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The science content in primary Initial Teacher Training (ITT)

Version 1.0



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Foreword

Wellcome believes that science should be exciting for all young people, giving them skills and opportunities to improve their futures. We are working to transform primary science education so that every pupil has an excellent first experience of science.

Teachers are the greatest resource we have to ensure that every pupil experiences great science. Unfortunately data from our 2017 'State of the Nation' Report found that a quarter of primary teachers are concerned about answering pupils' questions about science and most UK schools average less than two hours science teaching each week^{1, 2}.

It is vital that all new entrants to primary teaching are well prepared to teach science.

This report describes research we commissioned to better understand initial teacher training (ITT) for primary science considering information from a range of providers and from recently trained teachers. We are pleased that there is a lot of consistency across the ITT routes for primary science but there are many opportunities to improve the offer.

The timeframe for all primary ITT courses is tight and so providers cannot cover all of the subject knowledge needed for science. More than two thirds of teachers in this research had not studied science beyond GCSE (or equivalent) and trainees are responsible for identifying and addressing gaps in their subject knowledge. ITT providers prioritise training on common misconceptions that pupils may develop.

Good guidance for trainees is essential to address weak subject knowledge and misconceptions about science.

Several ITT providers reported difficulties in ensuring that trainees taught science while on placement in schools, although other providers were able to do so. The 2016 National Standards recognise clearly the role of schools and school-based ITT mentors in ensuring that trainees

have the necessary experience to meet the Teachers' Standards³.

ITT providers should ensure that every trainee teaches primary science while on placement and observes excellent science teaching.

Teachers Standards⁴ require teachers to 'demonstrate good subject and curriculum knowledge', and be able to 'make accurate and productive use of assessment'. Teachers stated that they would like more ITT covering practical experiments and lesson ideas, assessment of science, and opportunities to observe excellent teaching. To some extent better subject knowledge, pedagogical content knowledge and a better understanding of how children progress their ideas in science would address these concerns. It is unlikely that the restricted ITT period would be able to cover all of the content necessary for primary science teaching. The case studies in our report highlight how some teachers have addressed these needs through ongoing professional development. However when science has low priority in school, it is hard for teachers to access the professional development they need.

ITT providers, schools and school mentors should guide trainees towards ongoing professional development in science to ensure that they are able to cover the necessary content in their early years in the profession.

All teachers should be participating in regular, science specific professional development tailored to their needs.

¹ Wellcome Trust. 'State of the Nation' report of UK primary science education. London: Wellcome Trust; 2017 <https://wellcome.ac.uk/sites/default/files/state-of-the-nation-report-of-uk-science-education.pdf>

² Two hours per week is also the international weekly average for primary science teaching in similar nations <http://timssandpirls.bc.edu/timss2015/international-results/timss-2015/science/student-achievement/>

³ Department for Education, National College for Teaching and Leadership National Standards for school-based initial teacher training (ITT) mentors. 2016 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/536891/Mentor_standards_report_Final.pdf

⁴ <https://www.gov.uk/government/publications/teachers-standards>

⁴ As 5 above

1. Summarised findings

This research compared the science content within the main training routes into primary teaching (BA and Bed, SCITT and PGCE) in England and Wales, combining information from training providers with testimony from qualified teachers.

It has revealed several themes.

- Not enough time is dedicated to science on ITT, across all routes.
- Within any science input, there is a strong focus on practical science.
- Ensuring their content knowledge is adequate is largely the responsibility of the trainees.
- ITT providers say that it is not possible to make science teaching mandatory for trainees due to time pressures and timetabling issues going on in schools.
- In contrast, teachers surveyed for this research do not complain that they lacked the opportunity to teach science while on school placements.
- Teachers would like more opportunities to observe good science teaching while on school placements.
- Teachers report that they did not feel suitably prepared to assess science and notably, providers made little reference to the assessment of science in describing their courses.

2. Introduction

Wellcome has a strong interest in science education and believes all young people should be confident, active and informed citizens in science with more progressing into science related careers.

In March 2017, Wellcome, along with a consortium of other organisations involved in science education⁵, agreed a description (see Appendix 1) of what is expected in respect of leading and teaching science in primary schools. The description recognises that a teacher new in their role may not meet all the expectations but should have a plan to develop the skills and knowledge required.

High quality ITT is vital to build teachers' confidence and prepare them to teach primary science well. But recent changes to teacher training provision in England presents both a real diversity in the nature of training, as well as challenges for trainees in deciding what would be the best route to prepare them for teaching. Research shows that many primary teachers do not have a background in science or may not identify with science themselves, so it is important that initial training prepares them well for their futures.

Wellcome commissioned this research to gain a better understanding of:

- the routes into primary teaching
- the range of training courses on offer
- how the courses prepare trainees to teach science
- the experience of trainees.

⁵ Association for Science Education (ASE), Campaign for Science and Engineering (CaSE), Institute of Physics, Institute of Engineering and Technology, Primary Science Quality Mark, Royal Society, Royal Society of Biology, Royal Society of Chemistry and Wellcome.

3. Methodology for this research

During the spring and summer terms in 2017, primary data was collected from two distinct sources:

- A range of ITT providers, who took part in focussed telephone interviews lasting up to 45 minutes.
- 85 primary school teachers, who qualified since 2013, completed an online survey and five participated in follow-up interviews providing case studies.

3.1. ITT providers

Fourteen different ITT providers engaged with this project, twelve of whom are in England, (six in the South East, three from the South West, two from the West Midlands and one from the North East) and two located in Wales. Each of the providers offers a range of routes into teaching. These include:

- Post Graduate Certificate in Education (PGCE): 10 institutions
- Bachelor of Education: 4 institutions
- Bachelor of Arts with Qualified Teacher Status (QTS): 2 institutions
- School Direct⁶: 6 institutions
- School Centred Initial Teacher Training (SCITT): 5 institutions

This profile is not representative of all ITT providers in the UK but reflects the different routes into teaching. ITT providers who took part, did so on a self-selecting basis.

3.2. Teachers

Teachers were recruited via a snowball sampling approach and as such should not be considered a representative sample of the teaching population. Teachers did not necessarily attend the ITT providers interviewed. A summary of the online survey data is appended to this report (Appendix 2). The survey was completed by 85 teachers who trained and qualified in the UK since 2013.

Follow-up interviews were conducted with five case study subjects – recently qualified teachers whose experiences differed – to offer first-hand accounts of their experiences of training to teach science and what it is like once they have qualified. Interviewees took part in the online survey and indicated that they were willing to participate in further research. A short list of candidates was then compiled based upon a spread of the routes into teaching and science qualifications to gain a wide range of views to be featured in the case studies.

⁶School Direct is the salaried version of the SCITT route into teaching. Provision on both courses is therefore very similar.

4. How teachers are prepared to teach science: ITT provider perspectives

4.1. Entry requirements for all routes into primary teaching

To access all primary ITT courses in England and Wales, students are most commonly required to have GCSE English, maths and science at grade C or above (or the equivalent). Two providers required their trainees to hold these qualifications at grade B or above, while one required a grade B for both English and maths, but a grade C for science. One institution looked for A level science (or the equivalent) for those taking a science specialism.

In addition, most PGCE providers looked for graduates with a 2:2 degree in any discipline (in combination with the aforementioned grade C GCSEs in science, maths and English). One PGCE provider required a degree at 2:1 level, while a PGCE offering a science specialism⁷ only accepted graduates who held a degree in a science-related or science subject.

One SCITT required trainees to have spent ten days in a school getting experience before they could apply to their ITT course.

4.2. Course details

4.2.1. PGCE course details: ten institutions

The PGCE is a university-based course, completed by post-graduates lasting one year. Across the 10 institutions interviewed for this research, the time dedicated to preparing trainees to teach science ranged from as little as 7.5 hours up to 39 hours over the course of the academic year⁸ based upon the way each provider chose to design their course. The university with the lowest science content runs three, two-hour taught sessions (of which only one was in a laboratory) and a final 1.5-hour session in a school. In comparison, the institution with the 39-hour science input provides 13 three-hour sessions.

When compared to the other core subjects of maths and English, science gets less teaching time in most institutions: only three out of the ten institutions allocated the same amount of course time to each of the three subjects. Most commonly, science would get 60% of the time that either maths or English was afforded and a number of ITT providers stated that this was not sufficient, but that the time restrictions did not allow for any alternative.

The science content is always taught by people who have a background in both teaching and science, whether that means they have a science degree or more commonly have led science in a primary or secondary school.

Subject knowledge is something that is both taught and that is left to the trainee teachers to deal with themselves. Two institutions described a “subject knowledge audit” for science that they run at the start of the year, which is designed to identify gaps in the trainees’ knowledge. One of these was based on SATs papers, while the other was based on the topics in the national curriculum.

⁷ This course awards a General primary (5-11 years) with Science qualification

⁸ Other responses included: 8 hours, 12 hours, 15 hours, 20 hours and 36 hours over the course of the year.

When pushed, providers listed the following topics as areas they would most frequently teach:

- Life processes
- Electricity
- Magnetism
- Light and sound
- Forces and motion
- Earth and beyond
- Materials
- Rocks and soils
- Evolution
- How things work

Where science content is taught, PGCE providers acknowledge that they are unable to cover the entire national curriculum as time does not allow for this. Further, they report, the emphasis in the curriculum is more on science-specific pedagogy and enquiry than on content. However, it is common for providers to base their selection of topics on two things: those things that trainee teachers struggle with (as identified by the audit exercise where it is used) and those things that children struggle to grasp, though no specific examples of these were provided.

Other factors that inform the selection of topics to cover include those where there are common misconceptions (both among teachers and children) and those that might boost the confidence of the trainee teachers. Where there are gaps that cannot be filled by taught input, trainees are sent away to research for themselves. Two providers require the trainees to complete another subject assessment at the end of the year to see if those gaps have been filled, though most do not appear to follow this up. Another, where trainees can select a science specialism, often encourages “micro-teaching”, whereby trainees each take a science topic and go away and teach it in groups of six to their peers.

All interviewed providers put a big emphasis on pedagogy and report that this takes the bulk of the science teaching time on their courses. Trainees are taught how to teach the national curriculum and how to encourage various approaches to science enquiry, which providers described as:

- fair testing
- observing over time
- identification and classifying
- pattern-seeking
- research using secondary sources

One provider made reference to assessment for learning, another includes scientific modelling and processes in their syllabus, another spends time demonstrating to students how they can use stories to teach science, while one includes sessions on social constructivism. All providers reported that they prioritise pedagogy over content.

There is a strong focus on practical science from all PGCE providers. Commonly, all taught sessions have some practical elements to them. Two providers out of the ten (neither of which offer a science specialism in their ITT) have a laboratory space for the students to use, but they were keen to stress that it is not too “high-tech”, as that would not replicate a primary classroom. Students are encouraged to look at practical activities from both the pupils’ and teachers’ perspectives. Activities are designed to contextualise science and to demonstrate the real-world applications of the concepts the students will be teaching. Students often carry out their own mini-investigations, trying out different ways to demonstrate something or conduct experiments.

Most providers said that they expected their students to teach science while on placements in a school, but that they cannot compel them to do so, as they rely on the schools facilitating this. There were two exceptions to this: one provider specifies that students must do a number of science-based activities each week, while another (on their science specialist course) said that science teaching was compulsory.

All PGCE providers check with their students after placements have finished to see what their student teachers had the chance to teach, including finding out how many people taught science and how many did not. Students are encouraged to reflect on their experiences of teaching topics as they come up in lectures.

Providers cited a number of barriers to their students being able to teach science. Timetabling was the most frequent: increasingly, schools are “block timetabling” subjects, so it may be possible that they are not teaching any science to their children during a student placement if it is not scheduled for that period. Providers described the increasing diversity among school types and their departure from the national curriculum making it harder to ensure students get the chance to teach science.

When asked about student attitudes to teaching science, PGCE providers said they find that their students are often wary of science at the start of the course (though our online survey revealed that confidence levels in English, maths and science were about the same for the teachers surveyed, with around two-thirds of respondents saying that they were either quite or very confident about each of the three subjects before they began their teacher training – see section 4.2 below). One said that their students would often miss science lectures, as they weren’t perceived to be important enough. In contrast, however, another provider explained how they require students to do an assignment on a recent issue and increasingly they are choosing to focus on science.

4.3. SCITT course details (five institutions)

The SCITT is a one-year course run by approved networks of schools. They provide practical, hands-on teacher training, delivered by experienced, practising teachers based in their own school or a school in their network. The lead school must be outstanding and there must be an accredited teacher training provider within the SCITT network. SCITTs are funded to deliver ITT.

The amount of time allocated to science in each of the five SCITT providers interviewed ranges from just 15 hours over the course of the year, to six full days (out of a potential 55 teaching days at this particular SCITT). Overall, this compared favourably with the amount of time dedicated to maths and English, with all but one SCITT offering the same number of hours or days for all three subjects. One SCITT provider delivers seven or eight days each of maths and English input, compared to six for science and just one day for foundation subjects, such as history.

All SCITTs reported that science input is delivered by science specialists, such as science education consultants or advanced skills teachers and, ideally, someone who is passionate about the subject and who has the knowledge to be able to teach the progression of ideas and the science content up to Key Stage 3.

Where a SCITT is co-located within an institution that also offers the PGCE route (two institutions), students will follow the same course, regardless of which route they are on. The remaining SCITTs described programmes which were a mixture of taught and self-taught input, where students would develop their subject knowledge over the year, with a bigger input on pedagogy and behaviour. Students are introduced to a range of approaches to teach science concepts, ways to support learning and to adapt their lessons for those who may need more support and techniques to encourage mastery and questioning.

Subject knowledge is dealt with in much the same way as on PGCE courses: knowledge audits are conducted at the start of the year and gaps are identified. Students are then directed to resources to improve their knowledge, or the course content is adapted to support them where their knowledge may not be strong enough. One SCITT emphasised the need to ensure that trainees are confident in understanding science up to Key Stage 3, to demonstrate the progression of knowledge as children get older. Misconceptions are dealt with by all SCITTs, with one making use of regular quizzes to check students’ understanding and another stressing the importance of good scientific vocabulary. When asked about the topics they selected to cover, the SCITTs listed the following (though this list should not be interpreted to be exhaustive but rather illustrative of the things covered):

- Materials
- Forces
- Magnets
- Electricity
- The living world
- Earth and space

Most SCITTs described their science sessions as being very practical, with lots of opportunities to try out resources, take part in experiments or outdoor learning activities. One SCITT, however, said that the sessions they run in their centre were focussed on content, while the students would get the chance to do practical science when they were in school (though they do make teaching science while in school compulsory for their students).

For the one SCITT that offers a science specialism, the additional activities trainees can participate in include self-led enquiries, observing science teaching outside of the SCITT, attending the Association for Science Education (ASE)⁹ conference, attending

⁹ www.ase.org.uk

extra sessions on assessment and medium-term planning, studying child development theories and preparing for science subject leadership.

There was a split between those SCITTs who said that they had no science-specific requirements for students on their placements and those who said that they set science-based tasks. Interestingly, there was no correlation between those SCITTs offering a science specialism and the ones that set science-specific requirements, including observing science lessons, designing activities and teaching a required number of lessons – covering both key stages. Those who do not set requirements said that this was based on not being able to control what happens in school, given the variety of time dedicated to science between schools.

4.4. University BA and BEd with Qualified Teacher Status (QTS): six providers

University Bachelor of Arts (BA) Primary Education and Bachelor of Education (BEd) with Qualified Teacher Status (QTS) courses are three years long and all were co-located with PGCE courses. The amount of time dedicated to science on a BA or BEd is considerably higher than on other routes, given their respective lengths. The minimum time cited by any of the six BA/BEd providers interviewed was 46 hours over the three years, rising to 75 hours in another¹⁰. The provider that offers 75 hours of science time also requires its trainees to select a specialism, one of which is science, which results in an additional 20-50 hours of science teaching time.

Three providers report that the profile of science is improving – having previously treated it as a foundation subject, it is more likely now to be considered to be core and is therefore treated equally with maths and English, while in the other three institutions, science has less teaching time than literacy and numeracy, but more than the foundation subjects¹¹.

Science input is taught by science subject specialists with teaching experience, where possible, though not always a primary expert (e.g. ex-secondary school science teachers). Science expertise could come from their own studies (in science or a related subject, such as geography), or having worked as a science coordinator in school. Some institutions said that they try and bring in experts with specialist knowledge, such as earth sciences, to run specific workshops (e.g. on rocks and soils), or relevant partners from other universities, external CPD agencies or local industry.

Being longer in duration than the SCITT or PGCE route, the science syllabus for both Bachelor courses can deal with topics or aspects of pedagogy in more depth and detail. The principles remain broadly the same: there is a strong emphasis on thinking scientifically and developing enquiry and there is some time allocated to subject knowledge though the responsibility for this is jointly shared with the students. The three-year course allows for more time to be spent on themes such as:

- sequential planning, for the short, medium and long-term
- assessment
- teaching for all and inclusion in science (including SEN and EAL)
- progression of knowledge and skills
- differentiation
- questioning
- misconceptions
- contextualisation and real-world connections
- outdoor learning
- science subject leadership
- constructivism

BA and BEd providers also make use of a subject knowledge audit at the start of their courses. The results of the audit are used to guide the topics that are covered in lectures and students are directed to appropriate research and resources to improve their knowledge where necessary. Topics are chosen from the national curriculum, intending to ensure that students are confident to teach them all to all key stages and consideration is also given to those topics that are tricky to teach to children (such as electricity and forces), based on trends from previous cohorts.

¹⁰ The institution offering 46 hours of science input breaks it down as follows: year one: 22 hours, year two: 16 hours and year three: 8 hours. Another offers 60 hours of science over the three years.

¹¹ In the English primary national curriculum, English, mathematics and science are legally deemed “core” subjects, while art and design, computing, design and technology, geography, history, music and physical education make up the “foundation” subjects.

The provider that offers a science specialism allocates between 20 and 50 additional hours to it. The course is designed to support students to go on to become “standout primary science teachers” or science subject leaders and awards them a BEd (Hons) Primary (Science). During these extra teaching hours, students conduct their own project on a subject they select themselves, working as scientists. They also go on additional field trips to see science in action and industry’s application of science.

All BA and BEd providers stress the importance of practical science on their courses and that it is integral to their sessions from the first day students start their degrees. They also report that they cover the five strands to scientific enquiry. Sessions consist of a good balance of theory and practical activities. Students must conduct their own enquiries and consider the theory behind why they might select a particular teaching approach, carry out the investigation and then reflect on their experiences. They are set “real” problems to solve and are shown how to contextualise the science they will be teaching.

There is a divide between those providers who set their students science-based requirements for their time on school placements (the majority) and those who say that stipulating that students do science is not possible. All those who do ask their students to carry out science-based activities include some of the following things in their requirements:

- teaching a specified amount of science – to groups and whole classes
- reflecting on their science teaching
- observing a set amount of science
- undertaking marking and feedback
- producing medium-term plans
- carrying out a “science through stories” project
- keeping a log of misconceptions

The provider that does not require their students to teach science explains that they are beholden to schools and their timetabling, so if their placement does not coincide with any scheduled science lessons, the students miss out on teaching it.

4.5. Observations: the three main training routes

This research has found that there are very few differences, beyond course length, between the three main routes into primary teaching. Indeed, there are several key commonalities:

- there is a feeling that there is insufficient time available to concentrate on science during their courses (versus other subjects, but especially English and maths)
- all routes prioritise pedagogy over subject knowledge, relying on students themselves to tackle any gaps they may have (such as those identified via a subject knowledge audit at the start of the course)
- practical science is important and most providers ensure that all sessions have some practical elements to them
- all routes aim to have science input to their courses delivered by people who have a science background to some extent

Where some providers of PGCE and Bachelor courses state that they can set compulsory science-specific activities for their students while they are on school placements (n=4), others say that they cannot (n=6). Given that schools are given a fee for hosting a trainee teacher and that they agree to do so at the start of a school year (thus providing plenty of time to plan science into a trainee’s timetable), there should be scope for the latter group of providers to challenge this. Indeed, the fact that there are providers who are able to stipulate that science teaching is undertaken on placement suggests that all ITT providers should be able to do so.

SCITT providers that report a similar message about not being able to compel their teachers to teach science while in school should also be able to challenge this. Schools that lead a SCITT must be outstanding and should thus offer a curriculum with breadth and depth, which gives due profile and space to teaching science.

The most notable difference that emerged between the three routes was one of time: providers of Bachelor courses can spend longer on all elements of science teaching, whether content knowledge or pedagogy, as their courses last for three years, as opposed to just one year for the other routes.

5. The teacher perspective

5.1. Profile of respondents

5.1.1. Science experience

Teachers completing the survey cannot be assumed to be representative of the UK. However, the data highlight that many teachers who have qualified since 2013 have only the minimum science qualification that is currently a statutory requirement for primary teaching in England and Wales. More than two thirds of respondents (68% / n=58) did not study science beyond GCSE or equivalent. A fifth of teachers surveyed (n=17 / 20%) studied one science at A Level (or equivalent), of whom most studied biology (n=14). Two teachers had a physics A level and just one had a chemistry A level. Seven teachers (8%) studied two science A Levels (biology and chemistry), while only three teachers (4%) studied all three sciences to A Level or equivalent.

Table 1 Science qualifications held by trainee teachers

Science qualifications up to A levels	Number of teachers (n)	Percentage of teachers (%)
No science study beyond GCSE (or equivalent)	58	68
One science A Level	17	20
Two science A Levels	7	8
Three science A Levels	3	4
Total	85	100

Since gaining qualified teacher status, almost a quarter of the teachers surveyed (n= 20 / 24%) have taken on the role of science subject leader in their schools. Just over one in ten respondents (n=10 / 12%) work in schools that have ASE membership and just over four in ten respondents (n=35 / 41%) work in schools that either hold, or are working towards, the Primary Science Quality Mark (PSQM)¹². To contextualise this, currently there are 2,000 PSQM awards held by UK schools, which is approximately one in ten primary schools. The survey sample is therefore over-represented by teachers in schools holding the PSQM, which should be considered when interpreting the survey data. Similarly, the sample is also over-represented by science subject leaders.

5.1.2. Routes into teaching

One third (n=28 / 33%) of respondents followed the SCITT route into teaching, while nearly half (n=39 / 46%) completed a PGCE course and ten respondents (12%) completed a university BEd degree. Three teachers undertook the Graduate Teaching Programme¹³ (3%) and the five remaining teachers (6%) completed a university BA degree with qualified teacher status.

As a quick comparison, the Department for Education's data on recruitment to ITT programmes in England (2016/17) showed a split of 42% trainees following a Higher Education Institution (HEI) route (i.e. BEd, BA or PGCE); 54% following a school-based route (SCITT or School Direct) and the remaining 4% completed Teach First training.

Our sample was therefore slightly over-represented by HEI route trainees and slightly under-represented by school-based trainees, when compared to a recent year's recruitment into primary teaching.

¹² The Primary Science Quality Mark is an award scheme to enable primary schools across the UK to evaluate, strengthen and celebrate their science provision. <http://www.psqm.org.uk/>

¹³ Those teachers who reported that they completed this route referred to it as the Graduate Teacher Programme, though it is also known as School Direct training.

Table 2 Routes taken into teaching

Route taken into teaching	Number of teachers (n)	Percentage of teachers (%)
SCITT	28	33
PGCE	39	46
University BEd	10	12
Graduate Teaching Programme	3	3
University BA	5	6

Over half of the respondents had to select a specialism while qualifying as a teacher (n=46 / 54%), though only a fifth of those (n=9) chose science as their specialism.

5.1.3. Attitudes towards teaching the core subjects

Respondents were asked to rate retrospectively their confidence levels for maths, English and science, before they began their teacher training courses and after they had qualified^{14,15}:

Table 3 Attitudes towards teaching maths, English and science¹⁶

N=84	Maths		English		Science	
	Before training	After training	Before training	After training	Before training	After training
Not confident (%)	6	0	4	0	2	0
Not very confident (%)	20	1	18	1	25	4
Neither confident, nor not confident (%)	6	2	12	6	7	7
Quite confident (%)	51	62	51	64	51	61
Very confident (%)	17	35	15	29	15	28

Broadly, teachers reported that their confidence levels for all three core subjects began at the same levels: around two-thirds said they were either quite or very confident about each individual subject and around a quarter reported that they lacked confidence in maths and in science, while about a fifth of teachers said they were not confident in English.

After their training courses, the picture was broadly the same across all core subjects again. Confidence levels improved for all three, with the biggest improvement reported for maths (where 29% more teachers said that they were quite or very confident in

¹⁴ Teachers were asked: "How confident, if at all, were you about maths, science and English before training to be a teacher?", choosing from the following options: 'very confident', 'quite confident', 'neither', 'not very confident' and 'not confident at all' and then, using the same options, were asked: "At the end of your Initial Teacher Training, how confident, if at all, were you about maths, science and English lessons?"

¹⁵ N.B. Teachers were asked to rate their confidence levels post-training, so their responses may not be as accurate as if the research had been conducted before and after their courses took place.

¹⁶ Note that due to rounding, percentages quote throughout this report may not total 100.

maths after their training). The smallest improvement in confidence came for science, with 23% more teachers reporting that they were either quite or very confident in science after qualifying.

The data explained in the next two paragraphs are presented in table form in Appendix 2.

Comparing the perspectives of teachers who trained on the three main routes¹⁷ (SCITT, BEd and PGCE), those who took the SCITT route began with the lowest levels of confidence in all three core subjects (with only 61%, 57% and 64% teachers saying that they were quite or very confident in maths, English and science respectively), followed by those on the PGCE course (72%, 69% and 62% teachers confident in maths, English and science respectively), while those on the BEd routes were more confident at the start of their studies (70%, 70% and 80% teachers confident in maths, English and science).

Once they had completed their courses, the biggest improvement in confidence was visible among SCITT students (96%, 96% and 89% teachers said they were quite or very confident in maths, English and science respectively – increases of 35%, 39% and 25%). Levels of confidence improved for PGCE students too, though given that their starting point was higher than the SCITT students, the increases weren't quite as high (95%, 87% and 90% now quite or very confident in maths, English and science). Strikingly, 100% of BEd students reported they were confident to teach all three subjects at the end of their course.

Considering now the level of science that teachers had studied at school themselves before they embarked on their teacher training¹⁸, around 60% teachers (32 out of 54) who had no science A levels or equivalent before their teacher training said that they were confident about science, while those with one or more science A level were more confident. Three-quarters of those with one science A level (12 out of 16) said they were confident about science as did all of those with two or three science A levels (3 individuals). Once they had completed their studies, those without science A levels increased their confidence levels, with 93% (50) reporting that they were now quite or very confident. Those with just one science A level also increased in confidence, though not to such an extent, with 88% reporting that they were confident in science. 100% of those who had two or three science A levels reported that they began their courses confident about science and they remained so after their studies ended.

5.1.4. Preparedness to teach science

Teachers were asked to report the extent to which their ITT prepared them for various elements of science teaching.

Table 4 Preparedness to teach science

N=84	Have good subject knowledge?	Understand the science curriculum?	Work scientifically?	Assess primary science?	Use models to explain abstract concepts?	Demonstrate how science fits into the wider world?
Strongly disagree (%)	2	1	2	10	5	1
Somewhat disagree (%)	13	13	13	27	26	18
Neither agree nor disagree (%)	12	10	12	20	17	17
Somewhat agree (%)	51	52	49	33	38	46
Strongly agree (%)	21	24	24	10	14	18

Close to three-quarters of respondents somewhat or strongly agreed that their courses did prepare them to have good science subject knowledge, to understand the primary science curriculum and to work scientifically (72%, 76%, 73% respectively). Nearly two thirds (64%) of trainees said they were well prepared to demonstrate how science fits into the wider world. Just over six in ten of respondents (n=52 / 62%) said they were adequately prepared to use models to explain abstract concepts. Notably, however, only around half (n=43 / 51%) agreed that their course helped them to be able to assess primary science.

¹⁷ See Appendix 2, tables I, II and III

¹⁸ See Appendix 2, tables IV, V, VI and VII

Comparing the responses of SCITT students with those of PGCE students¹⁹, SCITT graduates were more likely to agree that their course prepared them well to have good content knowledge (75% versus 66%) and to work scientifically (82% versus 66%). PGCE graduates were more likely to say that their course prepared them well to understand the primary curriculum (82% versus 68%), to be able to demonstrate how science fits into the wider world (71% versus 54%) and to assess science (66% versus 46%). Around half of the graduates of both routes reported that their course prepared them to be able to use models to explain abstract concepts (55% PGCE students vs 50% SCITT students).

BEd graduates appear to feel better prepared than their peers, however²⁰, for four of the six questions (content knowledge, understanding the curriculum, working scientifically and showing how science fits into the wider world), at least 90% teachers agreed that their course had prepared them to do these things (increasing to 100% for content knowledge). Six out of ten BEd graduates felt that their course prepared them to be able to assess primary science and use models to explain abstract concepts.

5.1.5. Opportunities afforded to trainee teachers on their courses

Teachers were asked whether they had been given the opportunity to do certain things during their teacher training course.

Table 5 Science-based opportunities during teacher training

N=85	Take part in practical lectures	Watch science demonstrations	Go on visits to industry/science centres	Visit wildlife centres	Write a project or dissertation on science
Yes (%)	84	69	19	28	14 (of whom half did a science specialism)
No (%)	13	34	78	67	81
Can't remember (%)	2	2	2	4	4
Blank (%)	1	2	1	1	1

Comparing the responses of trainees who followed the three main routes (SCITT, PGCE and BEd), those who completed a BEd were more likely to have taken part in practical lectures and science demonstrations than their peers on SCITT or PGCE courses²¹, though PGCE trainees were most likely to have been on visits to industry or wildlife centres or to have completed a project or dissertation with a science focus than their BEd or SCITT peers. There were six SCITT students who neither took part in a practical lecture nor saw a science demonstration, compared to one PGCE student. There were no BEd students who missed out on both of these opportunities.

Trainees on all routes reported that the sorts of practical activities that they participated in could be recreated in their classrooms and also included looking at the progression of ideas for different age groups and looking at ways to work scientifically. Visits included science museums, planetariums and farms and some teachers were required to plan theoretical science trips. Teachers also reported that they sometimes benefitted from input from science specialists (such as external primary science advisors) to enhance their lectures.

¹⁹ See Appendix 2, tables VIII and IX

²⁰ See Appendix 2, table X

²¹ See Appendix 2, table XI

5.1.6. Opportunities afforded to trainee teachers while on teaching placements

Trainees were asked whether they had been able to teach science, teach practical science and observe science while on their teaching placements:

Table 6 Science-based opportunities during teaching placements

N = 85	Teach science	Teach practical science	Observe science
Yes (%)	96	89	64
No (%)	1	5	31
Can't remember (%)	1	2	5
Blank (%)	1	4	1

Comparing the experiences of teachers on each of the main three routes: all those on the SCITT and BEd routes were able to teach science while on placement, as were nearly all of those on the PGCE course (95%). Similarly, nearly all of those on the SCITT route had the chance to teach a practical science lesson (96%), as did nine in ten BEd teachers (90%) and nearly nine in ten PGCE teachers (85%). Opportunities to observe science were less available for all teachers (75% SCITT teachers and 67% PGCE teachers), though this was notably more of an issue for BEd trainees, of whom only 50% did so.

“I would have loved more opportunity to watch good science teaching. What I did see, or what was discussed/demonstrated at training sessions always seemed to be quite stand-alone science with not helpful enough links to curriculum objectives.”

Graduate Teacher Programme trainee

5.1.7. Teachers' commentary

Teachers provided some additional detail in their survey responses to support the data already cited. Two teachers suggested that there was insufficient time dedicated to science during their ITT, as one describes:

"[There was] extremely minimal focus on science during my PGCE"

University-based PGCE route

The second teacher suggests why this might have been the case:

"English and maths seemed to take up a lot of the time therefore science was overlooked."

University-based PGCE route

Teachers were asked an open question about what else they might have liked to have been included in their course, to better equip them to teach science as a primary teacher. Their responses are summarised in table 7.

Table 7 What else would trainee teachers like included in their courses?

Content	Frequency of response
Practical experiments and lesson ideas	21
Assessment of science	17
Observing excellent science teaching	14
Working scientifically	10
The progression of ideas	9
Advice on organising trips and visits	7
Subject knowledge	6
Planning	6
Being taught by science teachers	3
Developing pedagogical content knowledge	3
Training on how to use scientific equipment	2
Teaching science outdoors	2
Teaching about models and abstract ideas	2
Cross-curricular teaching	2
More time in school to teach science	2
Understanding pupils misconceptions	2
Teaching in early years/foundation stage	2
Accessing support or CPD once qualified	1
Health and safety	1
Class management for investigations/practical activities	1

Frequently, teachers commented that they would have derived benefit from having the chance to observe more, high-quality science lessons and especially those taught by science specialists:

“I think it would have been useful to spend more time seeing science in the classroom. It would have been interesting to see experienced teachers teach lessons that encourage scientific thinking/working scientifically, rather than just discussing it in seminars. We discussed teaching science theoretically, but it never quite works that way in practice. The more chance you have to observe, the more you can learn about what supports the best progress in children's scientific thinking and their ability to work scientifically.”

University-based PGCE route

“I believe watching other, more qualified, teachers as part of my training would have been useful to learn how to engage children. Perhaps, a list of important key questions to ask children to engage them and help them think deeper. Also, suggestions as to popular experiments known to capture the attention of learners for each topic throughout each key stage would have been really beneficial and time saving.”

SCITT route

Likewise, teachers were also likely to say that they would have welcomed more support to help them to teach children to work scientifically:

“I found that I understood the subject knowledge and knew how to teach it but found the prospect of teaching it with a working scientifically attitude was a bit daunting as the focus would be on child investigation and exploration. It was nerve-wracking to think that the lesson would need to be primarily child-led and open.”

SCITT route

Teachers were also often reporting that they didn't feel adequately prepared to assess science in the classroom as two teachers explain:

“[Our science sessions were] hands-on and [they] provided [us with] effective ways to teach it. However, due to the changes in the curriculum at the time, a lot of details about assessment were lacking.”

University-based BEd route

“Also, assessment changed during that time. No [teaching] was done in uni of how to assess a child's level of science.”

University-based PGCE route

Teachers were also asked to consider the importance that science has within the schools where they are currently employed. Of those who answered this question (n=46), over half (n=24) said that science was considered a core subject and was treated with the same level of importance as maths and English, with similar amounts of teaching time dedicated to all three subjects. Of these schools, 14 are PSQM schools and five are members of ASE. Five teachers said that their schools were working to improve the profile of science and a further three said that they were in the process of applying for PSQM. One teacher described her situation:

“Everybody knows it is important and most teachers teach it once or twice a week. This is in comparison to maths, spelling, reading and writing being taught every day yet other foundation subjects such as music get taught once a term if that. So, it lies somewhere in the middle of importance. It makes me feel nervous as I sometimes wonder if all the objectives can be covered in the time we provide.”

SCITT route, currently working in a PSQM school without ASE membership

Nearly four in ten (n=17 / 37%) of those who responded said that in their school, science was not as important as maths or English.

“Some schools don't treat science like a core subject e.g. if a Literacy lesson was missed they would get rid of science to fill it. I really enjoyed learning about science in the workshops in uni. I feel it should be given as much time as maths and English so the next generation of teachers see science as a priority subject.”

University-based PGCE route, currently working in a school that does not have ASE membership or PSQM

Five teachers suggested that there was simply not enough time to fit enough science into the timetable, given the other pressures from visits, projects and interventions which frequently take priority.

5.2. Observations on teachers' perspectives

- Most teachers surveyed did not study science beyond GCSE level (or equivalent).
- The PGCE route into teaching was the most common among respondents at 46% (note that DfE data for recruitment to primary teaching in 2016/17 shows that 51% trainees followed a school-based route and 42% took an HEI route, which includes both PGCE and BEd or BA courses).
- More than half of the teachers surveyed could have selected a specialism on their course, but of those, only a fifth chose science.
- Teachers felt that their courses prepared them well in terms of understanding the curriculum, helping young people to work scientifically and contextualising science.
- Many teachers also felt that they were prepared in terms of having sufficient subject knowledge at the end of their ITT, despite most providers saying that the development and acquisition of content knowledge was a responsibility largely left to trainee teachers themselves, as opposed to being taught.
- Only half of teachers felt that they had been well prepared to assess science.
- Fewer teachers reported that they struggled to teach science while on placement than the providers might have suggested (with 1% teachers saying they taught no science at all and 5% saying they didn't teach any practical science compared to most providers reporting that they cannot compel their trainees to teach science)²².
- A third of teachers had not had the opportunity to observe science teaching while on school placement: something which they felt would have been beneficial.
- Teachers recognised that observing high quality science teaching during their courses would have been beneficial to them.
- Only half of teachers said that science has the same profile as English and maths in the schools where they are now employed.

²² 8/10 PGCE providers said they could not compel their students to teach science. 3/6 BA/B.Ed providers requested that students undertook science teaching but were not able to enforce this. 7/11 SCITT providers said they couldn't compel their trainees to do science related teaching.

²³ As already mentioned, the teachers interviewed did not necessarily study at the institutions included in our sample, so their views will not necessarily reflect the experiences offered by the ITT providers interviewed.

6. Case studies

Teachers were asked a set of questions and invited to be as open and reflective as they could be. The case studies following arise from these interviews and have been agreed by the interviewees.

6.1. Case study 1: studied science to GCSE, completed a BA in Primary Education in 2013

Background to training to teach

I didn't have a strong interest in science before I started training to be a teacher. I studied it to GCSE, but no further – I had low science capital. I did a three-year BA in Primary Education and I qualified in 2013.

The science content of the ITT

We had strong science input during our course – there was a great science team, with two lecturers – one of whom was a Primary Science Teaching Trust²⁴ fellow. We had dedicated science lecturers and a science lab for our sessions. Science was considered as important as literacy and maths.

During the second and third years, you could choose a specialism and one of those was STEM (science coupled with Design Technology), which I took. We got the usual science input therefore, but with additional science and technology sessions on top.

The course was very much geared to equipping us with good subject knowledge, based on the national curriculum, making sure we really understood it. We spent lots of time on misconceptions too (more so via our specialism sessions, though). We were encouraged to take responsibility for our own knowledge and our own misconceptions. I'm quite confident with my content knowledge now.

One assignment we were given saw us putting together a mock risk assessment for a science trip and planning a scheme of work for three lessons including that trip. We sometimes had lectures out of the classroom, including a lecture on light in the National Portrait Gallery.

In terms of learning about pedagogy, this tended to be delivered through subject knowledge sessions, considering which approaches to working scientifically and enquiry to use. We spent time on cognitive conflict and how to encourage children to think in line with current scientific theory.

While I was on placement, I didn't have much opportunity to teach science. In my first year I was in reception and we did some things about plants, but I didn't get to teach much myself. In my second year, I was in a mixed year 3 and 4 class, where we taught science every week as a stand-alone subject and the class teacher was happy for me to do the teaching – it was a much better experience. We had a good science lead and got some good science CPD too. In comparison, my final year placement was not a great experience: science was perceived as a foundation subject and didn't have the core subject status it deserves. It happened at the same time as guided reading sessions and the TAs would be teaching science!

I didn't observe much science, either. A teacher checked my planning work, mostly to check that it was ok in terms of health and safety, but that was it.

Science in school as a qualified teacher

Since qualifying, I've worked in the same school for nearly four years. By the January of my NQT year, I asked if I could become the science subject lead and the head agreed. He wanted science to be bigger and better and has agreed for it to be a stand-alone subject, as opposed to weaving it into topics so much. I've created a scheme of work for all our teachers, starting off with materials from the Hamilton Trust²⁵ so teachers have something to use as the basis for their planning and we now teach an hour a week in KS1 and an hour and a half in KS2. I frequently monitor the children's books and colleagues' planning as well as run science-based staff meetings.

²⁴ <https://pstt.org.uk/>

²⁵ <https://www.hamilton-trust.org.uk>

Last year I agreed with our head that we would go for PSQM, aiming for silver. It was a good process – the whole school was involved, it felt very supportive and we got it in the autumn. It has been the best thing I've done so far – it really helped me to understand what we should and could, do as a school. I'm interested to see what happens after I leave this term (I am moving to a new school in the autumn). I wonder if I've done enough to embed this culture.

My training prepared me well to be a primary teacher and more than equipped me, even if I wasn't as passionate as I am now, to know what good science teaching looks like. The specialism wasn't great – our teacher was a secondary specialist, which wasn't ideal. There was lots of reliance on text books. The university recognised that, though and in our final year we had a primary specialist who put the focus on leadership and misconceptions.

Getting support for science teaching

If I need support now, I rely on the ASE – I attend their annual conference, I go to their CPD. I go with two hats on: what I need and what my school needs too. I also make a lot of use of twitter and various Facebook groups – we post articles and share resources on there.

6.2. Case study 2: holds biology AS Level, completed a School Direct PGCE in 2015

Background to training to teach

I have biology AS level – at the school I went to there was a bit of division between students who were either arty or “sciency”, so I did arts at school, but I then took the AS at night-school while I was working. I did more biology and psychology modules later on too. I love science though; I go to lots of free lectures and often spend time at the Wellcome Collection²⁶.

It took me a while to decide what to do for a career, but I've worked in schools as a TA and I knew I wanted to do something health or education-related and so teaching just made the most sense.

I did a BA in Art and Philosophy, but then I went on to do a School Direct PGCE. It gave me control over where I would be training, both in terms of the area and the schools. I was at university with the other PGCE students which meant I had the same training as them, but I could get to know my schools before I started and I knew I would be more likely to get a job there after I qualified in 2015.

The science content of the ITT

Science was given an equal weighting with maths, literacy and computing during our training at university – or at least that is how it was portrayed. In my opinion, schools generally don't really take science as seriously as other subjects though– they are maths and literacy focussed.

We started off the course with a science knowledge audit, to see where we had any gaps. Our lectures were good and interactive. The amount of time we spent on science was small though, compared to other core subjects, though one of our mentors on the School Direct course was a science lead so they ran extra workshops for us. We did some investigations that we could use in the classroom (if we had the resources and time to do them there, that is!), some time was spent on subject knowledge but more often we were given stuff we could go and replicate in school and we preferred that.

Covering the whole primary curriculum would have been impossible, in the time we had. My general science knowledge was ok, but applying that to the curriculum less good. We were encouraged to go and fill any gaps in our knowledge ourselves. We were also shown how to combine science with topic learning, to integrate it with other subjects.

Reflecting on the science input on the ITT

Looking back, we could have done with spending more time on science, but the education we got reflects the reality in schools today. There isn't enough room for science – we are always focussed on maths and literacy. Where I taught on my placement, we did science in blocks, which meant that while science wasn't taught as regularly as I would have liked, we were able to get our teeth into things via a sequence of lessons, as opposed to doing a short session in an afternoon and running out of time – and I welcomed that opportunity.

²⁶ <https://wellcomecollection.org/>

Teaching science while I was on placement was good – I had a lovely science mentor. We did a sequence of lessons on plants and plant growth – it's such a stereotypical school topic – but the approach she encouraged me to use was interesting and I was really involved in teaching the lessons. We began by finding out what the children thought different words meant and then broadened out their knowledge from that starting point.

We also did a good sequence on materials, which I've reused since qualifying, linked to a story called "Traction Man"²⁷ (about an action hero who has an outfit for every occasion), where we got the children to make him a coat, selecting their own materials, testing out their properties. It was a really good way to introduce them to working scientifically, making predictions, working out how they would do an investigation, making sure it's fair, recording their results and writing up conclusions. The children loved it!

It would have been nice to have had more science input in our PGCE, showing us how to deliver the curriculum by Key Stage and giving us more investigations to take away and use.

Science in school as a qualified teacher

Having worked in schools before I qualified, I knew the reality – that I wouldn't be able to teach science as much as I would have liked. Maths and literacy have such clear progression paths and schools have policies and medium term plans for them both – they don't have the equivalents for science – it's a much more short-term approach instead.

My current school is in quite a deprived area and we have high levels of children needing extra support in KS1 to access the curriculum in English, so that's what we have to prioritise. We don't really make enough of the links between science and other subjects and the rich use of language and maths it offers. The curriculum demands for maths and literacy and the need to evidence it all in the children's books leaves us as teachers exhausted without the energy to plan engaging science. But we still do it, though!

We are following the international primary curriculum through our topic work and there will be even more focus on that next year, so I am hopeful that people will integrate more science into it so that it actually gets taught. People do say that they would like to do more science, but realistically so much else takes over. We'd probably like to see more leadership from our middle managers with planning and science, ideally.

We spent some time after half term doing "work-week", where the children were learning about different job options. We asked them to draw a medic and a pilot and they all drew men. We are working hard to challenge these stereotypes and to get rid of this gender bias.

Getting support for science teaching

If I need support at school, I will always go to our science lead, who is also my partner teacher. I wouldn't ask for help with lessons, so much, though, I would probably use some of the websites my colleagues use. We haven't had any science-related CPD so far. I think we need to bring around big change within education and with the government to promote science education.

²⁷ <http://minigrey.com/books/traction-man-is-here>

6.3. Case study 3: did not study science beyond GCSE – completed the School Direct route in 2016

Background to training to teach

I studied science up to GCSE: I preferred the humanities at school. I became more interested in science since I qualified as a teacher in 2016– I hadn't thought about teaching as a potential career prior to this.

I've always enjoyed working with children and teaching is a really different, fun job. It's a big change from what I used to do – my last job was monotonous in comparison!

I took the salaried School Direct route, mostly because I had a friend who had also done it and spoke highly of it. Being salaried, it also meant I could afford to live independently too.

The science content of the ITT

The science elements of my teacher training were very practical and hands-on. Every day we would break into small groups and explore different practical experiments. We would look at all the different ways to create fair tests, write up observations – it was always lots of fun. We also had some training sessions in school too, which were also practical and fun. We looked at how to include cross-curricular subjects in science, such as using apps on iPads to get the children doing some IT – I could see how it was much easier to make science cross-curricular than other subjects!

Science was definitely one of the more important subjects on our course: we maybe spent 20% of our time on it, compared to less than 10% for foundation subjects, with the rest being dedicated to maths and English. We did a lot of maths and English - we would go through the school's marking schemes or look at strategies to teach a variety of calculations.

Science subject knowledge was pretty much left to us as students to explore: we were guided towards the right books to buy and it was up to us to read up on them! It didn't feel like anything was missed out on our course, however, though it would always be good to do things in a bit more depth, but other than that, the way science was taught was good. It was made to be a really appealing subject.

I taught science on both of my placements, Key Stage 1 and 2. I found it difficult though and this is not a reflection of the SCITT, but perhaps more of my mentor at the time. Science needs to be something that's well thought out and structured beforehand. Children can become very excitable and it's important to know how to contain or control that. Sometimes my lessons would be lost for that reason. The approach was often: "here's the lesson, let's see how you do..." and then my mentor would watch and occasionally intervene. Science wasn't seen to be as important as maths or English, so we would really be left to our own devices in terms of our science teaching.

I only observed one science lesson, but it was very good. It was taught by the science coordinator and was fast paced. They used concept cartoons to start the lesson off – just a five-minute input - which raised questions and got the children talking in pairs and then they went off and conducted their own experiments and wrote up their observations.

Reflecting on the science input on the ITT

More broadly, though, my experience while on placement was that the SCITT students were thrown in at the deep end. Our school was under lots of cuts and we didn't have many support staff so we had to take on a huge percentage of the teaching. This made it hard to leave the school and take part in other workshops or training opportunities.

In terms of content knowledge, my training didn't really prepare me well for teaching science. I was responsible for researching my own subject knowledge and there wasn't time during the course to go through all of it thoroughly. As a primary teacher, you have to teach so many different subjects – it's to be expected that you're naturally not good at all of them! But, in terms of how to manage the children and their (and your own) expectations in the classroom: my training was excellent.

It would have been useful if I could have had access to more lessons and workshops outside of my placement school and to engage in things that are relevant to what you're teaching. If the topics aren't applicable to what you're doing there and then, you just forget it. My mentor was keen on literacy and I got very good in-depth training for teaching English and maths, but not so much for science. It would have been better to have had a mentor who enjoyed science more herself.

Science in school as a qualified teacher

Since qualifying, I've found that I keep learning week by week. The better you know your class, the more you know what to expect and how they might respond. We have just had our science week and we had some successful experiments. We didn't leave anything to chance – we had all the equipment ready and ensured that the children understood the rules and the expectations for the session – it really made a difference.

I really enjoy teaching science – it's one of my favourite subjects to teach. I'm not sure where my own passion for it has come from, but I find it such an inclusive subject – everyone can be involved. If I need any help, I tend to go to the people who provide training to newly qualified teachers at the Local Authority

I don't think that science is perceived to be that important in my school. I work with the science coordinator a lot, but she has three other subjects to lead as well and she didn't volunteer to take it on – it was given to her. I have offered to take it over, but I've been allocated IT to lead from next year instead.

6.4. Case Study 4: holds two science A levels, qualified via School Direct route in 2015

Background to training to teach

I studied chemistry and biology at A Level, I always found them both interesting, especially chemistry. I love science – I try and keep up to date with it and I did a psychology degree at university as an undergraduate degree. I was especially interested in educational, clinical and developmental psychology and I spent time volunteering in a care home to get clinical experience and time in schools for the educational side. It really helped me to decide what I wanted to do.

I took the Schools Direct route – I had wanted to do a PGCE but I applied late so there weren't any places left, but the courses were exactly the same so it didn't make a difference. I qualified in 2015.

The science content of the ITT

I specialised in science during my teacher training – it was one my favourite parts of the course. Our tutor was so passionate about science – it really came across – and made the sessions so much easier to enjoy. We spent a lot of time on science lessons – more than others who did other specialisms. We did lots of experiments, talked about differentiation, the various strands within working scientifically and how to fit them in across the year, depending on the topics you teach. We also spent a lot of time on long-term planning, thinking ahead to when we might become subject leaders or achieving PSQM.

You had to have science-related A levels to be able to do the science specialism, but we all filled out a form at the start of the course to show what we knew and our confidence levels to teach various topics. Our tutor used this as a guide as to which bits of curriculum content she focussed on.

The experiments were all quite hands-on and they ranged from basic things like card sorts all the way up to bigger experiments with soils and water, for example. We would often look at example lessons for a certain topic and how you would differentiate it depending on their key stage and age.

Towards the end of the year, we were put into mixed groups (i.e. not split out by specialism) and had to present on topics from within your specialism, talking your peers through what you'd learned and how to teach that topic.

I definitely had the chance to teach science on my placements and to start with it wasn't so successful, but it made me realise that I had to increase my own subject knowledge – there is so much you forget! For example, I had to do space on my first placement, but having done chemistry and biology A Levels I hadn't covered it! Luckily I was given plenty of opportunities to ask questions and speak to our science lead and if I was ever unsure I had lots of people willing to help me and point me to resources or guidance.

I really enjoyed teaching science on placement: I felt quite confident. I loved the practical elements – I always wanted to make them as engaging as possible. All I remember from my time at school is being told to watch the teacher do an experiment and then having to write it up. I always want my children to have a go and get involved. I found the observations useful too – it was good to see how people teach things differently while still achieving the same learning objectives. There wasn't much difference between the schools on my placement, as they shared the same headteacher.

Science in school as a qualified teacher

It is very different in my current school, however – science is not as important there – there's a much stronger focus on maths and English. It feels like they forget that science is a core subject too. It's especially visible at this time of year too, as children are taken out of the classroom for maths and English interventions, which means that they miss an awful lot of science. It's such a shame: if you ask them what their favourite subject is, they will tell you science!

Our current teaching staff is all female, though we do have a couple of male TAs. We didn't really cover unconscious bias in my ITT, but I know that there's a big push to look at female scientists when you do secondary research and that there's a drive to get more women into science. Where I can I always present female scientists to inspire our girls.

Getting support for science teaching

I think my training prepared me well to teach science. We could have spent more time on the planning side of things, to ensure a more varied approach to working scientifically, but I am confident I know where to go to get answers if I need them, I know a good range of websites to use to build my bank of resources, so I know I can put together successful lessons to meet the necessary learning objectives. I've been on a course this year about helping children to work scientifically and I am in contact with the other students and the tutor from my course, so I have good support around me.

I'm not yet science lead, but I will be next year. I'm hoping we have the potential to work towards PSQM then too. I want to raise the profile of science – I know I need to be persistent. If you're passionate about it – you have to keep going – it rubs off on the children!

6.5. Case Study 5: did not study science beyond GCSE, qualified via School Direct route in 2016.

Background to training to teach

I didn't study any science beyond GCSE, but I was benignly positive about it before I decided to train as a teacher. I spent some time working as a teaching assistant in a school and that, combined with wanting to find a meaningful career (and the fact that my dad was a teacher) helped me to decide to train as a primary teacher.

I chose the school direct route into teaching: I knew that the provision was exactly the same as the PGCE course, with just as much university time, but I also knew that this route would allow me to have control over where I would do my placements – I applied to the school direct group where I was already a TA and was placed within a group of ten known schools. I qualified last year, in July 2016.

The science content of the ITT

The science elements of our training were really good. Subjects were covered in blocks on our course: science was allocated five. That represents a lot less than maths and English, but considerably more than the foundation subjects got. We had an inspiring tutor, who was really focussed on the working scientifically goals and she used them as the springboard for the work we did, as opposed to just working through the curriculum content objectives. There was a big focus on child-led science, on awe and wonder and on encouraging us to challenge the fact that science often gets left behind in schools these days.

The course was quite practical – lots of the time we would be given sets of equipment and were asked to devise ways of using it. We were encouraged to recreate the experiences of the children: this is what you need to find out...how would you go about it? There was also quite a bit of time spent on planning, both medium and short-term planning.

We also had some CPD sessions provided by the school direct schools on Thursday afternoons and one of those was entirely science-focussed. We did it at a school that was really pro-science and there was lots of focus on generic experiments: different ways to teach the same thing and it was delivered by their science coordinator.

I didn't choose science as my specialism on my course and I regret that now. I chose ESOL (teaching English to Speakers of Other Languages).

I taught quite a lot of science on my placements – it was a requirement of our course to teach a set amount of certain subjects and one of the tasks we had was to write up a science lesson. It went pretty well: my year 2 lessons involved lots of carousel activities, working in smaller groups, since the children are more used to a free flow environment. For my year 5 lessons, we did fair testing

and looked at changes of states and forces. It taught me a lot about how to get the balance between a lesson being child-led and it going off on a huge tangent!

I observed as many science lessons as I taught. Science was usually taught by a PPA teacher (someone who covers class teachers' planning, preparation and assessment time) and I got to see a lot of those lessons as it didn't coincide with my own PPA time. In the second school I probably taught more than I observed, but that is probably because it was my second placement, where there was an expectation that we would do more teaching. Observation was helpful: it is so good to see how science is taught across all key stages, getting ideas for practical science (especially in early years: they do science well, using very observational and child-led sessions).

We did spend some time on my course talking about the image of a scientist and how there's the assumption that all famous scientists are old, white men with beards. I'm not sure that our children at school feel quite like that yet, however – so far they seem quite liberal-minded, but I suspect that this bias exists more at secondary level.

Reflecting on the science input on the ITT

I feel like my training prepared me well for teaching science. Lots of the obstacles I encountered while training were a good replica for those I've experienced as a NQT. At the start of my course, the working scientifically objectives felt quite nebulous, but now I can see how they fit with the topics we have to cover and I am confident in mixing working scientifically and content objectives together into lessons.

Science in school as a qualified teacher

Since qualifying, I've worked in a school where science is seen to be fairly important: we've just achieved the silver PSQM. The whole school has been engaged in promoting science, recording and evidencing it and we've had plenty of science-based CPD this year. I suppose we might be guilty of taking the pressure off since getting PSQM, but our children still really love their science lessons, which is really gratifying.

Getting support for science teaching

If I need help or support for my science teaching, there are several websites I will always go to as a first port of call, our science coordinator is really helpful and I often go to www.stem.org.uk for resources as I know they're really good – they're obviously quality checked and reputable. We've also had quite a lot of our inset lately dedicated to science – CPD is always the most fun if it's about science!

6.6. Key themes from case studies for Wellcome to consider

- Trainees have very variable experience of teaching science on placements. This is also reflected in the ITT providers' comments. While it ought to be possible for an ITT provider to insist that trainees teach all subjects during their placements, this is not always easy.
- What more could be done to ensure that all trainees are given the opportunity both to teach science and to observe good science enquiry teaching?
- Trainees acknowledge that they had to research any gaps in their subject knowledge. This did not appear to be an issue for trainees. Instead, they were more interested in learning about how to turn that knowledge into good science teaching for their pupils.
- Given this approach to acquiring subject knowledge, how can we be sure that teachers know the misconceptions that children may pick up in science?
- Case studies reinforce the lack of priority for science in schools and how the focus is skewed towards English and maths, suggesting that there is a risk that trainees will expect this to be the case in school too.
- How can the balance between science, English and maths be improved within ITT?

7. Conclusions

This research has revealed a number of themes:

- There are few differences between the three main training routes, beyond the obvious difference in course length (a BA or BEd is three years long, while both SCITT and PGCE courses are just one year each).
- There is agreement that, were there more time available during ITT courses, it would be beneficial to dedicate some of it to science – it is often the poor relation, when compared with maths and literacy.
- Given that they are three years in length, BA or BEd courses are likely to have more science content in them than PGCE or SCITT courses.
- There is a strong focus on practical science in ITT: content knowledge (the acquisition and development thereof) is left to teachers themselves and is more of a vehicle through which ITT providers develop teachers' pedagogical skills.
- Dealing with misconceptions in teachers²⁸, knowledge, however, is important for all ITT providers.
- Qualified teachers surveyed for this research themselves do not complain that they lacked the opportunity to teach science while on school placements, though ITT providers suggest that it is not always possible to make science teaching mandatory for their teachers, due to the time pressures and timetabling issues going on in schools.
- Teachers do report, however, that they did not have sufficient opportunity to observe science teaching while training to become a primary teacher.
- Teachers report that they did not feel suitably prepared to assess science and notably, providers made little reference to the assessment of science in describing their courses.

²⁸ Please note: the term “trainees” is used throughout this report to refer people training to teach, while the term “teacher” refers to someone who has qualified.

8. Appendix 1: Leaders and teachers of primary science

Introduction

Teaching and learning science and closely associated subjects, at primary school supports every child as they explore, investigate and understand the world around them.

The definitions below describe what is expected in respect of leading and teaching science in primary schools²⁹. A teacher new in their role may not meet all the expectations but should have a plan to develop the skills and knowledge required.

Primary Science Subject Leaders

A Primary Science Subject Leader³⁰ should be a teacher of primary science as well as having responsibility for the leadership of science within their school. They should recognise the links and opportunities for learning between science and closely associated subjects.

Subject leadership

A Primary Science Subject Leader should value science, understanding the importance and relevance of science in our lives and recognising that teaching and learning science develops skills and ideas that can be either specific to science or can be applied across the curriculum.

They should:

- keep up to date with broad developments in science and science education and consider how to share these with colleagues and pupils when appropriate
- be aware of and take responsibility for developments that affect school science policy, including health and safety
- be aware of the existence of unconscious biases and the effects they can have on children's developing identities; take responsibility for countering gender stereotyping in science lessons and enrichment activities across the school - particularly when it relates to gendered expectations in the sciences and technical subjects.
- implement a whole-school vision for science and advise and support colleagues on the pedagogy and appropriate resources to achieve it
- ensure that they access continuing professional development (CPD) for leadership of science and that colleagues access CPD to address their requirements too
- monitor provision of science, pupils' progress and contribute to the strategic development of learning in school.

Subject knowledge

A Primary Science Subject Leader should have a deep understanding of the scientific concepts within the primary science curriculum, supported by an understanding of progression into the next phase of education. They should identify any gaps in their knowledge or weaker areas of understanding of the scientific methods and address these through appropriate sources, including good CPD.

²⁹ A primary school is defined as a school for pupils within the age ranges 3-11.

³⁰ A Primary Science Subject Leader is the person in school who has responsibility for ensuring that the science element of a broad and balanced curriculum is delivered effectively so that children make good progress in their understanding of science and develop the scientific skills they need to prepare them for the next phase of their education. Across the UK different titles may be used to describe this role, and science may not be referred to as a discrete subject but as a component of the curriculum. There is no requirement for a primary science subject leader to have qualifications above national statutory requirements for teaching.

They should understand the different methodologies for science enquiry and when to use them, including appropriate methods for recording and presenting different types of data. They should be confident in the use of scientific vocabulary related to the curriculum and able to explain these terms to colleagues.

Pedagogical content knowledge

A Primary Science Subject Leader should have secure knowledge of and be able to apply and model, an appropriate range of methods suitable for teaching across all phases in their school. Their knowledge should include enquiry-based teaching and learning methods, practical activities, out-of-classroom learning, independent and group work, problem solving and digital technologies. They should have secure understanding of both formative and summative assessment practices for primary science and evaluate outcomes to monitor the impact of science teaching and learning on pupils.

A teacher of primary science³¹

Subject knowledge

A teacher of primary science should have secure understanding of the scientific concepts within the primary science curriculum, with a focus on the age range they are teaching. They should understand how the content they are teaching fits into the progression from early years in to secondary education (ages 11-14). They should recognise areas where their knowledge is less secure and use appropriate sources to address these before teaching.

A teacher should use correct age-appropriate scientific vocabulary and expect pupils to do the same. They should understand and model the different methodologies for science enquiry, including appropriate methods for recording and presenting different types of data.

Pedagogical content knowledge

A teacher of primary science should have good knowledge of a range of teaching methods suitable for the science curriculum for all their pupils, including addressing gender stereotyping. Their knowledge should include enquiry-based teaching and learning methods, practical activities, out-of-classroom learning, independent and group work, problem solving and digital technologies. They should have good understanding of both formative and summative assessment practices and use outcomes to ensure their pupils make good progress.

³¹ Most class teachers teach science.

Appendix 2: Teacher survey data tables

I. SCITT teachers: confidence levels before and after training

N=28	Maths		English		Science	
	Before training	After training	Before training	After training	Before training	After training
Not confident	11	1	9	1	8	1
Neither confident, nor not confident	0	0	3	0	2	2
Confident	17	27	16	27	18	25

II. BEd teachers: confidence levels before and after training

N=10	Maths		English		Science	
	Before training	After training	Before training	After training	Before training	After training
Not confident	3	0	3	0	2	0
Neither confident, nor not confident	0	0	0	0	0	0
Confident	7	10	7	10	8	10

III. PGCE teachers: confidence levels before and after training

N=39	Maths		English		Science	
	Before training	After training	Before training	After training	Before training	After training
Not confident	7	0	6	0	12	1
Neither confident, nor not confident	4	2	6	5	3	3
Confident	28	37	27	34	24	35

IV. Teachers who did not study science beyond GCSE (or equivalent): confidence levels before and after training

N=54	Science	
	Before training	After training
Not confident	18	1
Neither confident, nor not confident	4	3
Confident	32	50

V. Teachers with one science A level: confidence levels before and after training

N=16	Science	
	Before training	After training
Not confident	2	1
Neither confident, nor not confident	2	1
Confident	12	14

VI. Teachers with two science A Levels: confidence levels before and after training

N=5	Science	
	Before training	After training
Not confident	0	0
Neither confident, nor not confident	0	0
Confident	5	5

VII. Teachers with three science A Levels: confidence levels before and after training

N=3	Science	
	Before training	After training
Not confident	0	0
Neither confident, nor not confident	0	0
Confident	3	3

VIII. SCITT trainee teachers: to what extent did your course prepare you to:

N= 28	Have good subject knowledge?	Understand the science curriculum?	Work scientifically?	Assess primary science?	Use models to explain abstract concepts?	Demonstrate how science fits into the wider world?
Strongly disagree	0	0	0	1	0	0
Somewhat disagree	5	6	4	9	11	11
Neither agree nor disagree	2	3	1	5	3	2
Somewhat agree	15	13	16	11	11	11
Strongly agree	6	6	7	2	3	4

IX. PGCE trainee teachers: to what extent did your course prepare you to:

N= 38	Have good subject knowledge?	Understand the science curriculum?	Work scientifically?	Assess primary science?	Use models to explain abstract concepts?	Demonstrate how science fits into the wider world?
Strongly disagree	1	0	0	0	2	0
Somewhat disagree	6	4	6	6	8	4
Neither agree nor disagree	7	4	8	8	8	8
Somewhat agree	14	21	14	14	13	19
Strongly agree	11	10	11	11	8	8

X. BEd trainee teachers: to what extent did your course prepare you to:

N= 10	Have good subject knowledge?	Understand the science curriculum?	Work scientifically?	Assess primary science?	Use models to explain abstract concepts?	Demonstrate how science fits into the wider world?
Strongly disagree	0	0	0	0	0	0
Somewhat disagree	0	1	1	4	2	0
Neither agree nor disagree	0	0	0	0	2	1
Somewhat agree	10	7	8	5	5	8
Strongly agree	0	2	1	1	1	1

XI. Percentages of all trainees on each route who were afforded the following opportunities during their training course
 N.B 'n' represents the number of ALL trainees who said they DID this activity during their training

%	Take part in practical lectures (n=71)	Watch science demonstrations (n=59)	Go on visits to industry/science centres (n=16)	Visit wildlife centres (n=24)	Write a project or dissertation on science (n=12)
SCITT	79	61	11	25	7
BEd	100	80	10	10	10
PGCE	90	79	21	36	18

Version 1.0

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**Wellcome Trust, 215 Euston Road,
London NW1 2BE, UK
T +44 (0)20 7611 8888, F +44 (0)20 7611 8545,
E contact@wellcome.ac.uk, wellcome.ac.uk**

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