

The Deployment of Science and Maths Leaders in Primary Schools

A study for the Wellcome Trust

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I. Executive summary

The Wellcome Trust commissioned this study to understand more about how science and maths are led, managed and taught in primary schools in England today. The study uses three main sources of evidence: an online quantitative survey of 209 schools; a set of qualitative interviews; and three case study schools.

What does science and maths leadership look like in primary schools?

No two schools are identical. And, even if schools share similar characteristics, or find themselves in similar contexts, the way that they choose to lead and teach science and maths will be different. However, it is possible to organise schools into two broad categories when it comes to their science leadership. The first is the ‘class teacher’ model, in which:

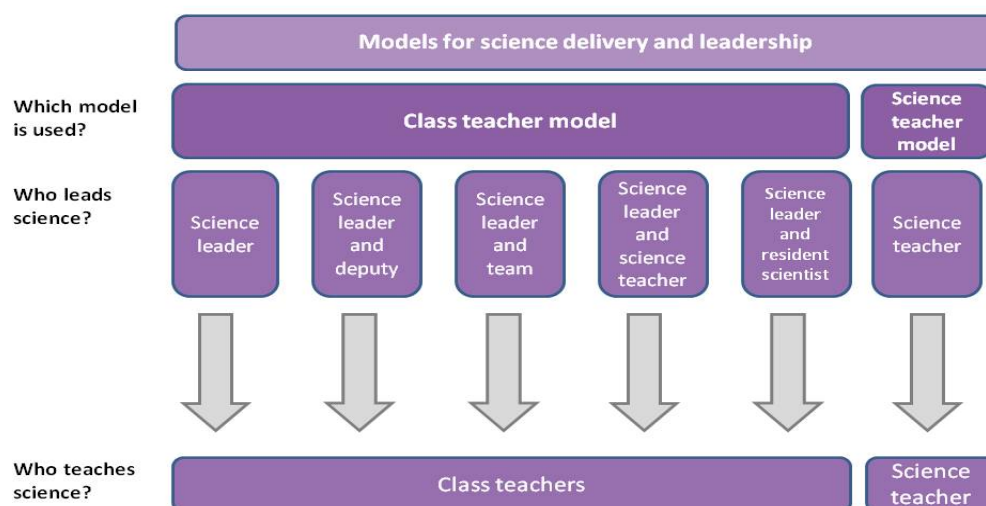
- an individual leads and champions science across the school
- all class teachers teach science to their own children.

The way that the class teacher model is implemented in practice may vary from school to school.

The second is the ‘science teacher’ model, in which the science teacher:

- is likely to have a science-based degree
- teaches all of the science within the school
- leads science on behalf of the rest of the staff.

There are some variations within these models, and there are also examples of schools using very different models (such as employing a scientist-in-residence) to deliver and lead science, demonstrating how exciting a primary science education can be.



In the online survey 95 per cent of schools used the class teacher model, whereas 5 per cent of schools (just 11) employed a science teacher.

Maths is led in a very similar way to the class teacher model. Schools do not tend to use specific maths teachers but make more use of ability setting and increased differentiation. Schools also operate with a stronger focus on pupil testing in maths than in science. A maths leader is likely to have a similar remit to a science leader, as in the model described previously, but will often benefit from a larger budget, as maths is considered to have a higher profile, and is under closer scrutiny both within and beyond schools.

What factors affect a school's selection of the model of science delivery and leadership?

The model for science delivery and leadership is rarely chosen strategically, driven by the outcome of rigorous self-evaluation for improvement or by other evidence. Instead, a number of alternative factors more commonly determine a school's choice of model. Such factors include budgets, current staffing levels, each teacher's qualifications and expertise, the profile of one subject relative to another, the priorities for the academic year, external accountabilities and the size of the school.

Schools using the class teacher model have commonly adopted this approach due to a lack of possible science teachers (i.e. those with specialist expertise) in the recruitment pool, but also because they display a commitment to the principles of generalist primary school teaching. They are keen to employ the best teachers who can engage their children in all subjects, who can offer continuity of contact with the pupils and who can make the most of cross-curricular links.

What are the advantages and disadvantages of each model?

The key benefits of the class teacher model are flexibility in curriculum delivery and in timetabling of science. It is also perceived to be easier in this model to link science to other areas of the curriculum and integrate learning. In contrast, a science teacher provides a rich source of expertise, ensures continuity of progression for students, and is better able to support transition to secondary education.

The disadvantages of the class teacher model centre upon lack of expertise and support in science. Where teachers have weak science knowledge, or low confidence, fewer science practical lessons may take place or classes may be less challenging for more able pupils.

For schools that employ a science teacher, problems may arise with succession planning. When a science teacher leaves a school, their expertise and any initiative that they may have instigated leaves too.

Access to science expertise is seen as desirable whatever the model used.

How does the selection of a model of leadership impact upon pupils, teachers and the wider school?

It has not been possible to evidence a link between the model of subject leadership and children's learning, though this may be something that schools should consider analysing in the future. Users of both models made similar claims about how well each class teacher or science teacher knows their children, and that this is due to the model they employ, but neither group was able to back this up with any data or other evidence.

The detailed case studies in this report demonstrate that children can be highly motivated, enthused and engaged in science whichever model of leadership is used, providing that there is good strategic leadership and commitment to teaching investigative primary science well.

Schools using the class teacher model suggested that having a science teacher might de-skill other teachers. However, in schools where a science teacher was employed no such impacts were identified.

What does this mean for schools?

Whichever model is used, there are consistent messages about what is needed to drive improvement in primary science. Some schools perceive that the status of science in primary schools has diminished in recent years, but others have invested in science, recognising the wider benefits to their pupils.

Headteachers said that the most significant way that they could strengthen their science provision would be to employ more expert teachers of science (along the lines of a Maths Specialist Teacher, or MaST) in their schools. Such teachers would not necessarily be called upon to teach all science lessons to all children, and they may or may not be chosen to act as science leaders. Instead, they would be deployed to help their class teacher colleagues to become outstanding science teachers themselves. Headteachers would like the science experts to challenge, support and offer high-quality science-specific continuing professional development (CPD) to colleagues, and to bring excellent and extensive subject knowledge to the school, in order to ensure that their children are able to experience the best possible science education.

Science and maths leaders identified a number of factors that would help them to lead their subjects more efficiently, including dedicated leadership time to enable them to give better attention to their roles, and an increased budget to resource both science and maths effectively. Subject leaders said that they would value better-trained teaching assistants and technicians in their classrooms, and would benefit from more subject-specific CPD opportunities.

What emerges from this report is that where science has a good profile within the school as a result of dedicated leadership, and where staff are expected to teach exciting, investigative science with access to high-quality science expertise, children are likely to enjoy learning the subject.

Key recommendations

- Schools should make better use of evidence and self-evaluation to inform strategic decisions in developing primary science.
- Every school should have access to expertise in science.
- All who teach, lead or support science in primary schools must be able to access high-quality, subject-specific continuing professional development (CPD).
- Science leaders should be given dedicated leadership time to lead science effectively.
- Schools should be appropriately resourced to deliver a rich science curriculum.

2. Introduction

There is a broad consensus that a good science education at school is important. The 2010 White Paper for schools¹ demonstrated the government's commitment to promoting science by pledging support to increase the number of specialist science teachers and to improve the skills of existing teachers.

The Wellcome Trust has a strong interest in science education, and its 2010–20 Education Strategy² prioritises the reinvigoration of science in primary schools. This study, therefore, seeks a better understanding of how primary schools in England lead, manage and teach science and maths. The Trust is interested in UK-wide science education; however, policy interests have led to this exploration being focused on schools in England.

The Wellcome Trust wants to answer some key questions:

- What does science and maths leadership look like in primary schools?
- What drives a school to select the model of science delivery and leadership it uses?
- What are the advantages and disadvantages of each model?
- How does the selection of a model of leadership impact upon pupils, teachers and the wider school?
- What does this mean for schools?

This study has been designed to find the answers to these questions.

¹ <https://www.gov.uk/government/publications/the-importance-of-teaching-the-schools-white-paper-2010>

² http://www.wellcome.ac.uk/stellent/groups/corporatesite/@msh_publishing_group/documents/web_document/wtx064002.pdf

3. Methodology

The research behind this study has been conducted in three stages. An online survey, designed by the Wellcome Trust and hosted on their website, was advertised and sent to all English primary schools³ via a number of digital methods. The survey⁴ required schools to provide basic data about their setting, an overview of how science and maths are taught and led in their school, and a brief analysis of the advantages and disadvantages of their approach to both subjects. Section 4 of this study provides the headlines of their responses and Appendix 1 looks at the data in more detail. However, the data should not be considered to be representative of all primary schools given the small sample size, and any conclusions drawn should be contextualised as such.

Schools that participated in the survey were also asked if they would consent to taking part in the second phase of the project, which involved being invited to take part in detailed telephone-based interviews. A shortlist of consenting schools was drawn up, which offered a good distribution across all nine regions along with a good variety of school types and sizes, and 21 schools from the list were interviewed⁵. A summary profile of these schools can be found in Appendix 2.

The interview stage was designed to give a broader and more in-depth picture of a school's arrangements for science and maths leadership and teaching. Up to four people were interviewed in each setting: the headteacher or deputy, the science subject leader, the maths subject leader and another class teacher. Where access to all four members of staff was not possible, interviews were prioritised with the head or deputy and the science subject leader. Interviews examined:

- the strategic context behind a school's chosen model of deployment in both science and maths
- the impact of those models upon the pupils, staff and wider school
- the practicalities of having a science and maths leader role in each school
- the pros and cons of the chosen model.

Interviews with subject leaders were based on the completion of a role matrix (see Appendix 3 for an example). The matrix listed a range of areas of responsibility that might make up a subject leader's role. Subject leaders were asked to detail whether they are required to undertake each responsibility, and if they are, what this means for them in practice. Their responses enabled a picture to be created of the roles assigned to primary science and maths subject leaders. Details can be found in section 5iii.

Finally, three schools were selected to be written up in more detail as case studies, in order to articulate how three different deployment models of science leadership work in practice. Each of these schools has been anonymised. The case studies can be found in section 7.

³ Direct emails were sent to generic email addresses for schools in England that served children in the primary age range.

⁴ Schools completing the survey were invited to enter into a prize draw to win £100 e-vouchers.

⁵ Each school interviewed was compensated with £100 to cover teacher release costs.

4. Survey data headlines

i. Introduction

The survey was completed successfully by 209 schools. An additional response was received from a high school, whose data have not been included in this report.

It is advised that the survey data should be used to illustrate the roles of science and maths subject leaders; they are not intended to be representative. Data collated from interviews provide more detail as to how maths and science are led in practice. A brief set of headlines from the survey data is presented below. A fuller exploration of the survey responses can be found in Appendix 1.

ii. The headlines

The majority of responses to the survey came from primary schools (163), though there were responses from infant schools (11), first schools (5), middle schools (4), junior schools (19) and others (7). On the whole, children in these schools are taught in single year groups, though around a third of surveyed schools organise their children into mixed year group classes.

Most schools (198) do not employ a specific science teacher to teach all of their science lessons, so class teachers are expected to teach science alongside the other curriculum subjects. There are a minority of schools (11) in which a science teacher is employed, though most of these schools use this teacher to teach all of their Key Stage 2 (KS2) science lessons and just one school uses the same science teacher for both KS2 and KS1⁶. Five such schools employing a science teacher have fewer than 100 pupils on roll.

None of the surveyed schools employs a specialist maths teacher to teach all of their maths lessons. Maths lessons are nearly always taught by the usual class teacher and are more likely than science to be taught in ability groupings.

Schools are more likely to appoint someone from their senior leadership team to lead maths than science, and a science leader is more often a full-time teacher.

The latest School Workforce Survey⁷ suggests that just over 9 per cent of primary school teachers have a science-related degree. It is not possible to make a direct comparison between this figure and the data in this survey, as some survey respondents did not distinguish clearly between whether their subject leaders hold a teaching degree or a science/maths-related degree. However, in 18 per cent of the surveyed schools the highest relevant qualification the maths leader holds is an A level, and in 22 per cent of schools the maths leader's highest maths-based qualification is a GCSE. Similarly, 15 per cent of schools said that their science leader's highest science-based qualification is an A level, and 21 per cent said it is a GCSE.

⁶ In England Key Stage 1 refers to pupils aged five to seven; Key Stage 2 refers to pupils aged seven to eleven.

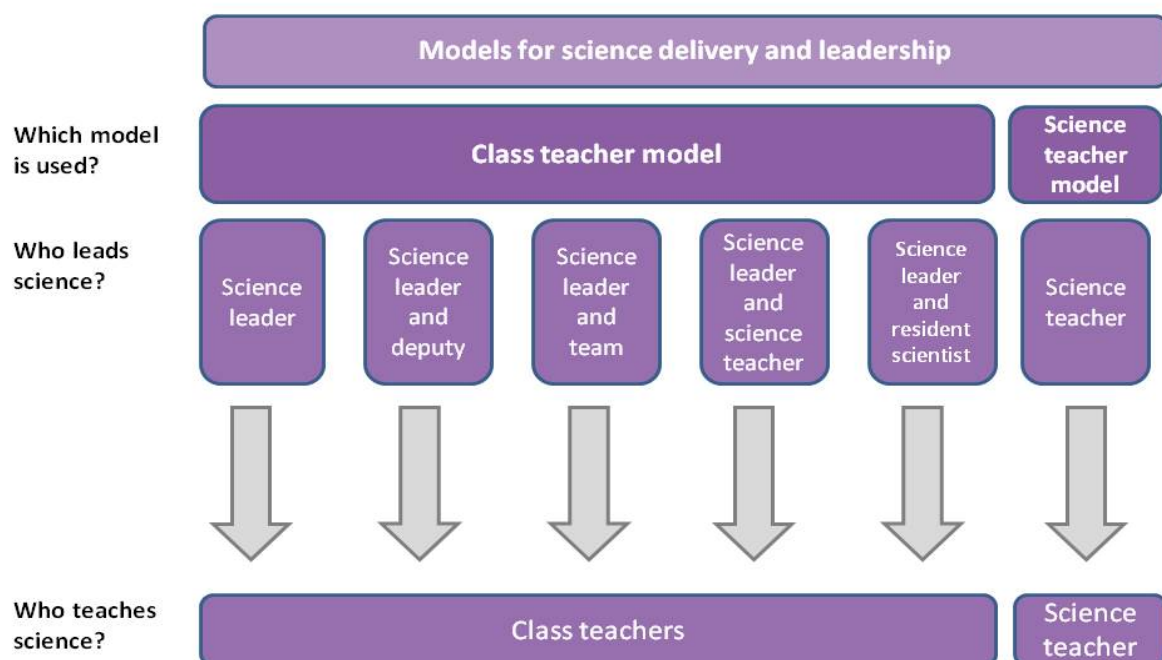
⁷ <https://www.gov.uk/government/publications/school-workforce-in-england-november-2012>

5. What are the different deployment models used for science delivery and leadership in primary schools?

i. Introduction

Primary schools in England use a range of models for the delivery and leadership of science. However, our research has shown that these models can largely be divided into two main groups. Most primary schools can be said to use a more traditional ‘class teacher’ model, where science is taught by the class teacher, but there has been a move in some schools to employ a ‘science teacher’ who is also responsible for leading science in the school. Nearly all schools can be plotted somewhere on a spectrum between these two models, with a few common variations existing in-between the two groups, as in Figure 1, below.

Figure 1. Models of science delivery and leadership



A broad-brush definition of science leadership might look like this:

A 'science leader' is the person in the primary school with responsibility for overseeing and coordinating all aspects of science teaching. Their remit can include all or some of the following things:

- setting the strategic direction for the subject
- determining the priorities for science in their school for the academic year
- outlining high-level curriculum plans for each year group
- monitoring the quality of the teaching of science
- monitoring learning and achievement in science
- reporting on science to the senior leadership team (SLT), governing body and parents
- leading extracurricular and enrichment activities relating to science
- championing the subject across the school
- attending science-specific continuing professional development (CPD) courses
- handling a dedicated science budget and managing science resources
- supporting colleagues by delivering CPD, coaching, team-teaching or demonstrating.

A 'science teacher'⁸ tends to have specific science training, completed either at university or since becoming a teacher, or may have come from a scientific job before teaching. They are likely to have a similar remit to the science leader, with one significant addition:

- they take responsibility for teaching *all, or the large majority of*, science lessons within the school.

There are other permutations on a continuum between these two models.

A science leader supported by a deputy may be chosen to:

- share the workload in a large school
- divide responsibility between Key Stage 1 (KS1) and Key Stage 2 (KS2) science
- provide development opportunities for a more junior member of staff
- ensure there is always someone available to take over the subject leadership should staffing arrangements change.

A science leader supported by a team may be preferred, in order to:

- maximise the expertise available within the school
- offer development opportunities across the staff
- encourage collective responsibility for an important subject
- support succession planning when staff move on or change roles within the school.

A science leader and a science teacher together:

- ensure that there is strong subject leadership accompanied by excellent subject expertise among the staff

⁸ For the purposes of this paper, the term 'science teacher' refers to the definition above, as opposed to someone who has completed a formal Primary Science Specialist qualification.

- offer specialist teaching to some children in the school where appropriate (commonly used for Years 5 and 6, where this model exists).

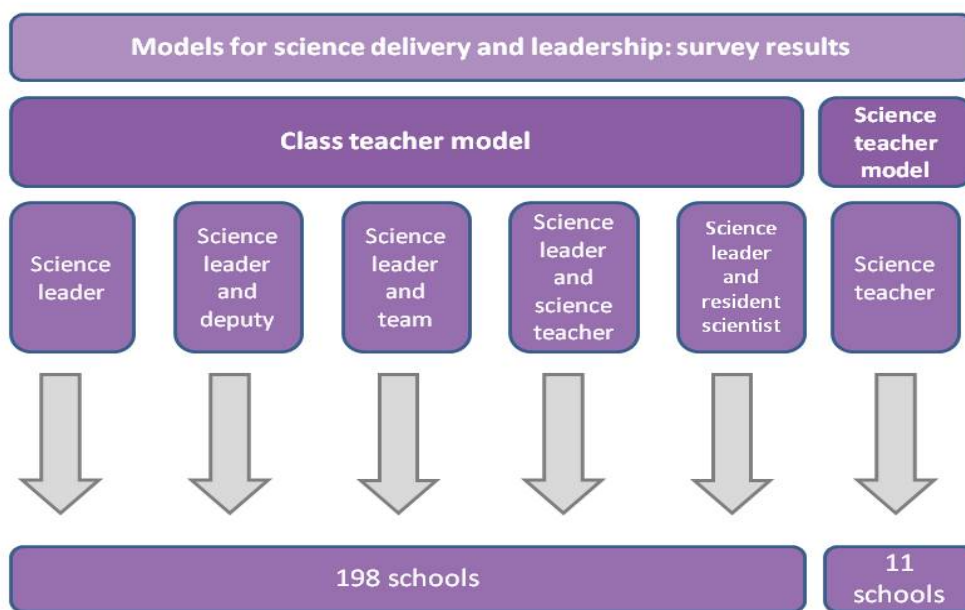
Alternatively a science leader and a scientist-in-residence may be favoured, with the scientist enabling pupils to explore and investigate their science questions beyond the school curriculum, using a designated science room⁹.

ii. Who uses which model?

Of the 209 schools that responded to the online survey, just one said that it employs a science teacher for the teaching of all science to all pupils in the school. A further ten said that they use a science teacher for the teaching of all science to all KS2 pupils but not to their KS1 learners.

The majority of survey respondents (198 schools) said that the usual class teachers are responsible for the teaching of all science to their pupils (Figure 2).

Figure 2. Distribution of deployment models in survey schools

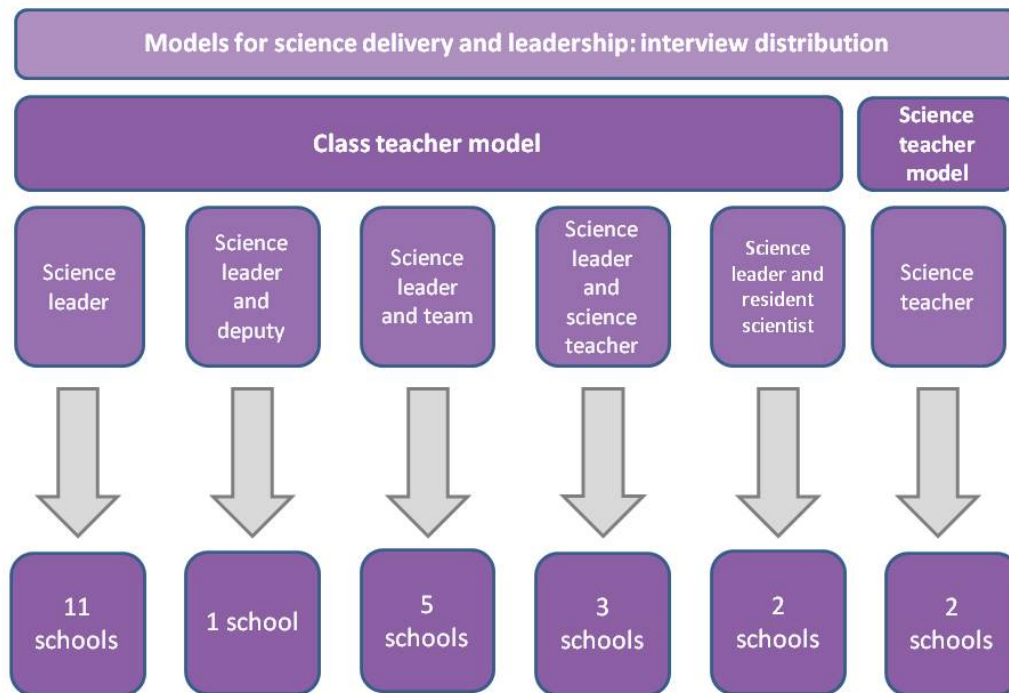


No school said that it employs a maths teacher who is responsible for teaching all of its pupils' maths lessons. However, 15 schools use a combination of ability grouping and withdrawal by a specific teacher (but not a maths specialist) for lower ability or higher ability sets in KS1, and 26 schools use a similar combination of approaches in KS2. These approaches are used within setting or streaming for maths generally.

⁹ The concept was developed by the charity Ignition* (<http://www.ignitefutures.org.uk/ignition/lab-13/>).

In order to get a more in-depth picture of the spectrum of deployment models for science, the interview sample (a total of 21 schools) did not draw on the different models proportionately, but overrepresented the science teacher model, as shown in Figure 3.

Figure 3. Distribution of models in interview sample



iii. What science and maths leaders do: what the survey said

When the surveyed schools were asked what their science leader (regardless of the school's deployment model) does to fulfil his or her role, the most common answers were:

- supporting colleagues in their science-specific CPD (72 per cent)
- monitoring the quality of science teaching (66 per cent)
- monitoring learning and achievement in science (74 per cent)
- curriculum development (74 per cent)
- resource management (74 per cent).

According to the survey results (Appendix 4), it appears that the role of a maths subject leader is given more prominence in terms of the expectation of what the subject leader will do. The maths leader is significantly more likely than a science leader to coach colleagues, monitor the quality of teaching and learning, monitor achievement, be involved in strategic development, liaise with governors, and hold question and answer sessions for parents. However, a science leader is more likely to add enrichment to the subject by leading an extracurricular science club.

iv. What a science leader and a science teacher do: what the interviews told us

Interviews with subject leaders examined their day-to-day roles in greater detail, in order to build up a picture of what a science leader's job entails.

Teaching specialist and demonstration lessons

In schools where a 'class teacher' model is used, class teachers take science lessons for their own pupils, as they do for nearly all other subjects. However, for a number of reasons science leaders may teach demonstration lessons. They may do so to share ideas and good practice when a colleague is struggling with a topic, a new piece of apparatus or a more practical approach to a subject. Demonstration lessons are often used to help to improve colleagues' confidence levels as well as to extend their knowledge. Such lessons are also a key element of science-specific CPD provided by science leaders, particularly for newly qualified teachers, and tend to be delivered on request.

By definition a science teacher's role requires that a good proportion of their time be dedicated to science teaching. This is more likely in smaller schools, where there are fewer classes that comprise mixed ages and year groups. Furthermore, a science teacher may be part-time, meaning that all of their contact time with pupils is spent teaching just one subject, frequently timetabled during other teachers' planning, preparation and assessment (PPA) time. Demonstration lessons are not usually required in such schools, since other teachers rarely teach any science.

Coaching

Unsurprisingly, science teachers are not called upon to coach colleagues in relation to their science teaching, since they deliver nearly all science lessons themselves. However, science leaders stated that recently there has been an increase in the level of demand for science coaching. Coaching can either be requested informally by an individual, or can be a more formal process initiated by the SLT. Informal requests for coaching may stem from situations similar to those that require demonstration lessons, and are more likely to come from colleagues without a science background or formal science training. Where coaching is a more formal request via the SLT, it often forms part of a wider monitoring process designed to ensure that class teachers are covering the required science curriculum and that the scientific content of lessons is accurate and up to date.

Monitoring the quality of teaching

Science leaders have some responsibility for monitoring the quality of science in their schools, though often this is a more informal practice than the regular performance management process undertaken by their senior managers. Monitoring involves lesson observations, book scrutinies to check the quality of marking and feedback given to children, learning walks, looking at wall displays, sending surveys to parents and children, and interviewing pupils. These activities are used to reveal any CPD needs, or to provide suggestions for demonstration teaching or coaching sessions.

Science teachers are not responsible for monitoring the quality of science teaching in the same way as science leaders, as they are likely to be the only person teaching it. Instead, they have to undertake some form of self-evaluation and are accountable through performance management.

Monitoring learning and achievement

All science leaders and science teachers are involved in monitoring learning and achievement to some degree. They may be required to analyse achievement data to look for trends, and to report to their senior management team or governing body. Tied in closely with the monitoring of how well science is taught in

their school, science leaders also conduct book scrutinies, interview pupils and review teachers' plans to check that pupils are learning well and making progress. There is little difference between how this is conducted by science leaders or science teachers.

Lesson planning

Almost every school said that the science leaders put together an overarching curriculum plan for the year but that individual class teachers are responsible for the detailed lesson plans. The science leader makes sample checks of how lessons are planned to ensure that consistent approaches are being used and to check that the curriculum is being covered.

Science teachers are responsible for all science planning.

Strategic development and curriculum development

Science leaders and science teachers have a key role in the strategic development of their subject. They are often required to prepare an initial set of priorities or a plan for science for the year, which is then discussed and fleshed out with their senior leadership colleagues, and sometimes the governors. The following may all be parts of their responsibility: determining the approach for the coming year's lessons, identifying training needs among the staff, setting a direction for the subject, establishing a balance between practical and more theoretical lessons, or selecting the most appropriate assessment methodology to use. It does not appear that this role differs particularly, based on whether the school uses a science leader or a science teacher.

Curriculum development often forms part of the science leader's and science teacher's remit. They also lead discussions and staff meetings on how the science curriculum fits in with a broader cross-curricular approach elsewhere in the school.

Resource management and budget holding

Either the science leader/science teacher manages a dedicated resource budget for science, or schools use a system whereby individual requests for money are submitted to the SLT on an ad hoc basis. However, in nearly all cases the science leader or science teacher coordinates those requests. In most schools interviewed the resource budget for science is slightly lower than that allocated to maths or English.

"[The science budget is] much lower than maths and literacy. It is maybe a quarter of what they get. It's on a par with other subjects though."

"[Our science budget is] not equivalent to maths and literacy, but is more than other foundation subjects."

In just a couple of instances schools said that their science budget is equivalent to that for maths or English.

Nearly all schools reported that budgets for science resources are stretched, and many said that their annual resources budget is somewhere in the region of £300 to £500. Some schools said that they had successfully applied for additional funding via private companies' corporate social responsibility programmes or by entering competitions, and that this had been an essential way to make a serious investment in their science resources, using such money to fund the development or maintenance of an outdoor learning space such as a wildlife area or a vegetable garden.

Purchasing physical resources and equipment tends to be done by the science leader or the science teacher. When it comes to funding science-specific CPD, both science leaders and science teachers said that requests are usually considered on a case-by-case basis. Schools have a separate budget for staff development managed by the SLT, though there was no evidence that schools use a set formula for the allocation of this money. However, it is possible that spending on numeracy and literacy CPD may take priority during an academic year in which either of those subjects is the focus of the school-wide development plan.

There are no significant differences between how a science teacher or leader deals with resourcing and budgets.

Liaison with governors and parents

Nearly all science teachers and leaders said that it is their responsibility to liaise with the school's governing body about any issues relating to science, and that there is a science link governor who acts as an external source of challenge and review. The science leader/teacher is likely to report to the governors frequently throughout the academic year, delivering information on attainment, progress and the latest priorities for science. A link governor for science may watch science lessons and report back to the wider governing body.

Again, there is no real difference in the way that a science teacher or a science leader liaises and interacts with parents: variations tend to occur on a school-by-school basis, as a result of each school's established culture. The science leader or teacher may invite parents to take part in the science that is going on in school via occasional workshops, science events (such as an annual science week) or even by running science clubs aimed at pupils and their parents at weekends. Some schools said that they ask parents to volunteer in school to help with science-based activities, such as taking part in practical experiments, talking to pupils about a science-related job to help them to understand the role of science in a wide range of workplaces, helping out in after-school clubs, or even maintaining the gardens or outdoor space.

Extracurricular and enrichment activities

There is no obvious pattern between the level of extracurricular science activities offered in a school and the model of science leadership used. It is more the case that the degree to which enrichment activities are offered is a reflection of the status or profile of science within each individual school.

It was common to hear that a school has historically run a regular science club, and that the club has been very popular, or frequently oversubscribed. However, many said that their science club is not running this academic year, often due to budget constraints or staff availability. The only school that said it is running multiple clubs has a scientist-in-residence, who offers the activities. These clubs include one for KS1 pupils and one for KS2 children, one for the committee of children who run the school science lab, and one on Saturdays for dads and their children.

Schools reported taking part in a large range of exciting and stimulating science-based enrichment activities, including science-based outings, regular science weeks, inviting in external speakers or companies who have a science focus, and running a forest school either on site or close to the school premises.

Continuing professional development (CPD)

Encouragingly, all the science leaders and science teachers interviewed said that they have good access to science-specific CPD, and that they had undertaken some in the course of their roles. Some science leaders said that they had attended courses specifically about how to be a science subject leader, and many said that they had undertaken training provided by the national network of Science Learning Centres.

“With regards to CPD, it’s the science leader’s responsibility to stay up to date and to identify appropriate courses. CPD is linked to our school improvement plan and science doesn’t have a particularly high priority on that.”

It was common to hear that science-specific training provided by the local authority has declined in recent years, both in terms of availability and quality, and this is assumed to be due to a reduction in funding. Science leaders said that they send their class teacher colleagues on science-specific training in order to spread expertise around the school, as opposed to always being the person going on science-based courses.

Science leaders are always required to pass on their learning to their colleagues upon returning to school, commonly via short staff meetings. In rare cases, they share their learning via email to colleagues, though this is felt to be less effective than offering a mini training session directly.

Science teachers gave a slightly different view. As they are likely to be the only person teaching science in a school, it is more often the case that they pass on science-specific learning to teaching assistants, or that they are required to share the more generic aspects of the course that they have undertaken (i.e. something applicable to all teaching and learning) with their colleagues instead.

v. How science leaders compare with maths leaders: what the interviews told us

Maths teachers

No school in this study said that it makes full-time use of a maths teacher, though there are a few instances in multiple-form entry schools where Year 6 pupils receive their maths lessons from the same teacher. The analysis that follows, therefore, compares the role of maths leader directly with the science leader model (as described in section 5i), and is derived from data gained through the interview stage of the research. At first glance, the role of maths leader is not very different from that of science leader, as the overarching areas of responsibility are the same, although there are some nuances explored below.

Teaching methods

Maths is taught differently from science in primary schools. It is likely to be timetabled every day, and is usually taught in the morning either before or after daily literacy lessons, whereas science is taught weekly, usually for up to an afternoon at a time. Maths lessons are more likely than science to be taught in ability groups. Even where children are not split into sets for maths, there is likely to be greater differentiation within the classroom and greater use of teaching assistants to support small groups in the lesson. The maths leader is more likely to teach Year 6 than any other year group, while most science leaders are fairly evenly distributed over Years 4, 5 and 6¹⁰.

Monitoring learning and achievement

Monitoring learning and achievement in maths is more formal than in science, and more data-driven. Reporting by the maths leader takes place more frequently, and there is a greater analysis of data. Relationships with governors are more established, and maths is timetabled at leadership meetings more frequently than science. This is closely linked with the fact that maths is more assessment-driven than science, given the accountability requirements currently placed upon schools. Maths leaders are required to moderate assessment between classes, across year groups and between schools. In contrast, moderation was

¹⁰ Survey data suggested that most science leaders were teachers of Years 3, 4 or 5, with maths leaders being significantly more likely to teach Year 6.

not something cited as being part of a science leader's remit (this is not to say that science leaders do not do it, but rather that it is less prominent in the roles of those people interviewed).

Monitoring the quality of teaching

Monitoring the quality of teaching appears to be a more formal arrangement for maths (lesson observations are timetabled more regularly and tend to be carried out by members of the SLT) than science, which is monitored via ad hoc observations by the science subject leader.

Working with parents

Maths leaders and science leaders work with parents differently. Maths leaders may run workshops about maths homework or training sessions for parents to demonstrate calculation techniques. Science leaders said that they encourage parents to spend time getting involved in informal science at home, but take a less prescriptive approach to making this happen.

Professional status

Maths leaders frequently said that they are either a Mathematics Specialist Teacher (MaST) already or that they are in the process of becoming one, whereas no science leaders interviewed referred to an equivalent qualification¹¹. MaST status seems to enable more opportunities within and beyond school for coaching, demonstration lessons and team teaching, and also offers maths leaders more chances to network with their colleagues in other schools. A teacher with MaST status is perceived to be the resident maths expert within a school, and their teaching colleagues are likely to approach them for advice, or with problems relating to maths teaching. Furthermore, maths leaders with MaST status said that they feel that they are also identified as being more senior within the school's hierarchy having achieved that qualification.

Budget

Maths leaders' budgets are likely to be bigger than those held by science leaders, due in part to the fact that in most schools interviewed maths is a higher priority on the school's improvement plan. Frequently the profile of maths was greater than science in a school because it was the main focus for the whole school for the academic year. Only one school said that its main focus for the whole school for the year is science.

Extracurricular activities

While extracurricular opportunities led by maths leaders are rarer than those offered by science leaders, those maths opportunities that are offered are more academic and less informal than the science clubs. There are more examples of maths booster clubs for Year 6 pupils ahead of SATs (Statutory Assessment Tests), and a couple of schools offer a gifted and talented maths club, whereas no school said that it provides an equivalent group for science.

Networking

Networking opportunities for maths leaders are more available (i.e. more common and held more frequently) than for science leaders. There appears to be more local networking for maths through groups facilitated by the local authority or by clusters of schools. In addition, maths leaders are more likely to be members of professional associations than science leaders.

¹¹ The nearest equivalent might be the Chartered Science Teacher designation (<http://www.sciencecouncil.org/content/chartered-science-teacher-csciteach>).

Summary

While both science and maths leaders have similar responsibilities, arrangements in the maths role tend to be less fluid and more strategic. There is relatively more financial support and more structured training available, a greater focus on data and recording attainment and progress, and a different emphasis in the way parents are engaged over their children's maths learning.

6. What are the strategic drivers for the adoption of different models for science leadership and delivery?

i. Introduction

The selection of a model for leadership and delivery depends largely upon the context of a school. Rather than having the luxury of being able to consider the pros and cons of a science teacher model over a class teacher model and then make a strategic decision as to which way to proceed, schools are much more likely to have to find the best way to deploy their available resources, expertise and budget, and from there develop and evolve an approach that fits their current circumstances.

ii. What are the limiting factors when adopting a model for science teaching?

Science expertise

Given the low percentage of the primary-teaching workforce with a science-related degree, it follows that in the majority of schools headteachers are unable to automatically allocate science leadership to a member of staff with a science background. It is possible that no teacher in a school will have a science qualification above GCSE level, and in such scenarios the adoption of the science teacher model may not be an option. This is not to say that the lack of a science qualification must preclude a teacher from taking on leadership of science, but rather that headteachers are often required to look beyond qualifications for enthusiasm and interest in the subject instead. Nonetheless, there are schools where no one holds a relevant science qualification, and where leadership of science is perceived to be difficult, leaving senior leadership teams (SLTs) in a difficult position and often requiring the head or deputy to take on the science leader role.

Teachers' confidence

Where primary teachers have not studied science at A level or beyond, confidence levels in teaching the subject may be lacking. Not only do some primary teachers feel that their subject knowledge is inadequate, they are also intimidated by the need to shift the focus to more creative, practical and investigation-based science, and thus may be reluctant to lead the subject in their school. Again, in such schools the selection of the science teacher model is unlikely. A particular issue – not prevalent in maths – is health and safety, where a lack of knowledge in science could cause a teacher to feel much less confident about children doing practical activities.

School size

In schools where the number of pupils on roll is low, staffing arrangements tend to be complicated. Such schools often have fewer classes, frequently in mixed year groups, and a teaching staff with a combination of part-time and full-time members. Timetabling in primary schools is also complicated by the requirement to teach daily literacy and numeracy lessons along with the need to enable class teachers to have planning, preparation and assessment (PPA) time. A small school may choose to use the science teacher model, therefore, not only because one part-time teacher has a strong skillset in science, but also because it suits the rest of the teaching staff and the timetable for that individual to teach all science while simultaneously covering their colleagues' PPA time.

Budget

Many schools report that employing a good quality science teacher is not affordable. With the accountability focus resting more on numeracy and literacy, and with fewer class teachers being equipped to teach other subjects such as modern languages or music, such a model of teaching is more likely to be used in other subjects before science.

Succession planning

Schools may be reluctant to select the science teacher model for future planning reasons. Given that it is common for the model of subject leadership to be selected to fit the 'here and now' of staff, expertise and school circumstances, headteachers are less keen when recruiting a new member of staff to prioritise the need for expert science knowledge and experience over the wider requirements of being an excellent generalist and an outstanding teacher of young children. This approach makes it easier to replace staff when they leave the school as it opens up the recruitment pool.

Opportunity

Two of the interviewed schools are running a Lab_13 project for their science provision¹²: a model in which a scientist-in-residence is employed on a part- or full-time basis and, together with a committee of Year 6 students, is in charge of a dedicated science laboratory space on site where children have open access to more science learning opportunities. The two schools using Lab_13 heard about the scheme in different ways, and have both found themselves working hard to secure funding for the continuation of their labs. Thus, the selection of this model by any other school in the future is less likely to be a strategic decision, and more one of opportunity, enabled by funding.

Change within school

Taking all of the above factors into account, schools often find themselves having to adapt their model of subject leadership when change occurs. A science teacher may leave and not be able to be replaced, thus forcing a move to using the class teacher model instead. Likewise, the need to increase the number of pupils on roll may mean that it is no longer best for a school to employ a science teacher, and instead for each class teacher to teach science. Equally, the person who leads English or maths may leave the school, and filling this vacancy could be perceived to be a higher priority than continuing science leadership, so a science leader who has developed subject leadership skills may take over English or maths leadership instead. Indeed, some schools purposefully rotate subject leadership responsibilities in order to ensure that expertise is shared and that things do not stagnate.

iii. What are the pros and cons of science teachers versus class teachers?

No headteacher interviewed felt that either the science teacher model or the class teacher model was the perfect answer. There are distinct advantages and disadvantages to both, and what is an advantage in one model can be a disadvantage in another. Additionally, the pros and cons described for each model are not exhaustive. Data has been summarised in Appendix 5.

Almost every school interviewed said that they were unable to extrapolate whether the model they use for subject leadership has a particular impact on their children's learning, as they either had not considered making this link, or had not collected data. This is even more relevant for science where formal testing through SATs (Statutory Assessment Tests) has ended. Schools said that as formal ability measuring has

¹² <http://www.ignitefutures.org.uk/ignition/lab-13>

declined, they now place less of a focus on testing their children's ability to remember scientific facts, and instead have shifted their attention to how well children are able to take part in practical experiments or undertake a fair test.

However, all schools testified that whatever the leadership model they use, their children display great enthusiasm for science, visible in their enjoyment of science lessons and activities, their participation in extracurricular clubs and groups, and their development of scientific skills.

The benefits of the class teacher model

In a school where all class teachers teach science "everyone is armed with the full skillset"¹³, and is thus expected to be an excellent general class teacher. This approach means that all staff are able to teach and encourage learning in every aspect of the curriculum, whereas a science teacher model means that the best science expertise is potentially limited to one or two individuals. By ensuring that all class teachers teach science, schools said that children are exposed to multiple approaches and teaching styles, broadening their experiences and expanding their minds.

Where all class teachers are involved in science teaching, there can be more opportunities for collaboration, idea sharing and joint planning. Different approaches can be combined, and projects can take on different flavours depending on the combination of people involved. Accountability for science learning and achievement is shared, and it is easier to get the whole school (including parents) involved. Headteachers said that it is harder to hide any shortcomings in the way that science is taught: if all class teachers teach science, then issues are brought to the surface more easily and frequently. Schools testify that teachers' confidence in teaching science improves if they teach the science curriculum to their own class, supported by a knowledgeable science leader. If the science leader really champions the subject, class teachers benefit. Providing good quality science-specific continuing professional development (CPD) opportunities for all teachers and teaching assistants is also important.

Teachers can inspire their children, letting them see that it is good to be skilled in a number of different areas rather than just being good at one thing, and that it is important to develop a range of skills upon which to draw. Children begin to see the bearing that science has on other things that they are learning, as well as the real-life application of science. Equally, lessons with a scientific focus can also include real opportunities to develop literacy and numeracy skills. In addition, headteachers said that it is a powerful message for children to see all of their teachers enthused and excited about science.

Schools said that children's enjoyment and immersion in science are always extended by their involvement in extracurricular activities relating to science. In this research, extracurricular science activities were more commonly described in schools using the science leader model.

Finally, requiring all class teachers to be responsible for their own science teaching allows for more flexibility in the timetable. Science investigations can take time, and can often take longer than anticipated, so to have to end a lesson by a particular time due to the availability of a science teacher is a limitation that does not necessarily apply when using the class teacher model.

¹³ Headteacher, in study interviews.

The disadvantages of the class teacher model

Schools reported that there are instances when the lack of science expertise means that teachers may encounter topics that they do not know in sufficient depth, or investigations or experiments that they have never had to teach before. Not having a science teacher to go to for advice or support can be a disadvantage and requires staff to look beyond their own school. In addition, it may be true that in schools lacking expertise there are fewer practical lessons taking place, due to a lack of confidence among teaching staff.

Headteachers felt that there is more potential to take children's science learning to a higher level when the subject is led by a science teacher, as the added knowledge may enable more challenging topics or approaches to be tackled.

The benefits of the science teacher model

While no school was able to produce data to support this assertion, some schools suggested that the use of a science teacher might contribute to better outcomes for their learners. This theory is based on the fact that someone who teaches all science lessons within a school will know: all the pupils and how well they are doing in science; what they have been learning; and how best they learn. A science teacher is able to track and respond to all pupils from their start at primary school right through to the end of Year 6, potentially maximising their chances of progress. Schools said that it is easier within this model to gather and monitor data on attainment and achievement, as science is taught and assessed separately from the rest of the curriculum. Schools did not claim that the quality of their children's learning in science is directly linked to the science teacher model. However, they suggested that children are enabled to make more progress, since their science teacher remains constant throughout their primary schooling, adding continuity to their science lessons and increasing the opportunities for personalised science learning.

Where a school uses a science teacher for Years 5 or 6 there are potentially more opportunities to tackle harder and higher-level topics, pushing learners towards understanding more complicated concepts and trying more complex investigations (due to the specialist knowledge of the teacher). A science teacher may also have fewer constraints on how they teach science due to their training. Schools said that when children engage with their science teacher, they demonstrate a really good understanding of the way science works. The children engage well with investigations, have good enquiring minds and are keen to learn new things. The way that children talk about science indicates their high level of enjoyment of the subject.

A science teacher can assist children to make the transition into Key Stage 3 (KS3), where they may be working with a different teacher for each subject they study. Thus, a science teacher can help to prepare children for the secondary school way of working.

Schools said that where they use a science teacher, other class teachers are not demotivated by the fact that they do not teach science: instead they recognise that it is the science teacher's passion and area of expertise.

Science may be better protected within the timetable when a school uses a science teacher, as the subject is taught on designated days and cannot be squeezed out due to other curriculum pressures. In addition, it can help with the scheduling of other teachers' PPA time: if a separate teacher is available to teach the same subject to all classes throughout the week, this releases class teachers for their preparation time.

The disadvantages of the science teacher model

Most schools said that they prefer to use a creative, cross-curricular approach to teaching, based upon topics. A new topic is usually selected each term, or each half term, and as far as possible all subjects are

taught around the topic. Having science taught by a separate teacher at designated times makes it harder for science to be integrated into the overall curriculum in the same way.

Furthermore, when science is taught in allocated timeslots the science teacher is given limited time with the children each week. When their time is up, they have to stop what they are doing: investigations cannot be as fluid and flexible as when they are being taught by the usual class teacher. Science becomes something that is taught only once a week and momentum may be lost between those weekly sessions, something a class teacher can avoid by weaving science into other lessons during the week.

The science teacher model creates succession-planning problems for the school. When the science teacher leaves or is absent from school for any length of time, it can be difficult to find a like-for-like replacement, since science skills are so rare at primary level. In addition, schools find that they can lose more than just the teaching if the science teacher moves on: any extracurricular science clubs, activities or projects may have to end if they are dependent on the specialist knowledge of the science teacher. One school said that it had been taking part in the Eco-Schools¹⁴ programme, but as its science teacher had been leading and championing it, when she left the school its involvement in Eco-Schools came to an end too, as the science teacher took all the expertise with her.

Some schools said that they would never consider employing a single person to teach all science for fear of de-skilling the rest of their teaching staff. They are conscious of their teachers' future career paths, and perceive the non-teaching of science as something that could set their teachers at a disadvantage when they are looking for their next role. Given the pace of change in science, it could make having to teach the subject again after a period of not having done so highly challenging.

A further disadvantage of the science teacher model cited by schools is that where just one teacher is responsible for all the science teaching in a school, there are fewer (if any) opportunities for moderation, and there is not the same culture of 'holding each other to account' that primary school staff build for other areas of the curriculum.

iv. What would improve the way that schools lead science and maths?

Schools were asked to articulate what would improve the way they lead science and maths. The questions were asked independently, but the answers were strikingly similar (as demonstrated by Figures 4 and 5) and reflect recommendations arising from other research¹⁵.

In both subjects, schools said that their biggest need is CPD that is current, cutting-edge, accessible and affordable, but most importantly subject-specific. Likewise, they said that the subject knowledge of their teaching staff needs to improve, and that this is closely linked with a need for better CPD. The survey data show that schools engage in CPD, but that most is obtained through local authority provision (Appendix 6).

Similarly, there is a need for better resources for both subjects, matched closely by a need for increased budgets to enable them. Teachers recognise that they need time to lead their subjects; nearly every science leader or science teacher said that they do not get any additional release time (beyond that which every class teacher is allocated in PPA time) to carry out their leadership role.

¹⁴ www.eco-schools.org.uk

¹⁵ http://www.score-education.org/media/11808/score_resourcing_primary.pdf

Figure 4. What would improve science teaching and learning in your school?

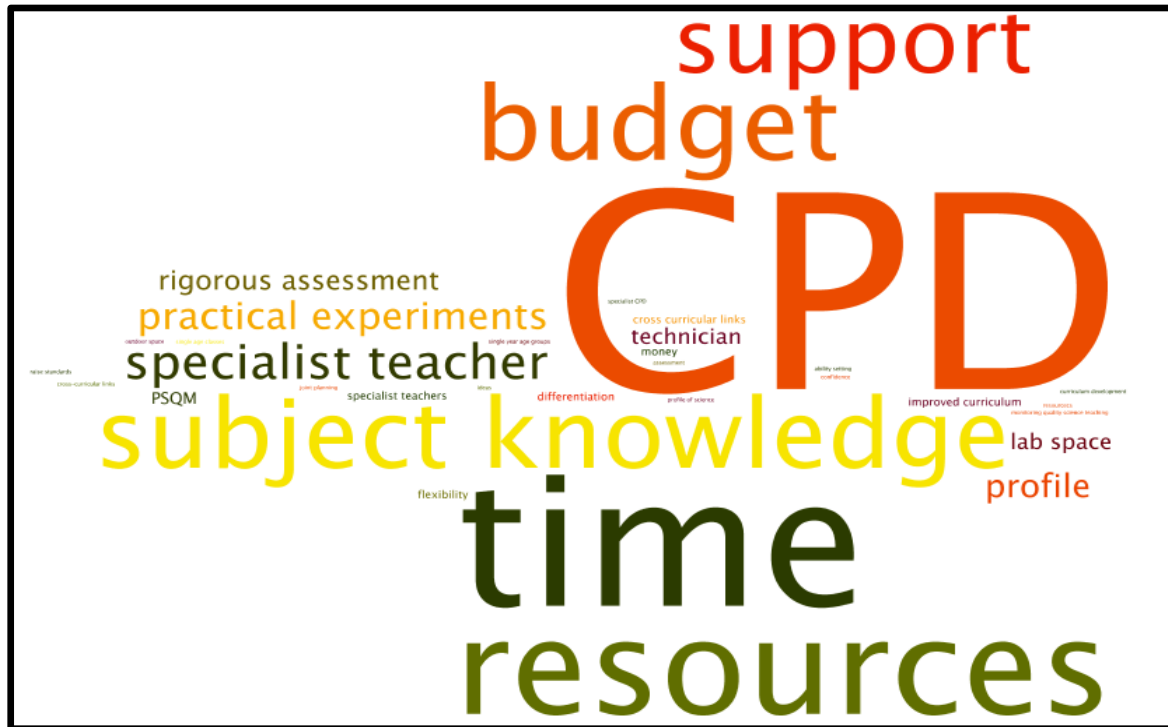
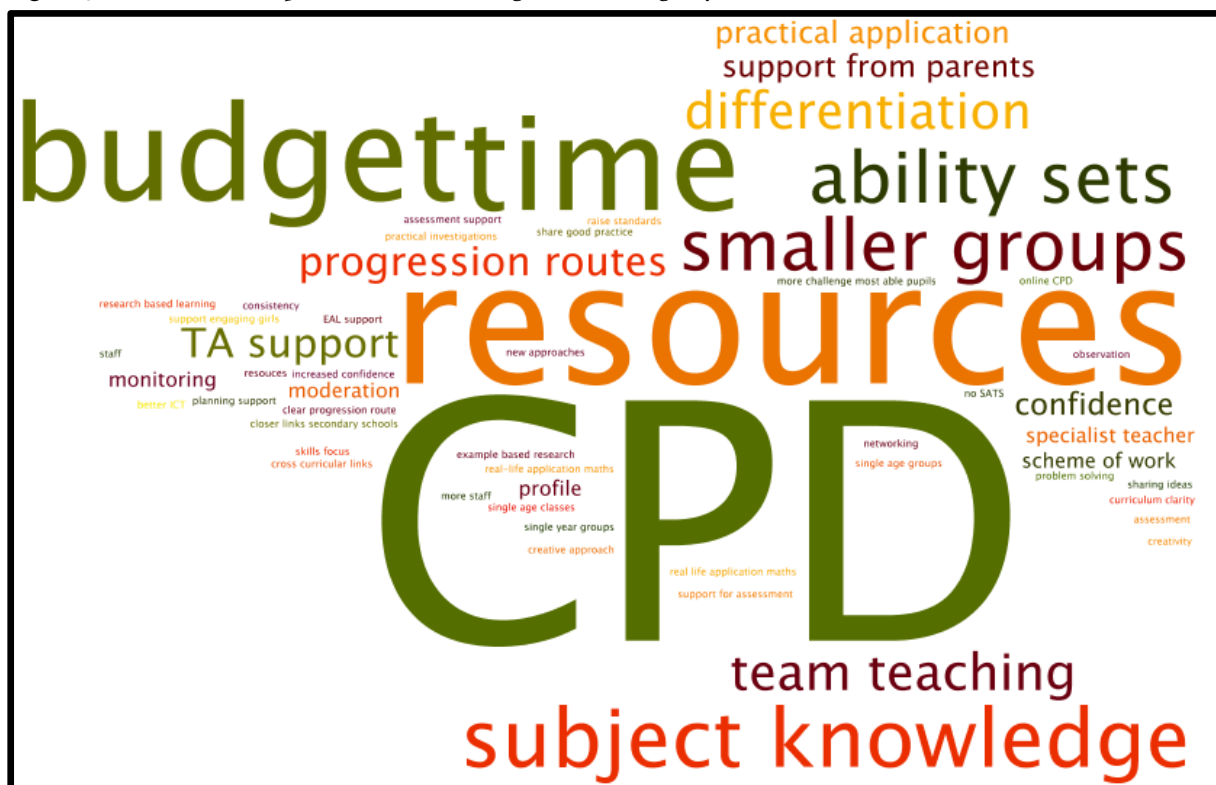


Figure 5. What would improve maths teaching and learning in your school?



Note: Word clouds do not attribute statistical significance; they only represent frequency. The font size of a word is proportional to how frequently the word was used in reply to the question.

For both maths and science schools said that their subject leaders need additional support, whether in the form of extra staff (such as teaching assistants in maths or lab technicians in science), from their SLTs (to enable them to better lead their subjects, by facilitating leadership time, providing more space or resources, or prioritising strategic direction) or from parents (to help champion their respective subjects beyond the school day).

Many science subject leaders said that they would benefit from having a science teacher on their staff, something that maths teachers echoed, but to a lesser degree. Maths leaders were more interested in increasing opportunities to differentiate: by reducing class or group sizes and by making better use of ability sets.

v. So where does this leave schools?

Only one school said that it would change its model of science leadership if it had the budget to do so; the school currently uses the class teacher model, but would use a qualified science teacher if it were able to afford one. This school felt that while its class teachers are all highly skilled, there is a gap in their understanding of more sophisticated science topics (which is required in order to deal with the children's increasingly demanding and complex questions). The school said that it can identify limits to its pupils' science education when the children reach the limits of the class teacher's knowledge.

Most schools said that if money, resources and time were no object, then they would probably opt for something of a hybrid model. They would be keen to hold onto the principles of the subject leader approach, whereby an individual – either alone, or ideally supported by a deputy, or even a team – takes responsibility for developing science in the school. Each class teacher would still teach science lessons to their children, and science would be integrated into the rest of the curriculum in creative and spontaneous ways. But, the schools felt that they would benefit greatly from having a science teacher on their staff (possibly to take the role of the subject leader, or at least to be part of the team) who would be available as a source of expertise for all class teachers and children. This 'expert' would challenge (but also support) teachers to attempt more complicated or larger-scale experiments, or lead science-specific CPD for all staff.

7. Case studies

i. Case study 1: Scientist-in-residence model

School profile

The school is a community primary school, located in a semi-rural village, with 340 children aged four to eleven. It is two-form entry with single-age class sizes of 22 to 26 pupils, although there are three mixed year group classes for Years 5 and 6. All lessons are taught in those classes, apart from maths, when children are divided into ability sets.

Science delivery and leadership model in brief

The school uses the class teacher model for its science teaching and also has a Lab₁₃, staffed by a full-time scientist-in-residence on site. The science leader is an outstanding teacher, who has a science degree and who previously worked in the science industry. She is also a Key Stage leader. She has responsibility for the way that science is taught in the school, as most science lessons are taught by class teachers (though some are taught in conjunction with the scientist-in-residence).

The scientist-in-residence is based in the school's converted laboratory space full-time, and is available for the children to come and speak to and work with throughout the school week. She is line-managed by the science leader, but her work in the lab is led by a committee of eight children from Years 5 and 6.

The science leader's role

The science leader's role is a fairly broad one. She is responsible for setting the strategic direction for science within the school: deciding upon the curriculum and how science will be taught. The school uses a cross-curricular approach for most subjects, and topics are selected for each six- or seven-week period. As far as possible, the science leader is responsible for fitting the science curriculum into these topics, though individual lesson plans are created by each class teacher, using a child-led approach (more of which below). Sometimes the topics support the science requirements, but sometimes science lessons need to be taught on a stand-alone basis. Science lessons are as practical as possible, and make use of the extensive outdoor learning spaces available, as well as the lab. Science is taught for two afternoons a week across the whole school, but every now and then the school has a week off-curriculum dedicated to science: all other subjects are woven in to a scientific topic. For example, in a topic about forensics, learning ranged from fingerprinting to writing news reports.

The science leader is also responsible for monitoring the quality of science teaching and learning, though more formal arrangements are in place with the senior leadership team for performance management purposes. This monitoring is done via a range of activities, including informal observations. The science leader monitors class teachers' science planning, reviewing their termly and unit plans regularly. There is a science display board (monitored by the science leader) where each year group shares some of its science work each week, so as to give the rest of the school a flavour of the range of activities being completed and the coverage of the science curriculum. The science leader also conducts learning walks, interviews children, and issues surveys to her colleagues to obtain their views about how science is being taught and to look for training needs.

The science leader places great emphasis on science-specific continuing professional development (CPD) and delivers most of the CPD needed by her colleagues herself. She has undertaken courses on how to

extend the role of the science leader, and makes regular use of courses provided by the network of Science Learning Centres. She also delivers CPD in partnership with the scientist-in-residence to clusters of local schools and the local university.

The science leader is very active in science-based networking; she has good working links with science leaders in other primary schools (who often send groups of children to work in the lab space) and secondary schools (who invite the school's children to come and try out lessons in their science spaces, working with older students).

The science leader has overall responsibility for Lab_13, managing the space and overseeing the committee from a distance, although the detail of this work is left to the scientist-in-residence.

The role of the scientist-in-residence

The scientist-in-residence has a degree in environmental biotechnology, a Master's degree in sustainable biotechnology, and was working within a lab environment before joining the school. She was recruited by the children in the school (who wrote her job description, shortlisted applicants and interviewed candidates before making their selection) and has her work directed by the Lab_13 committee.

Children are encouraged to access the lab before, during and after school, and to post science-based questions on a dedicated wall in the lab. The scientist then reviews the questions and designs activities and experiments to help the children to find out the answers. Children are encouraged to bring in things they find at home or in their gardens to stimulate discussions or experiments. No question is deemed too difficult: the scientist frequently has to admit to not knowing the answer to a child's question, and they will then work together to find it, thus demonstrating to the children what being a scientist is like in real life!

One of the key principles of the lab, and a priority for the scientist-in-residence, is to share the message that science is not a subject reserved for the most academically able, but rather that it is something that is accessible, relevant and real for every child in the school. She also takes responsibility for much of the extracurricular science that happens in the school, running a range of after-school, weekend and holiday clubs.

Networking forms a large part of the scientist's remit outside of her lab duties: she works closely with external organisations, local universities, subject associations, industry and the local community to find opportunities to expose the children to even more scientific opportunities. She runs CPD sessions with the science leader for her colleagues and for other schools. She also regularly takes groups of children to the local university both to give presentations to undergraduate students and to listen to lectures.

The role of the children and the Lab_13 committee

Science is child-led and child-centred in this school. While the teachers (led by the science leader) determine the topics to be studied, they invite the children to influence how each topic is taught by asking them what they would like to learn about within each subject. The class teacher then plans lessons guided by these questions.

Positions on the Lab_13 committee are really sought after. Students sit on the committee for a maximum of two terms and select new members via a rigorous application process based on applicants' willingness to get involved and the skills that they can bring to the lab. Committee members commit to attending weekly meetings, for which they set the agenda and write the minutes. They also each take on a role, such as looking after the Lab_13 blog, monitoring resources in the lab, writing press releases for local newsletters, or

organising competitions or fundraising activities. If any child on the committee does not take their responsibilities seriously they can be given a warning by their fellow committee members and removed from their post if they do not improve.

Impact

Children in this school said that they love science and that it is their favourite subject. They love the hands-on nature of the subject and the opportunities to really get involved in big, practical experiments using scientific equipment. The children said that before the school was using the Lab_13 model science was 'boring' and they were always sitting at their desks. In contrast, they are now excited about their science lessons and often try things out at home with their parents.

The children are inspired by being surrounded by adults who are passionate about science: from their class teachers to the science leader, the headteacher and the scientist-in-residence – and this enthusiasm spreads. The school is located in an area where most parents are unlikely to have stayed in full-time education beyond the age of 16 and few have science-related careers. However, science is now well-embedded in the wider community of the school, and parents frequently get involved: the Saturday dads' club is really well-attended, with one parent reportedly sneaking out of work to attend!

ii. Case study 2: Class teacher model

School profile

This two-form entry school is a recently converted primary academy with 510 children on roll, aged three to eleven. Children are taught in single age group classes. Science is led by a Year 6 class teacher, supported by a team of colleagues.

Science delivery and leadership model in brief

The school has always used the class teacher model, and does so for most other subjects, though the detail of the science leader's role has changed over recent years. There are sufficient teachers to ensure that each core subject leader is supported by a team of colleagues. The science leader is supported by two other teachers, and they all have science degrees. This model is designed to make succession planning easier for the school: by working in subject teams, there is always more than one person capable of taking over should staffing arrangements change. Furthermore, there is an increased sense of collective responsibility in making science teaching excellent.

In previous years, the science leader also taught science to all children in Years 3 and 4, but her focus has shifted to ensuring that all class teachers are confident and able to teach high-quality science to their classes themselves. There is a big emphasis upon science-specific CPD to improve class teachers' subject knowledge, model excellent science teaching and provide support to colleagues where it is needed.

The role of the science leader

The science leader's role begins with the creation of an annual development plan for science, which includes a set of objectives for the whole school to meet that academic year. Objectives are shared with the staff at regular meetings so that a clear direction is set.

Ensuring that each class teacher has the best subject knowledge possible is the priority for the science leader. It is important to try and guarantee that lessons are of the highest quality and challenge the children's learning, as well as to help teachers respond to unexpected difficult questions that their pupils might ask. This is achieved via a number of mechanisms.

The science leader regularly offers demonstration lessons to other class teachers, covering areas of the curriculum that they may not be as confident in teaching or showing them how to use new pieces of equipment, such as digital microscopes. There are also lots of opportunities for team teaching, whereby the science leader comes into other class teachers' lessons to jointly deliver a topic or a complicated investigation. The science leader is available to deliver specific bespoke training sessions to her colleagues when they ask for help, and there are coaching arrangements in place to support any teacher struggling with an aspect of their science teaching.

The science leader spends a lot of time monitoring the quality of the science teaching taking place across the school. Much of this monitoring is informal and done in a non-threatening way, via lesson observations, book scrutinies and sending questionnaires to teachers and parents each year. The science leader reports regularly to the senior management team and governing body on what this monitoring reveals, and feeds her findings into the next set of objectives for the science development plan. The school uses the Primary School Quality Mark (PSQM)¹⁶ gold level as the benchmark against which to self-assess the quality of its science provision because PSQM is a framework supported by the subject associations.

Lesson planning is collaborative. As an academy the school does not have to deliver the national curriculum, but it does loosely base its curriculum on the Qualifications and Curriculum Authority scheme of work¹⁷, with an increased focus on investigative science. Where class teachers wish to deviate from this they are able to do so, so long as they can justify to the science leader why the deviation is necessary and that their plans will work. As the school is two-form entry, for each year group the two class teachers and their teaching assistants work together to plan the lessons they will deliver. The idea is not to end up with all children in any given year doing exactly the same lessons, but rather to share ideas, resources and methods to encourage creativity.

The science leader also leads the monitoring of science learning and achievement. The way that assessment for learning is used is discussed at staff meetings, and each class teacher uses as varied a set of assessment methods as possible. Children are encouraged to self-assess and peer-assess, supporting each other and discussing how they have responded to a particular learning objective, or to assess their own work alongside a teaching assistant or their class teacher. The school does not use formal tests to monitor achievement, preferring to use tools like concept cartoons, for instance, which children are given after completing a section of work to encourage discussion. The teachers listen to what is said and the quality of the scientific language the children use, and look for any misconceptions, which will then be considered in future lessons.

There is a good range of extracurricular activity available. There has been a science club running for the past ten years, and more recently an environmental club (named 'Our World' by the children). The children are responsible for a small woodland area, which they have extended by planting trees and a native species hedgerow, an orchard, from which they harvest their own fruit, and a nursery garden, with herbs and vegetables that the older children help the younger children to maintain. The science leader regularly invites in external speakers and arranges competitions with a science focus. Each term she also runs a scheme where each class votes for a 'science star' for the child who has shown the most interest in (or has done something exciting in) science, who is then rewarded in a special termly science assembly.

¹⁶ <http://www.psqm.org.uk>

¹⁷ <http://webarchive.nationalarchives.gov.uk/20090608182316/http://standards.dfes.gov.uk/schemes2/science/?view=get>

Networking is also really important. The science leader communicates regularly with parents, sending out newsletters and questionnaires gauging and encouraging involvement in science at home. She also works closely with the Geographical Association¹⁸ as there is crossover between the two subjects, and is hoping to develop similar links with the Association for Science Education¹⁹. There is a science hub run by the local university in which she is very actively involved, and which invited her to deliver a course to postgraduates on the role of the science coordinator (or leader) in primary schools.

Other class teachers

Class teachers have a good working relationship with the science leader; she is very approachable and open to new ideas and suggestions. Class teachers said that they benefit from the quality of the science-based CPD that the science leader delivers, and they actively participate in science-themed staff meetings when they are scheduled. The flexibility that is encouraged around the science curriculum allows class teachers to respond to their children's interests. For example, when a group of children suggested learning more about meerkats, their class teacher worked with the science leader to find local opportunities to see some real meerkats and to develop lessons focusing on their habitat, diet and behaviours.

Impact

Science has a high profile in the school. It is well-led, and features regularly in whole-school assemblies and around the school on wall displays. The school's location lends itself well to taking advantage of local science-based opportunities, as it is situated between a hospital and a large car production plant, and it is this local context that acts as a driver for the school to promote science and technology so prominently.

Children tell their teachers that they enjoy science, and they respond particularly well to getting involved in messy practical experiments. Their enthusiasm is visible in the way that they take part in the extracurricular activities going on, and their scientific knowledge and skills are demonstrated by the way that they talk about what they are learning. Teachers look for evidence of a love, passion and curiosity for science in their children, and prioritise this over more formal testing, which the school feels does not do justice to the children's knowledge and skills.

iii. Case study 3: Science teacher model

School profile

This school is a small voluntary-aided primary school, located in a rural village. There are 70 pupils taught in three mixed-year-group classes. The recently built premises were designed with an emphasis on being eco-friendly and feature high levels of insulation, a sedum roof and a biomass boiler for heating. The school grounds have a forest to play in, a large organic vegetable garden that is looked after by the children, and a musical woodland!

The children are arranged into three classes: Reception and Year 1; Years 2, 3 and half of Year 4; and the remainder of Year 4 and Years 5 and 6. The children in Year 4 are split by their readiness and ability to cope with the highest age class.

¹⁸ www.geography.org.uk

¹⁹ www.ase.org.uk

Science delivery and leadership model in brief

Science is led by a part-time science teacher, who teaches science to all children from Year 2 to Year 6, and who also teaches music to all classes. She also maintains the school garden. The teacher for the Reception–Year 1 class teaches science to her children, and runs the forest school²⁰.

The model selected for science delivery and leadership has been in place for a long time. In such a small school there are only five teaching members of staff, of whom three work part-time. The rationale for using one teacher to teach the large majority of the science in the school is based on the practicalities of timetabling the work of the five teachers. The model accommodates the availability of those who are part-time, enables the teaching headteacher to have management time away from her class, and makes the best use of the skills of each member of staff.

Science has a high profile: the school is passionate about sustainable development, and believes that children should develop an understanding of what it means along with their social awareness. Staff are only recruited if they share these values – this is as important as their ability to be an excellent class teacher.

The role of the science teacher

The school uses a predominantly subject-based (as opposed to topic-based) curriculum, and science is mostly taught in discrete lessons. Ad hoc links are made across the curriculum, but given that all science (from Year 2 upwards) is taught by a specialist teacher, it is hard to deliver a truly cross-curricular approach.

The whole-school development plan is written jointly. Any science input is led by the science teacher, who is on the school leadership team. She is also responsible for ensuring that elements of sustainability feature in other subjects, and has, for example, championed the school's participation in the Eco-Schools²¹ programme.

Lesson planning is based on a topic plan that is worked through on a three-year rolling basis, in order to cater to the mixed-year-group and split-year-group class structure, to ensure that no child has to repeat topics. Individual lessons are designed by the person required to teach them. Every Wednesday afternoon the three classes rotate between taking part in the forest school, working in the school's vegetable garden and going swimming.

The science teacher works closely with parents. Each term she sends out a précis of what each class will cover in their science lessons, and the older class is set homework every week that often involves parents. The science teacher speaks informally with parents daily at the school gates, and also runs curriculum evenings where parents are invited to see how specific things are taught in science. In addition, there is a link science governor who works with the science teacher to monitor the quality of science in the school.

There is little call for demonstration lessons or team teaching in this school, since there are only two people teaching science. However, the Reception–Year 1 teacher sometimes observes the science teacher's lessons (and vice versa), as do any newly qualified teachers joining the school. Formal observations of science lessons are conducted periodically by the headteacher.

The science teacher has completed a number of science-specific training courses provided by the network of Science Learning Centres, which have been particularly valuable since the primary science adviser in the

²⁰ <http://www.forestschools.com/>

²¹ <http://www.eco-schools.org/>

local authority ceased to be funded. The science teacher organises staff training sessions as a result of the science-specific courses she has completed, though these sessions are more to share cross-curricular or pedagogical messages than to improve other people's science knowledge. The science teacher has also applied for Science Learning Centre ENTHUSE Awards²² to fund science-specific training for the school's teaching assistants to further their curriculum knowledge.

Impact

While the school acknowledges that it is not possible to evidence the direct impact of using a science teacher on its science results (particularly since the end of formal testing), its staff offer anecdotal evidence to suggest that the model is effective. Children seem to have a good understanding of the way that science works and are really enthused about taking part in practical activities. They particularly benefit from the forest school and gardening sessions, and the impacts of these are visible across the curriculum: many children choose to write about these activities in their literacy lessons. Furthermore, taking part in the forest school requires that the teachers take measured risks with the children (such as teaching them how to use a penknife safely), which in turn have benefits for the children's behaviour.

Since only two people teach science in this school, there are lots of opportunities for the science teacher to take ownership of the curriculum and the way that science is taught. Her participation in courses at the Science Learning Centres counteracts the relative sense of isolation she experiences in being the main teacher of science at her school, as the courses provide networking and idea-sharing opportunities.

The science teacher acknowledges that she may not experience as much of a challenge in the way that she leads the subject as she might in a school where all teachers teach it, but the close working relationships she has with the rest of the teaching staff reiterate the supportive culture and ethos of the school.

The school has identified a possible disadvantage to its science teaching arrangements in terms of its future succession planning. The school admits that it will be hard to replace the science teacher with someone who is similarly qualified and experienced if the need arises, though this issue is not limited to her role. The small staff means that it is not possible to have understudies, and makes it hard to train people up (as they all have their own additional responsibilities), but the school makes a big effort to share science learning and responsibility where possible – something that has worked well with its participation in Eco-Schools. This project has enabled all staff and children to think about the environment and to consider their responsibilities towards their community and resources. The staff work hard to ensure that actions in school (such as the disposal of waste, for example) match what is being taught across the curriculum; children are taught not only that they should recycle, but to consider the reasons why, and the effects their behaviour has on the wider world.

²² <https://www.sciencelearningcentres.org.uk/about/bursaries/enthuse-awards/>

Appendix 1: The survey data in more detail

Who completed the survey?

The large majority of respondents came from primary schools (163), with a further 19 junior schools, 11 infant schools, 5 first schools, 2 junior high schools, 4 middle schools and 5 other schools being involved.

Most of the respondents labelled themselves as community schools (111), while 66 said that they are either voluntary-aided or voluntary-controlled. There were 23 responses from academies, 2 from free schools and 1 from an independent school.

There was a good spread in terms of the number of pupils on roll among respondents: just over 30 per cent of respondents were from schools that have between 200 and 299 pupils on roll; 27 per cent have over 400 pupils; and 21 per cent have between 100 and 199 pupils. Around 12 per cent of schools have between 300 and 399 pupils on roll, while the remaining 10 per cent have fewer than 100 learners.

The large majority of respondents stated that their pupils are taught in single age group classes (65 per cent), and equal numbers of schools have mixed age group classes or a combination of single and mixed age group classes (17.5 per cent in each case).

How are science and maths led and taught?

Who leads science or maths?	Percentage leading science	Percentage leading maths
Headteacher	5	13
Head of school	1	0
Deputy headteacher	6	16
Assistant headteacher	5	7
Advanced skills teacher	2	4
Full-time teacher	67	52
Part-time teacher	14	8

Year group taught by subject leader	Science leader (percentage)	Maths leader (percentage)
Foundation stage / Reception	6.3	6.6
1	9.8	4.9
2	9.5	13.2
3	14.7	10.5
4	19.7	15.5
5	18.7	16.4
6	19.0	30.6
None	1.9	2.3

Most respondents stated that a full-time teacher is their science or maths subject leader. A headteacher tends to take the role of maths or science subject leader when a school is small, often with 100 pupils or fewer.

Where full- or part-time teachers lead science or maths, they are spread across different year groups.

How pupils are taught maths or science (as a percentage of respondents, rounded to nearest whole number)	Science		Maths	
	KS1	KS2	KS1	KS2
Mixed ability taught by class teacher	95	87	79	55
Mixed ability taught by specific teacher of maths or science	1	6	0	0
Classes streamed into ability sets, taught by class teachers	2	3	13	29
A mixture of above options	2	4	8	16

Just one school uses a science teacher in Key Stage 1 (KS1), whereas no school relies on a maths teacher to deliver all maths lessons. Ability setting is uncommon in science compared with maths.

What subject qualifications do leaders have?

It is clear that the highest science qualifications described by many respondents in this survey are teaching degrees with a science element. Thirteen respondents (6 per cent) clearly indicated that they have a specific science degree. In 41 schools (20 per cent) the highest science qualification the science leader holds is A level science, and 35 (17 per cent) said that their science leader has no science qualifications above GCSE science.

Nearly 12 per cent (25) of respondents have achieved or are working towards the Maths Specialist Teacher qualification. Eighteen per cent (37) of maths leaders' highest maths-related qualification is at A level and 22 per cent (47) of maths leaders only have GCSE maths.

Specialist science teaching: who uses this model?

Only one school out of the 209 surveyed stated that it uses a science teacher for all science teaching, and a further ten schools that said that they use a science teacher for all KS2 science teaching.

The profile of the schools using a science teacher can be summarised as follows:

- Nine (82 per cent) are primary schools, two are middle schools and one a junior high school
- Five (45 per cent) are community schools, five (45 per cent) are voluntary-aided schools and one (10 per cent) is an academy converter school
- Five (45 per cent) have fewer than 100 pupils on roll, and three (27 per cent) have over 400 pupils
- Five (73 per cent) use mixed age group classes
- Six (55 per cent) use a full-time teacher to lead science, and the remaining five (45 per cent) use a part-time teacher
- Six (55 per cent) use a member of the senior leadership team to lead maths.

Appendix 2: Interview respondents: profile

In-depth telephone interviews were conducted with 21 schools. These schools can be broken down as follows:

a) Location

East	East Midlands	London	North-east	North-west	South-east	South-west	West Midlands	Yorkshire
2	1	4	0	2	3	3	3	3

b) School type

Foundation primary	Community primary	Voluntary-aided primary	Community junior	Independent	Academy
1	10	6	1	2	1

c) Number on roll

Under 100	101-200	201-300	301-400	400+
4	4	5	1	7

d) Class arrangements

Single year groups	Mixed year groups	Combination of mixed and single year groups
10	5	6

Appendix 3: Subject leader deployment matrix sample

SCIENCE: DEPLOYMENT MODEL MATRIX	teach specialist science lessons	teach demonstration science lessons	teaching outside of your school	team teaching	coaching colleagues	monitoring quality of teaching	monitoring learning & achievement	strategic development of science	curriculum development	resource development	liaison with governors	liaison with parents
SCHOOL NAME (for our ref)												
MODEL USED												
RESPONSIBLE FOR												
(answer yes/no)												
DETAILS												
(describe how this takes place/ what it involves)												
IF NOT YOU, WHO DOES THIS?												
(name appropriate member(s) of staff)												
LIAISE MOST CLOSELY WITH												
(list others involved in task)												
RESPONSIBLE FOR	resource mgt	budget holder	enrichment activities: planning	enrichment activities: delivery	networking: with relevant science bodies/companies	networking with other schools	reporting to SLT	assessment methodology	workforce development: subject specific CPD	workforce development: career progression	workforce development: performance management	OTHER
(answer yes/no)												
DETAILS												
(describe how this takes place/ what it involves)												
IF NOT YOU, WHO DOES THIS?												
(name appropriate member(s) of staff)												
LIAISE MOST CLOSELY WITH												
(list others involved in task)												

Appendix 4: Online survey data: science and maths leaders' responsibilities compared

The table below compares how frequently science and maths leaders said that they have to undertake specific tasks as part of their subject leadership role. It then highlights where there are statistically significant differences between the two roles.

	Science leader (percentage)	Maths leader (percentage)	Significantly different? ²³
Teaching specialist lessons	22	23.5	No
Teaching demonstration lessons	28	36	No
Team teaching	28	27	No
Coaching colleagues	44	55	Yes
Supporting colleagues in continuing professional development (CPD)	72	70	No
Monitoring quality of teaching	66	81	Yes
Monitoring learning and achievement	74	84	Yes
Strategic development as member of senior leadership team (SLT)	31	57	Yes
Curriculum development	74	77	No
Liaising with governors	43	59	Yes
Parent Q&A sessions	9	46	Yes
Resource management	74	76	No
Budget holding	53	58	No
Running subject club	34	18	Yes
Networking with other schools	27	35	No
Other activities	9	7	No

²³ Significance determined using chi-squared test where $p \leq 0.03$.

Appendix 5: Summary of the advantages and disadvantages of different models for science leadership and delivery

Model	Advantages	Disadvantages
Class teacher model	<p>All teachers teach science, indicating that science is for everyone.</p> <p>Planning, teaching and moderation of assessment can be achieved jointly.</p> <p>Cross-curricular learning can be emphasised so that children see the relevance of science throughout their learning.</p> <p>Timetabling is flexible, allowing time for longer investigations.</p> <p>Accountability is shared.</p>	<p>Success depends upon the confidence and level of expertise of the science subject leader.</p> <p>There may be a lack of science expertise within the school that could limit: the breadth of curriculum; enrichment; understanding of, and progression through, challenging concepts; or working scientifically.</p> <p>Some teachers may lack confidence or have weaker subject knowledge, and this can impact on pupils' progress and attitudes to science.</p> <p>Continuing professional development (CPD) may be weaker if provided mostly by a science subject leader without a science background.</p> <p>In a cross-curricular topic approach, some aspects of science may not be developed well or there may be irregular timetabling of science.</p>
Science teacher model	<p>A high level of science expertise supports a broad curriculum, and ensures a good progression through concepts and a deeper understanding of working scientifically.</p> <p>Positive attitudes to science and good progress are more likely to be encouraged in pupils where there is high confidence in science teaching.</p> <p>Provides good preparation for the transition to Key Stage 3.</p> <p>High expertise may support good CPD delivery.</p> <p>Local networks of science teachers may provide wider resources, joint initiatives, or moderation of assessment.</p>	<p>Timetables are likely to be fixed, which might be limiting.</p> <p>Some teachers may feel de-skilled unless there is support to ensure that this does not happen (e.g. through additional whole-school science focus days or weeks where all staff are involved, or through science CPD or moderation tasks).</p> <p>A very high degree of liaison is required to ensure that cross-curricular links are supported.</p> <p>Accountability may rest with few individuals.</p> <p>Succession planning may be compromised; recruitment of a primary science teacher may be difficult.</p>

Appendix 6: Online survey data: percentage of schools participating in different forms of continuing professional development (CPD)

Type of CPD	Science	Maths
Accredited specialist course	6.7	21.6
Local authority training	48.1	63.9
National centre courses ²⁴	28.4	2.9
Local schools network	41.3	49.0
School-based bespoke training	28.4	43.3
Subject leader-led development	58.7	64.4
Online learning or e-learning	4.3	5.3
Action research	2.9	5.8
Mentoring or coaching	22.6	39.4
Other CPD	20.2	7.2

²⁴ For example, courses provided by the National Centre for Excellence in the Teaching of Mathematics or the National Science Learning Centre.

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