depth interviewee)

4. Respondents consider that achieving the benchmarks would have highly positive 'knock on' effects for science teaching as a whole, not just for practical science activities. Those respondents within science departments that are, by their own admission, already highly evaluative, collaborative and have excellent attainment, say they are less likely to use the benchmarks, as they are confident they *"know what good looks like, and we're already working in that way"*.
5. At the other end of the spectrum, respondents in institutions they say are extremely poorly resourced, question whether they would be able to make any use of the benchmarks, as they feel nothing (bar a considerable injection of funding) could enable them to achieve them.
6. One survey respondent comments that the survey questions have helped understand the need for, and value of, having a written policy for practical science.

> "Completing this [survey] has made me consider that we do need a policy which outlines the importance of practical science as a tool for learning and as an experience for students. Although our school does believe that practical science should be at the heart of learning and it is used as such it is only now, with the new GCSE in science and the required practical element that we are discussing practical skills as part of their assessment."
>
> Middle school, South-East (survey respondent)

15: CONCLUSIONS AND RECOMMENDATIONS

1. The key barriers and enablers[25] to achieving the benchmarks are:
   - A. Time;
   - B. Inexperience or understaffing;
   - C. Curriculum content/exam requirements;
   - D. Culture and processes/policies; and
   - E. Funding.

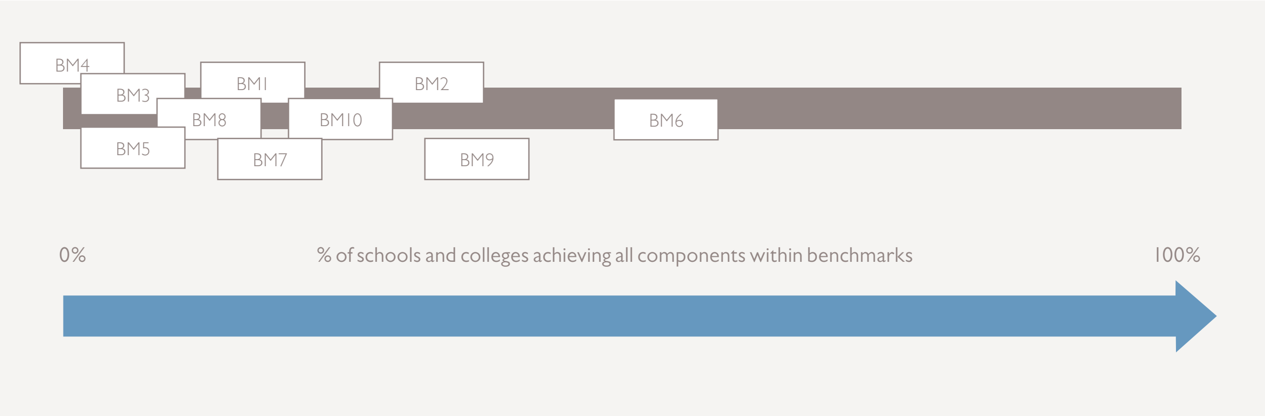
2. Figure 89 shows the extent of distance to travel in relation to achieving the benchmarks. This shows a clustering of on the left of the benchmarks with fewer than 5% of schools achieving them:
   - A. Benchmark 4 (frequent and varied practical science – 2% achieving);
   - B. Benchmark 5 (laboratory facilities and equipment – 4% achieving; and
   - C. Benchmark 3 (expert teachers – 6% achieving).

3. Fewer than 10% of schools are achieving:
   - A. Benchmark 8 (investigative projects – 6% achieving);
   - B. Benchmark 7 (real experiments, virtual enhancements – 7% achieving); and
   - C. Benchmark 1 (planned practical science – 9% achieving).

4. Those closest to being achieved are:
   - A. Benchmark 10 (assessment fit for purpose – 17% achieving);
   - B. Benchmark 2 (purposeful practical science – 23% achieving);
   - C. Benchmark 9 (a balanced approach to risk – 30% achieving); and
   - D. Benchmark 6 (technical support – 42% achieving).

[25] i.e. the converse situation turns a barrier into an enabler; where lack of time is a barrier, sufficient time is an enabler to achieving the benchmarks.

Figure 89: Extent of distance to travel in relation to achieving the benchmarks



5. Taking these in turn, and first looking at time as a barrier, this relates to a number of factors. Primarily, insufficient time for science teachers, which could for example be used to plan more, or more varied practical activities; to discuss/reflect with colleagues, technicians and/or other schools; and to attend training or undertake informal CPD. Secondly, insufficient time for technician support i.e. not enough paid hours allocated to technicians, who may be employed term-time only, meaning no assistance is available to teachers for planning during holiday time. Finally, insufficient time for students following the 'content-heavy' science curriculum – for example to undertake curricular or extra-curricular extended projects.

6. Leading on from this, lack of time or insufficient time can be linked to staffing shortages and/or skills gaps in the science department. Experienced teachers, technicians and heads of department may need to spend more of their time training and supporting inexperienced teachers, and/or spending more time teaching where the department is under-resourced. This has a knock on effect on the amount of time they have available for planning etc. Institutions experiencing difficulties recruiting science teachers and/or technicians say it has become increasingly difficult in recent years because of a shortage of science graduates entering the teaching profession.

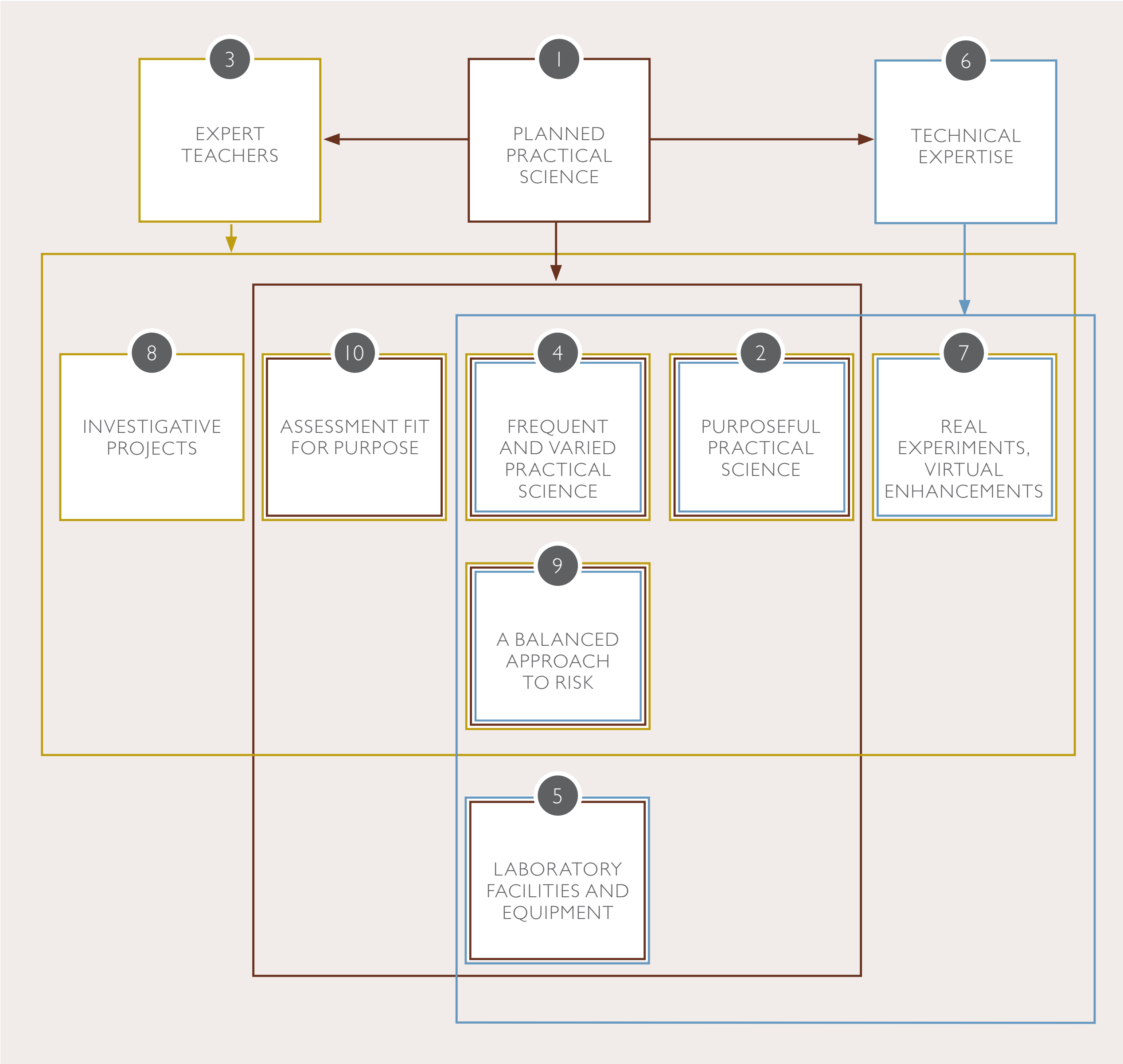
7. Some respondents referred to the 'content-heavy' curriculum as a barrier, given the amount of content that needs to be taught, leaving limited time for practical activity. Not all respondents share this view, with others saying that the new GCSE and A-level specifications will act as a catalyst for more practical work. However for this to be firmly embedded, respondents agree that practical work must clearly feature within assessment processes.

8. The internal culture of a school or college appears a critical barrier where there is not an SMT 'sponsor' for science. This individual can strongly influence key factors such as the amount of timetabled hours for science, time (and space) available, technician hours and salary, the science budget including funding for resources and equipment, and CPD. Akin to are the policies and processes in place to support science (including having a written policy on the use of practical science) – which may relate for example to risk assessment, training and development (for teachers and technicians), purpose and outcomes for practical science etc.

9. Having sufficient funding to deliver effective practical science seems likely to be underpinned by having an SMT sponsor for science. The SMT in turn could be influenced if there was a nationally-led recommendation for a minimum ring-fenced budget for science, based primarily on the school size but also taking into account the new GCSE and A-level specifications.

10. There are clear interrelationships between the benchmarks, meaning that achieving one would play a role in helping to achieve others. This is illustrated in Figure 90, which uses arrows to indicate the likely positive knock on effect of achieving Benchmarks 1, 3 and 6, on helping to achieve others.

Figure 90: How achieving Benchmarks 1, 3 and 6 may enable achievement of the remaining benchmarks



11. Recommendations for the Gatsby Foundation are therefore to consider:

A. Lobbying of policy-makers as appropriate to maintain consistency in the science curriculum;

B. Lobbying of policy-makers as appropriate to seek ring-fenced funding and timetabled hours for science;

C. Prioritising the benchmarks, as it appears that investment into achieving Benchmarks 1, 3 and 6 would act as enablers for achieving other benchmarks without incurring additional cost;

D. Clearly communicating the minimum estimated financial cost of achieving the benchmarks to help schools make the case for change as required; and

E. Publishing, with the benchmarks, information and guidance as to how different members of the science department can make use of them.