A black and white photograph of several dandelion seed heads, some in full bloom and others as seeds blowing away, set against a light background. The image is partially obscured by a white box containing text.

**Primary science specialist (2013 -14) and
New and aspiring primary science specialist (2014 -15)**

Report outline

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The course has given me more confidence in my role as science lead... I have been able to give science a higher profile in the school. Children were always keen to learn science but by encouraging a more practical approach this has increased interest further.

Course participant

”



1_CPD description

The primary science specialist course was designed for teachers with responsibilities for science subject leadership and was particularly useful for those who are new to the role.

This innovative programme combined hands-on subject knowledge workshops with specially sequenced sessions that supported teachers in initiating and leading change in their schools. International and UK research evidence¹ indicates that teachers who are highly knowledgeable in their subject content knowledge tend to be more effective teachers, consequently this CPD focused on the development of teachers' science content and pedagogical knowledge, exploring common misconceptions in biology, chemistry and physics.

Excellent teachers have a need for deep and flexible knowledge of the subject matter including an understanding of the relevance and use of the subject knowledge² in everyday life and situations. This kind of understanding provides a foundation for pedagogical content knowledge that enables teachers to make ideas accessible to others, to help students create useful cognitive maps, relate one idea to another, and address misconceptions.

By improving science conceptual and pedagogical knowledge and skills of primary science leaders, the CPD helped teachers improve their confidence and enthusiasm for science and gave practical advice on how to teach science in engaging and innovative ways. This personal professional development led to positive changes in participants' teaching and, by sharing best practice and providing leadership and support to their colleagues, improved science teaching and learning across the whole school.

As the result of the course teachers were expected to:

- › improve their science-specific knowledge
- › employ effective pedagogical skills
- › lead improvement in the quality of science teaching and learning within your school
- › lead professional development of colleagues in your school

This was a residential course structured as three separate training periods spaced within an academic year. After intensive learning at each residential period participants designed their own 'action plans', which were best suited for their school, and received other assignments, i.e. 'gap-tasks', which they were expected to implement in their schools before they returned for the next training. They were also provided with additional opportunities for regional networking and collaborative learning in-between residential training sessions.

¹ For international research see Hanushek, Eric A. und Piopiunik, Marc und Wiederhold, Simon (2014): The Value of Smarter Teachers: International Evidence on Teacher Cognitive Skills and Student Performance. Münchener Wirtschaftswissenschaftliche Beiträge (VWL) 2014-51. Domestically, Ofsted has repeatedly made this argument. See, for example, 2011 Ofsted report on the quality of science education

² Shulman, L. (1986). Those who understand: Knowledge growth in teaching. Educational Researcher, 15 (2), 4-14.

2_Methodology

The data for this report comes from the participants of two course instances:

- Primary science specialist course which ran in 2013-14 academic year (further on referred as (PSS 2013/14)
- New and aspiring primary science specialist course, which commenced in October 2014 and finished in June 2015 (NAPSS 2014/15).

Various evaluation and impact evidence was collected at different points during or after each course instance. This data and method triangulation helped to offset other methodological limitations, such as small n-size or absence of comparison data, thus increasing the robustness of findings and reliability of conclusions. This approach also produced a dynamic perspective on how, on the one hand, the number and depth of impacts grew with time and, on the other hand, how teacher feedback was helping to modify and improve the CPD.

The data includes:

- a) evaluation and impact data collected via the standard STEM Learning impact toolkit forms completed during and after residential training sessions
- b) teacher testimonies (both written and oral, e.g. 'My Champagne moments' course task completed by the NAPSS 2014/15 participants of the third residential training in June 2015, teacher interviews and impact presentations captured on media)
- c) observation of CPD sessions
- d) end-of-the-course online survey of teacher participants(n=36), which gathered data on previous and new school teaching practices, pupil learning and teacher views on the impact of this CPD course
- e) interviews with the professional development leaders who run the abovementioned CPD courses
- f) individual pupil data collected from a third of NAPSS 2014/15 participants, which contained pupil attainment and progression data for the 2014-15 academic year

It is important to note that the collection of impact data from teacher participants was always preceded by their attendance at CPD sessions specifically dedicated to reviewing their post CPD 'gap tasks' and 'action plans'. At these sessions, facilitated by course leaders, teachers discussed their experiences and achievements, presented impact evidence and learnt to scrutinise their impact claims. This training in providing evidence of impact is part of STEM Learning standard multi-residential CPD 'package', which helps teachers acquire useful research and evaluation skills and makes the self-reported accounts of impact more consistent and reliable.

3_Participants' background

There were some differences in the experience and background of the teachers in each course instance:

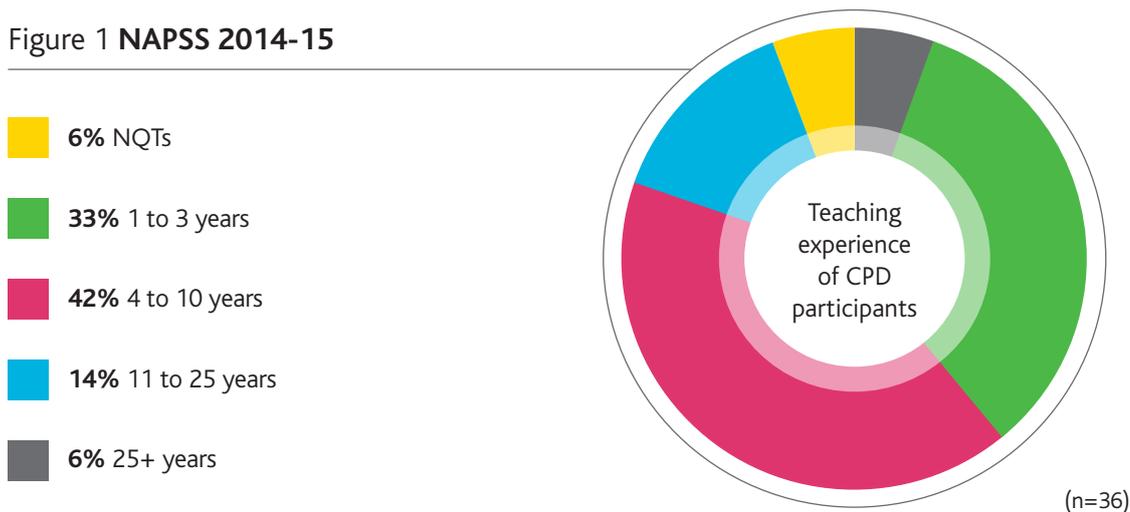
- > about 40% of the PSS 2013/14 course participants were regular classroom teachers interested in improving their science subject and pedagogical knowledge; the other 60% of participants were subject leaders (50%) or had other leadership responsibilities (9%).
- > in 2014-15, science subject leaders constituted the majority of NAPSS 2014/15 participants (76%) while the proportion of classroom teachers was low (18%) and the number of senior leaders remained roughly the same (6%).

A survey carried out at the end of the NAPSS 2014/15 course (June 2015) collected additional data on participants' teaching experience and the year groups they were teaching.

It showed that teachers on the course had very different level of teaching experience:

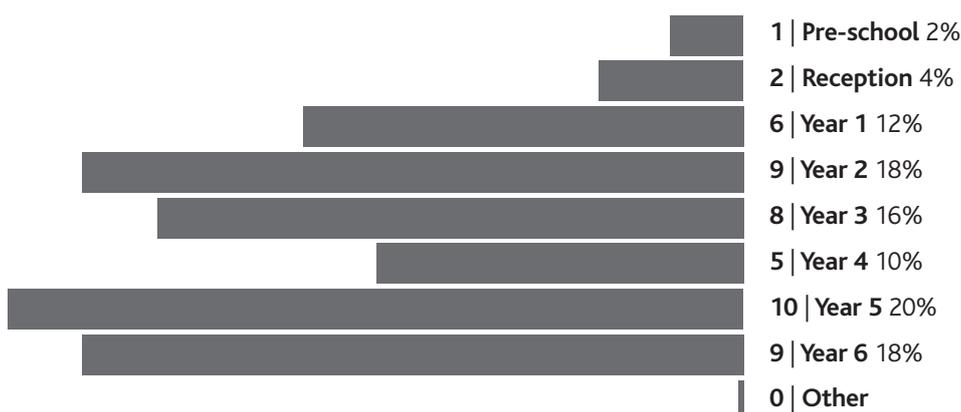
- > 39% of the teachers were in their early career years (0-3 year) and two of the participants were still doing their NQT training),
- > 42% were experienced mid-career teachers
- > 20% have done more than ten years of teaching (see Figure 1).

Figure 1 NAPSS 2014-15



When asked about the year groups that they were teaching, around one third of the course participants indicated that they taught more than one year group and, predictably, there were slightly more teachers working with KS2 pupils than with KS1 (see Figure 2).

Figure 2 Year group(s) currently being taught



My subject knowledge has improved massively. It has improved in key areas where I did not realise I had gaps. I can now go back and run the sessions I did here as staff CPD. Also in my own practice I will be able to give children a more in-depth knowledge and question them better as I have a better understanding.

(PSS 2013/14)

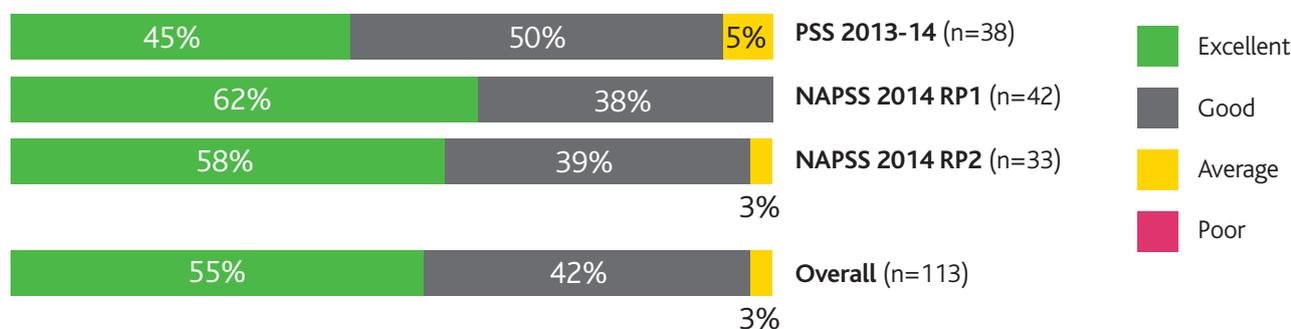


4_Teachers' feedback on the CPD training

Teachers were overwhelmingly positive about the course with more than half of them rating the course as 'excellent' and nearly all of the rest marking its quality as 'good' (see Figure 3).

Figure 3 Overall quality of CPD

Question - How would you rate the overall quality of the CPD?



In their feedback teachers commended the structure and organisation of the CPD and commented that, although it was challenging and tough in terms of science content knowledge development, it was very enjoyable and extremely beneficial:

The course has given me invaluable subject knowledge that has helped me focus my own learning and directed me as to where our school needs to go. Very informative with all questions answered to the level that I needed in order to understand.

(PSS 2013/14)



The course, so far, will definitely help me to improve certain aspects of science throughout the school.

(NAPSS, 2014/15, RP2)



A thoroughly enjoyable two days with the principle aim to ensure good subject knowledge and highlight areas where misconceptions occur. I can see lots of applications for apply the practical investigations at KS2 but there was little focus for KS1.

(NAPSS 2014/15, RP1)



Excellent and in depth levels of subject knowledge. Great for developing explanation and ensuring correct use of vocabulary.

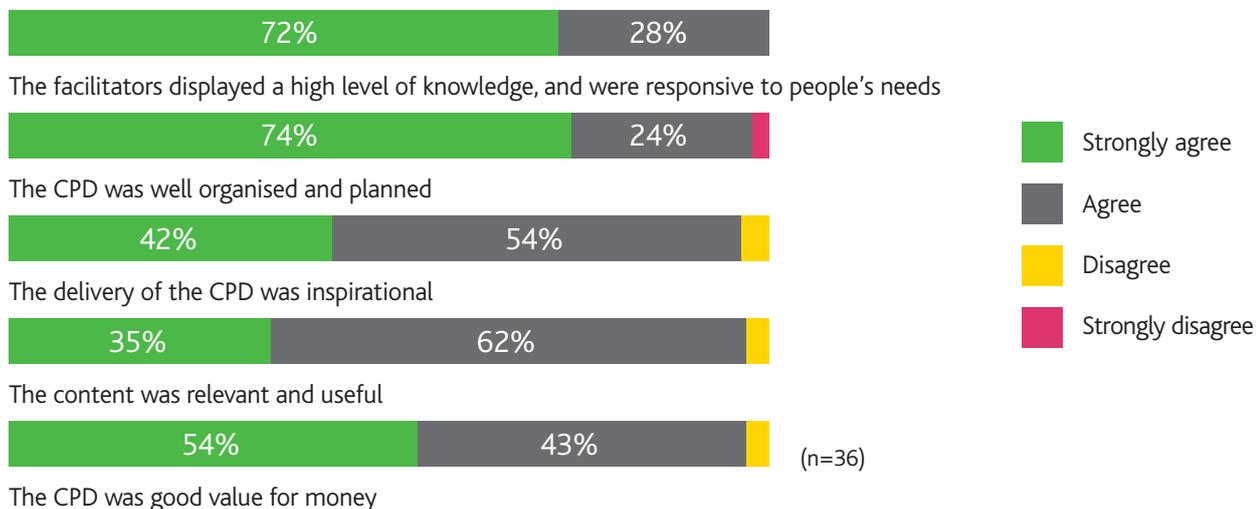
(NAPSS, 2014/15, RP1)



When rating different aspects of CPD organisation and delivery, teachers had very similar views and comments (Figure 4). They rated the level of knowledge displayed by presenters and their responsiveness to audience needs particularly highly (100% strongly agree/agree).

Figure 4 Overall quality of CPD

Participants feedback on the quality of CPD



Fabulous course leaders - very enthusiastic about their course area. Very interesting and practical. They explained the theory well and gave practical demonstrations (watermelon/peach). It refreshed my A-level human biology understanding.

(PSS 2013/14)



All sessions were very well presented with clear objectives displayed at beginning. Then revisited at the end of most sessions. Resources and tasks laid out to suit.

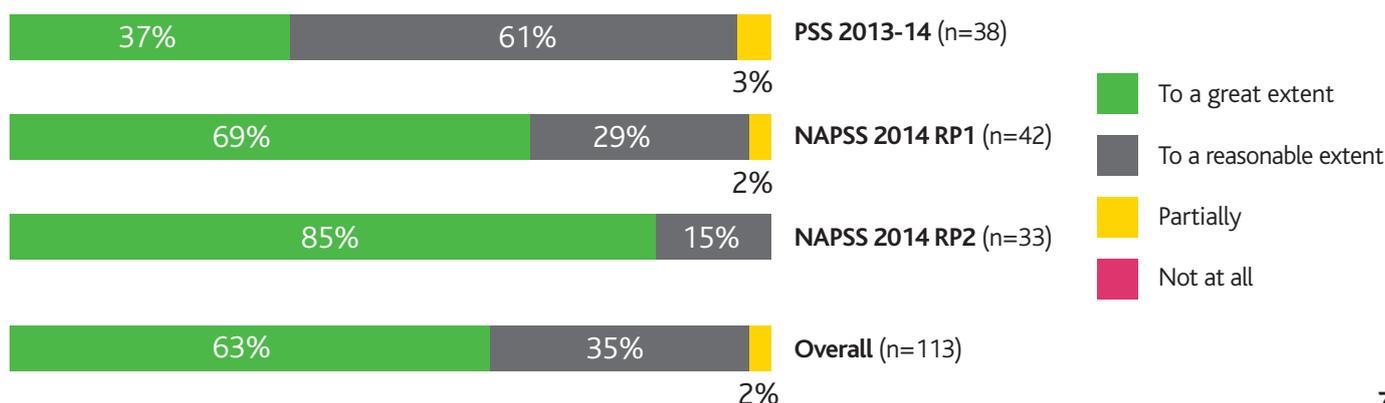
(NAPSS, 2014/15, RP1)



When comparing quantitative and qualitative feedback of the CPD received from the participants on the PSS 2013/14 and NAPSS 2014/15 courses, the evaluation of PSS 2013/14 was less positive and contained slightly more critical comments from teachers than the feedback from NAPSS 2014/15. For instance, this is evident in the difference in teachers' assessment of how well the CPD achieved its stated learning outcomes (Figure 5). Although at all points, people were overwhelmingly positive (97-100%) that the outcomes were achieved, in 2014-15 there was a significant growth in the number of participants 'strongly agreeing' with the statement, especially at the last residential period (RP3).

Figure 5 Achievement of CPD outcomes

Question - To what extent were the stated professional development outcomes achieved?



A small, but significant difference between the course instance evaluations relates to teacher perceptions of how well the subject knowledge covered in the CPD sessions was integrated in teaching practice, i.e. how easy it would be for teachers to apply new knowledge to improve science teaching in primary schools. A few of the PSS 2013/14 participants indicated that the level of subject knowledge given in CPD was unexpectedly high and challenging and not relevant to their teaching needs. A selection of comments below gives a good overview of these sentiments:

I found the subject knowledge extremely difficult and feel that if it was up to year 7 / 8 this would be more appropriate than for primary school teachers.

Some of the course content was of a very high level which was quite difficult.

Lots of very interesting knowledge and experiments. However uncertain of relevance back in school.

The subject knowledge I gained was great. Would have liked more practical ideas for cells and evolution and inheritance.

The hands on sessions were much more effective and useful. Although subject knowledge was developed in all sessions, some was well beyond the level required.

”

This formative feedback was used by the course leaders, who consequently adjusted the course materials and resources and made more explicit links to primary science with more practical suggestions for enriching and improving primary science teaching. The research and practice-based evidence underpinning the CPD, strongly indicates that conceptual understanding of science is crucial for developing effective and confident teachers of science. Therefore, it was necessary to ensure that learning of the science subject content knowledge was a core aspect of the CPD. This had two important implications for further revisions of the primary science leadership CPD:

- a) any increase in time spent on improving teacher pedagogical practice did not jeopardise teachers' learning of science content knowledge; and
- b) prospective and actual course participants have to be fully informed of the benefits of learning science content knowledge.

Following this review the CPD leaders made revisions to the course description and content, improving the explanation of the conceptual model underpinning this CPD for primary teachers: to achieve the improvement in teaching and learning of science by developing teachers' subject knowledge and addressing common misconceptions and knowledge gaps that stretch beyond the minimum level necessary for teaching science in primary school.

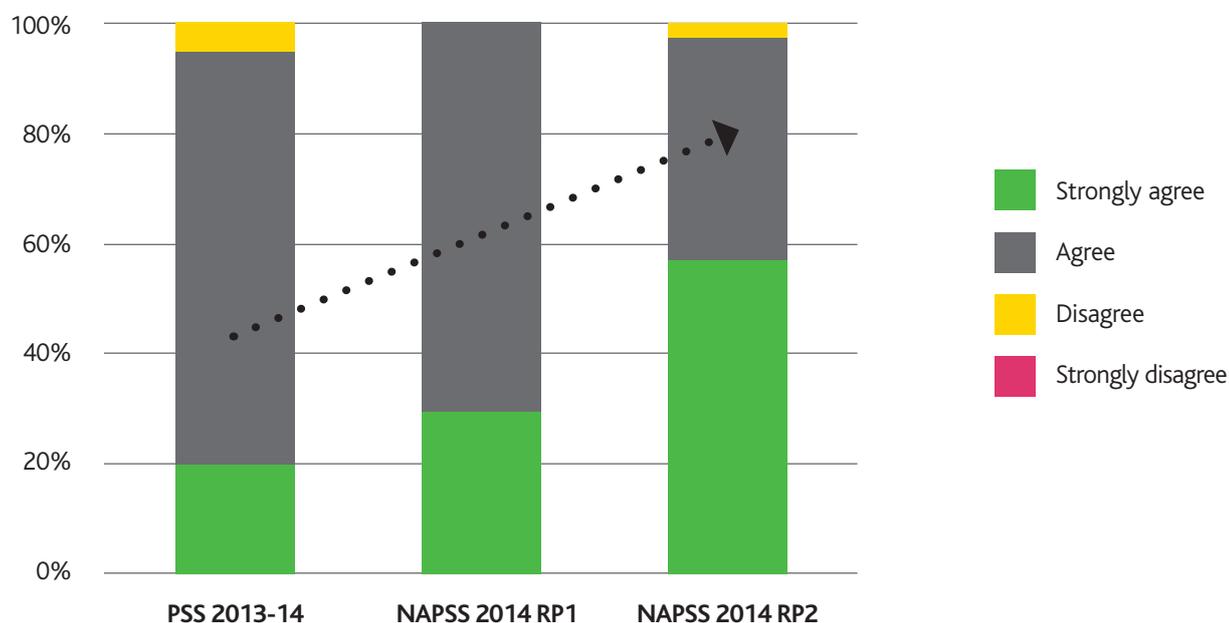
The feedback after the first residential period of the NAPSS 2014/15 course showed that the measures helped alleviate most of teacher concerns, yet a minority of participants continued expressing wishes for the course to be fully focused on teaching primary science:

I feel that it has made me more confident with my subject knowledge so that I can teach to a higher level and extend the children's knowledge and answer their questions fully. However I feel for some sessions there were not enough links back to the primary curriculum and bringing it back down to the level of the children we teach which would give us more ideas of how to teach these areas in our schools.

”

More adjustments were made to the course materials for the following residential training periods, which was positively reflected on the later evaluation data: participants were significantly more positive about the applicability of the CPD to their teaching practice. Figure 6 shows a comparative improvement in participants' views on the relevance of the course content.

Figure 6 'The content was relevant and useful'



Teachers' follow-up comments complement the picture and show that teachers felt confident that what they learnt on the course was relevant and useful for their teaching practice:

This RP (residential period) has had a much tighter focus on the requirements of primary teaching whilst also going beyond to KS3 concepts which can allow gifted and talented pupils to be extended if necessary or misconceptions to be challenged.

The course, so far, will definitely help me to improve certain aspects of science throughout the school.

Feeling more confident to lead science. Feel more confident with my own knowledge. Feel motivated to return to school and raise profile of science across school.

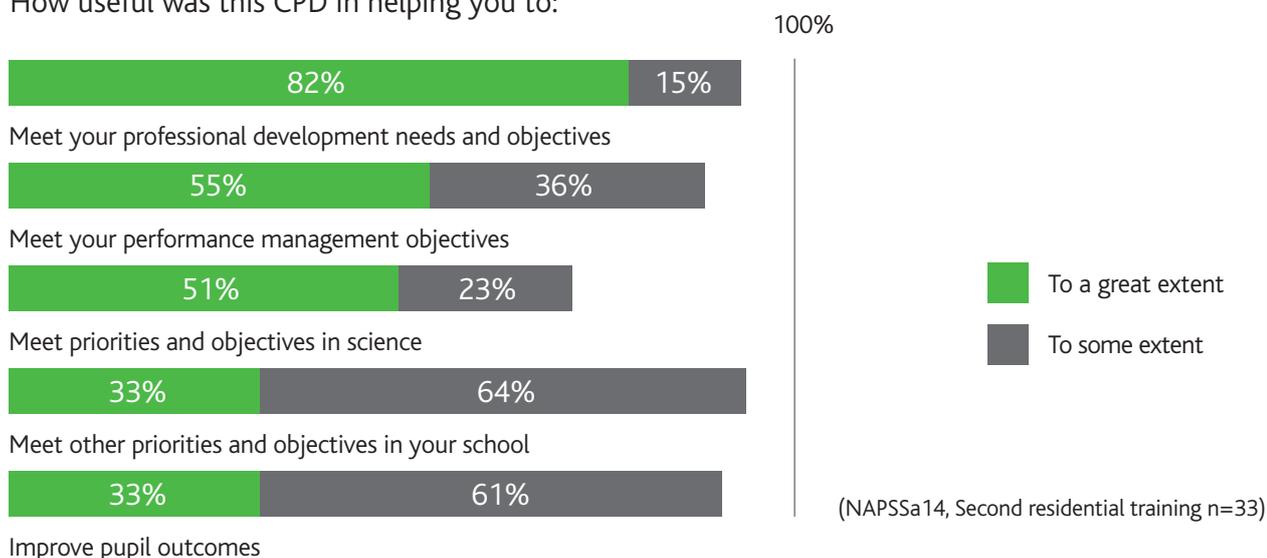
The course has provided lots of practical and useful ideas to take back to school. Lots of relevant information.

”

A new evaluation form which was used for feedback from the second residential period of NAPSS 2014/15, provided additional evidence of how effective the course became in supporting teachers' own professional development and in helping them improve science teaching across school (Figure 7).

Figure 7 **Linking CPD to school needs**

How useful was this CPD in helping you to:



This data is similar to the average evaluation statistics from other primary courses, especially in terms of meeting individual CPD needs and objectives. Yet, it also indicates that more could be done to support teachers' knowledge application and transfer.

It is a very good course. It really makes you work as you have to make action plans and completed them at school.

I have really enjoyed the CPD and am looking forward to the next residential.

Fantastic two days. Could not have asked for anything more. A great opportunity for me. Thank you.

The whole course has been extremely valuable in extending my subject knowledge and in leading science in school. I have taken away some great ideas that I can use in the classroom and suggest to colleagues. The gap tasks have led me to have a greater understanding of science in school.

”

5_Reported impact

Impact data collected from various sources and at different points during the CPD course has provided consistent evidence that the primary science specialist courses have been very successful in achieving their main objective, i.e.

to develop teachers' science subject knowledge and pedagogies and by doing so achieve tangible and verifiable improvements in teaching practice and pupil outcomes as well as raise the quality of science teaching across the whole school.

All teachers (100%) were able to achieve changes, which positively impacted their knowledge and teaching practice, their pupils, colleagues and school. All PSS 2013/14 course attendants and 97% of NAPSS 2014/15 teachers rated the overall impact of CPD as high or medium (Figures 8 and 9).

Figure 8 Overall impact

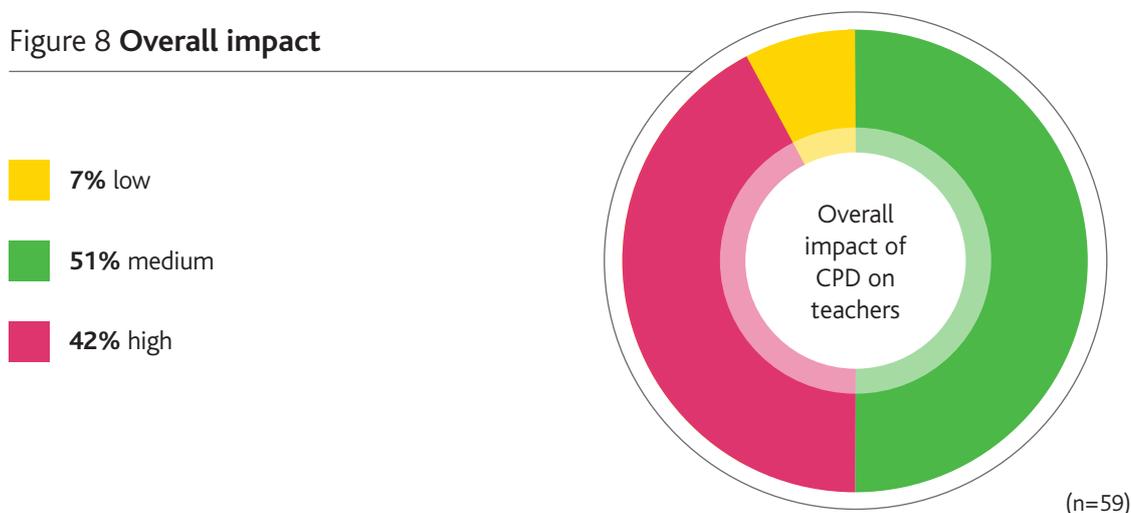
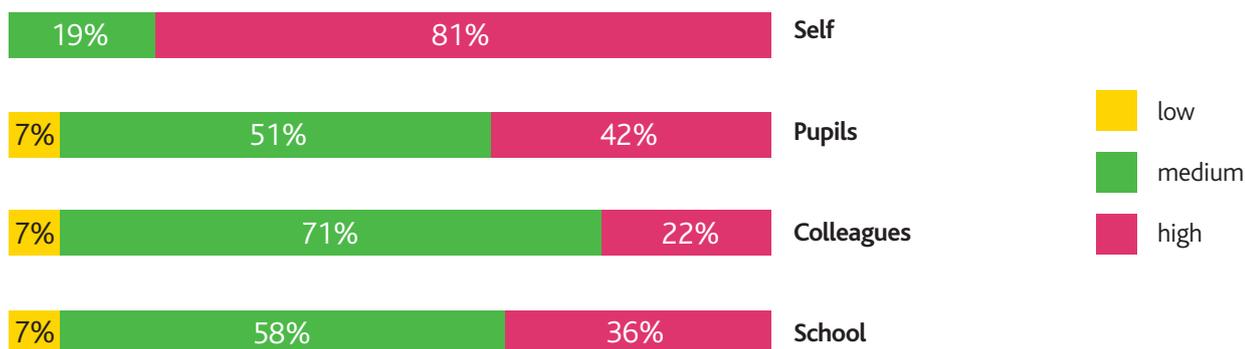


Figure 9 Rating of impact in regard to different outcomes



I have developed the confidence to support colleagues and have implemented a new scheme of work and assessment system for science. I have raised the profile of the subject because of my improved enthusiasm.

(PSS 2013/14)

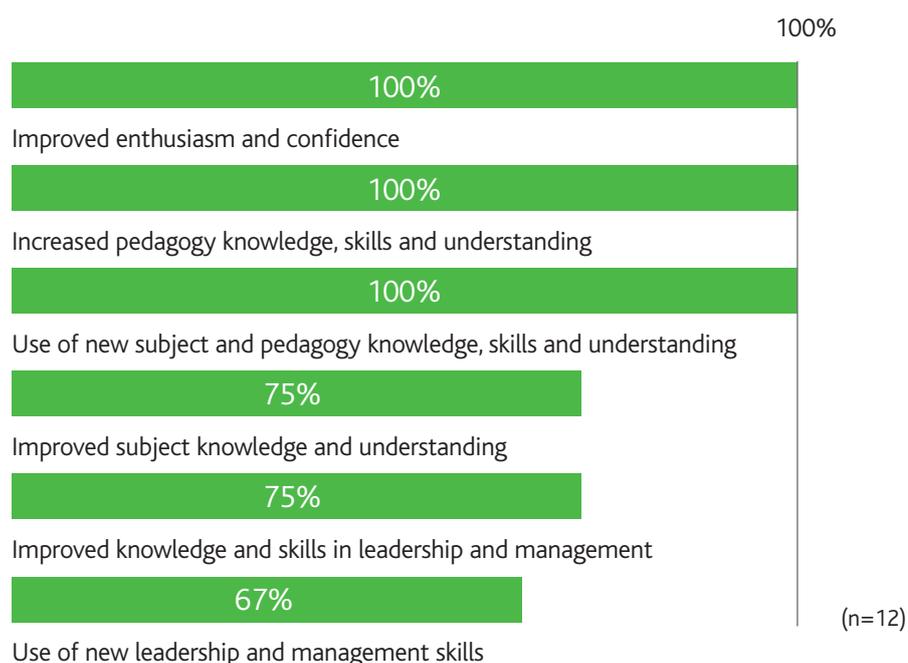
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5_1_Impact on teachers

Teachers were unanimous in crediting CPD with very significant impact on their own knowledge and understanding of science subjects and pedagogies, on their ability to teach primary science in engaging and innovative ways and on their skills in supporting/leading colleagues' development of science teaching.

When completing their impact reports, all but one participants of the PSS 2013/14 course (93%) rated the impact on self as 'high' with the remaining teacher marking it as 'medium'. When asked to identify relevant areas of personal impact, all teachers identified multiple impacts, demonstrating a wide-ranging and comprehensive impact on their professional knowledge and practice (Figure 10).

Figure 10 PSS 2013-14: detailed impact on self



Although the impact data collected for the PSS 2013/14 course was very positive, it had a relatively small sample size, n=12, which limited the robustness of conclusions. In 2015, we were able to gather more comprehensive and diverse evidence of impact for the NAPSS 2014/15. The data showed that the impact on teachers reported in 2014-15 (NAPSS course) was very similar to the PSS2013/14 statistics: 83% of the NAPSS 2014/15 participants rated this impact as 'high' and 17% as 'medium'.

NAPSS teachers made very similar positive comments on the improvement in their professional knowledge and practice, improvements that were visible in their classroom teaching and in leading/supporting science teaching in school:

I had gaps in biology, which the course has helped me with. I have a much more practical attitude to science teaching.

I have become much more confident and can now run CPD at my school to improve the practice of others.

This has been a fantastic course. My knowledge has improved immensely and I have greater confidence when supporting staff and leading a core subject. I have used many of the activities in the classroom and have started a science club that has been oversubscribed since it began.

The course has provided a good network of resources and given me the confidence to begin to tackle the improved teaching of science in my school.

”

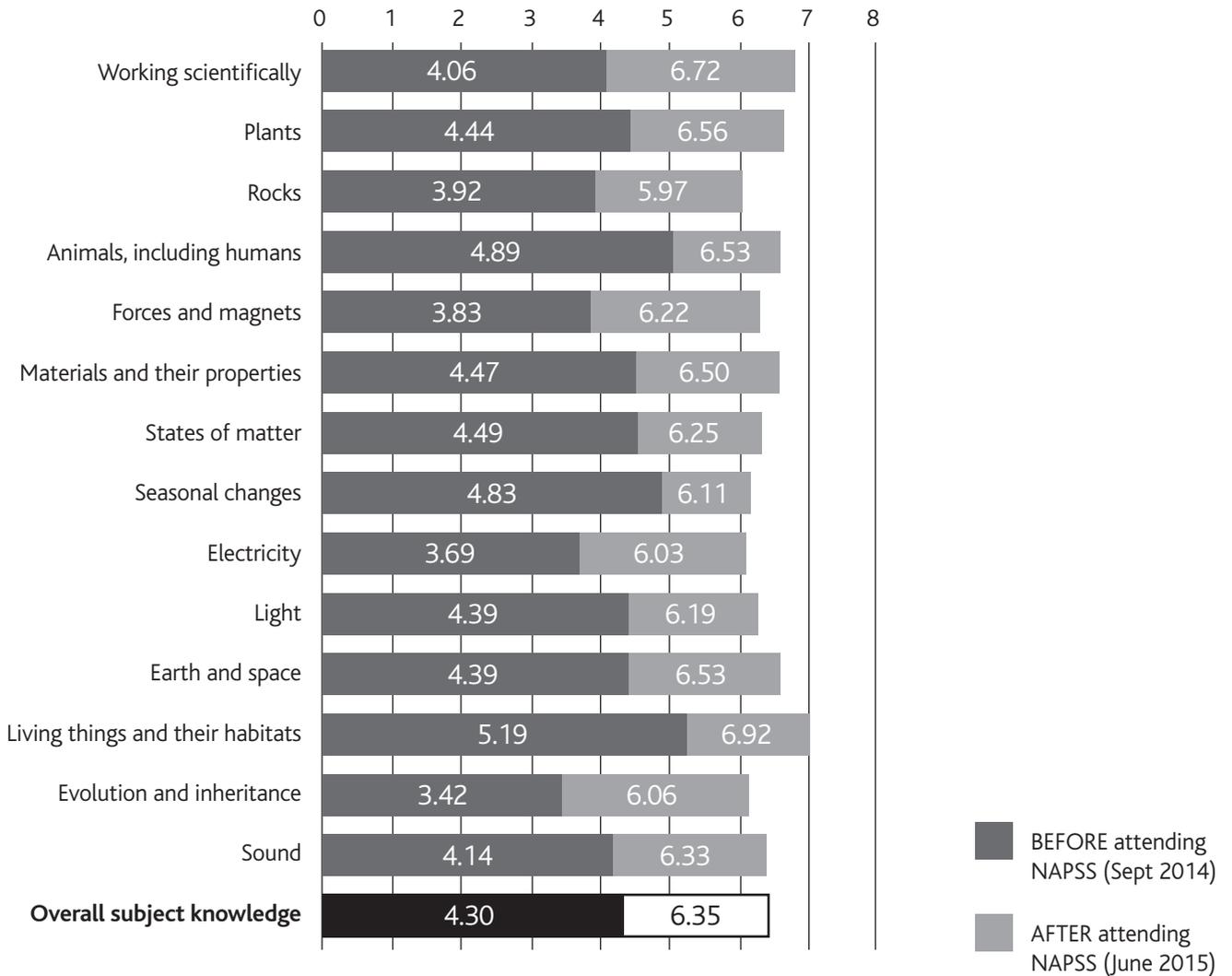
New data not only confirmed the findings from the previous year, but also presented an opportunity to explore the breadth and depth of achieved outcomes and impacts. For example, to further investigate the impact of the CPD on teacher content and pedagogical knowledge, we designed a special survey instrument (using an 8-point scale design) and invited teachers to assess their science subject and pedagogical knowledge against a list of items representing key subject areas of the new primary science curriculum and key science-specific pedagogical practices. Teachers were asked to complete the survey before³ and after their engagement with the CPD.

The 'before-after' comparison of teacher knowledge and skills are presented in Figure 11. They indicate a substantial increase in teacher science and pedagogy knowledge across all aspects of teaching the primary science curriculum. The overall difference between the scores 'before CPD' (M=4.27, SD=0.53) and 'after CPD' (M=6.34, SD=0.33) was more than 2 points, which corresponded to a 49% overall improvement to the 'baseline' position. Implementing a paired T test confirmed that the observed change in scores was statistically significant, $t(20) = 19.38, p \leq 0.01$.

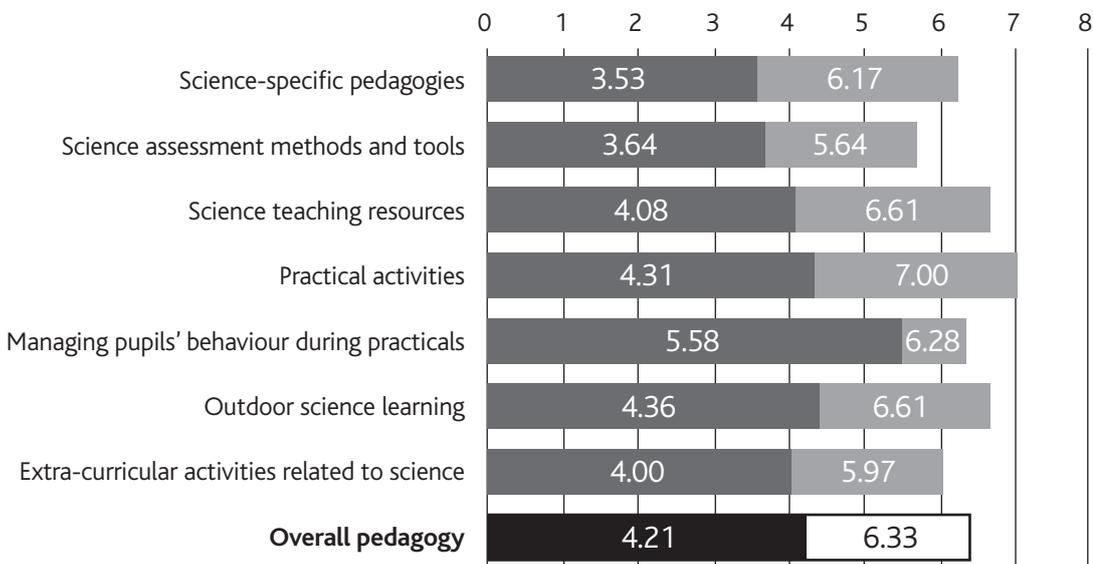
³ This was a retrospective measure

Figure 11 Teachers' self-assessment of their subject and pedagogy knowledge of teaching the primary science curriculum: *BEFORE* the CPD course (Sept 2014) and *AFTER* (June 2015)

Science content knowledge



Science pedagogy



The two areas of subject and pedagogy knowledge that showed the largest increase were:

- knowledge of 'evolution and inheritance' module of the primary curriculum: rated at M=3.42 (out of maximum 8) at the onset of the course, the knowledge of this subject area grew 77% to reach M=6.06 by the programme end
- knowledge and use of science-specific pedagogies: before CPD teachers on average rated their position as slightly below the midpoint of the scale (M=3.53), which by the end of the CPD course grew 2.69 points (M=6.17), demonstrating a 75% improvement to the initial score.

Other areas of subject and pedagogy knowledge, which showed increase in access of 60% were: working scientifically, forces and electricity, awareness of science-specific teaching resources and use of practical activities.

The abovementioned quantitative measures of impact on teachers were well supported by the qualitative evidence collected from the participants:

It has made me think harder in science lessons to make sure all children have practical experiences of science - moving away completely from using worksheets and taking opportunities whenever they occur, for example, the solar eclipse this year.

I have used a cross curricular approach displaying scientific knowledge through hyper linking. This proved to be very popular and it was only by feeling confident in explaining the expectations and encouraging the dialogue with pupils about how the work would be appropriate for their age expectations.

I have learnt that I can inspire and challenge teachers to provide better learning opportunities for the teaching of science.

(NAPSS, 2014/15, RP3)

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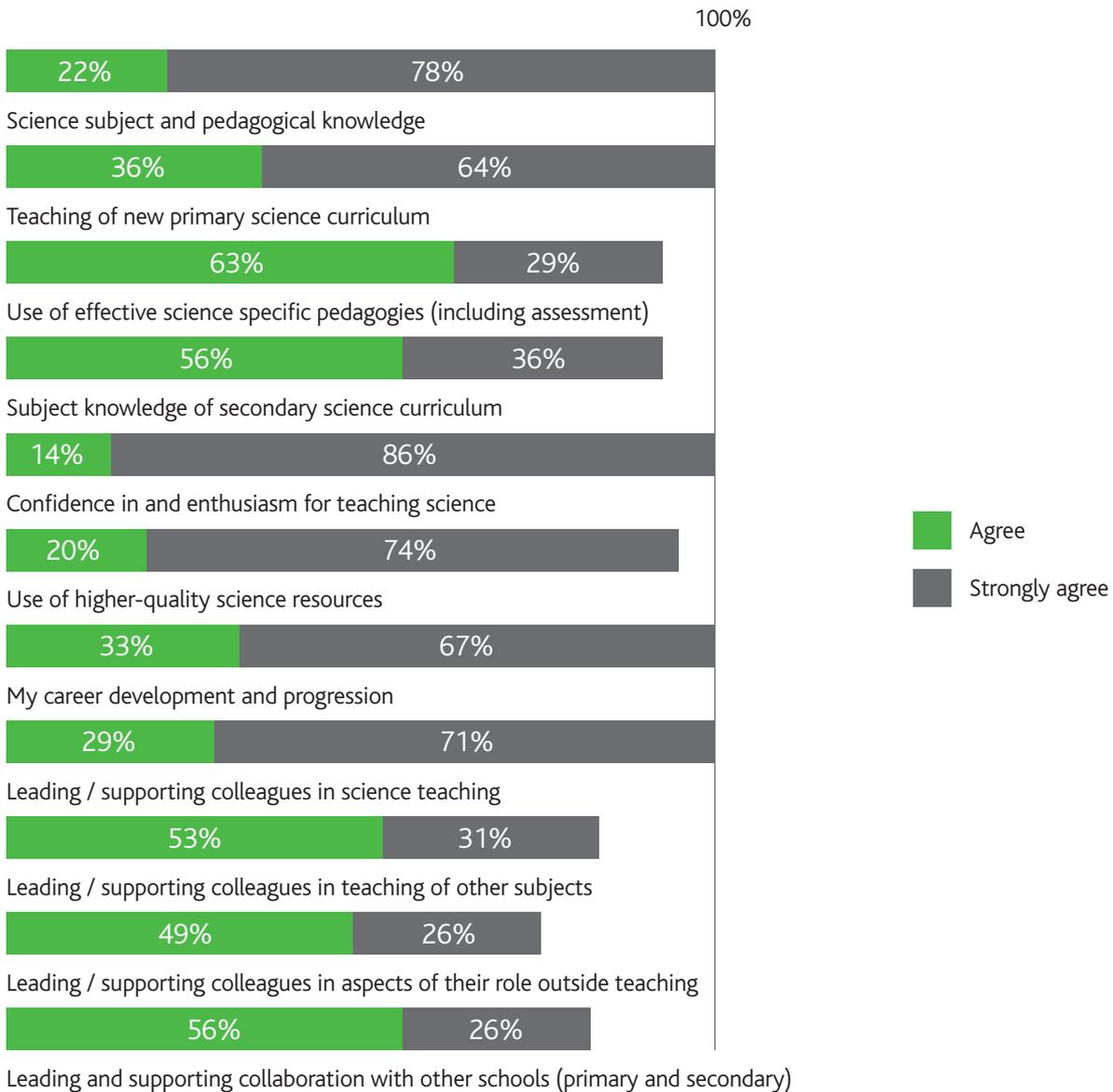
The online survey collected from the NAPSS 2014/15 participants also provided insights into how the CPD affected personal and professional life of its participants, thus creating a more comprehensive picture of impact on those directly involved in CPD. The results, presented in Figure 12, show numerous positive outcomes of the course which often extended beyond teaching and learning of science. For example, 84% of participants said that they were more able to lead their colleagues' professional development in areas other than science, while 75% saw impact on their general leadership skills (e.g. coaching and mentoring of colleagues).

Another important area of impact was the effect on participants' career development and progression. As is shown in the Figure 12 all teachers reported positive changes in regard to career growth. This claim received additional support when we compared how teachers described their professional position within school in April 2015, during the second residential period, with their position in June 2015, during the third period of residential training. In April 2015, 76% of teachers described their position as a 'science subject leader however, when they returned for fourth CPD session in June, nearly all (92%) described themselves as 'science coordinator/subject leader'.

Figure 12 **Impact on teacher participants**

(% of teachers who agreed / strongly agreed with the impact statements)

'This project has helped me improve in the following areas:'



"Miss, you have unlocked the mystery of science for me"

NAPSS teacher recalls her pupils' attitudes to science lessons

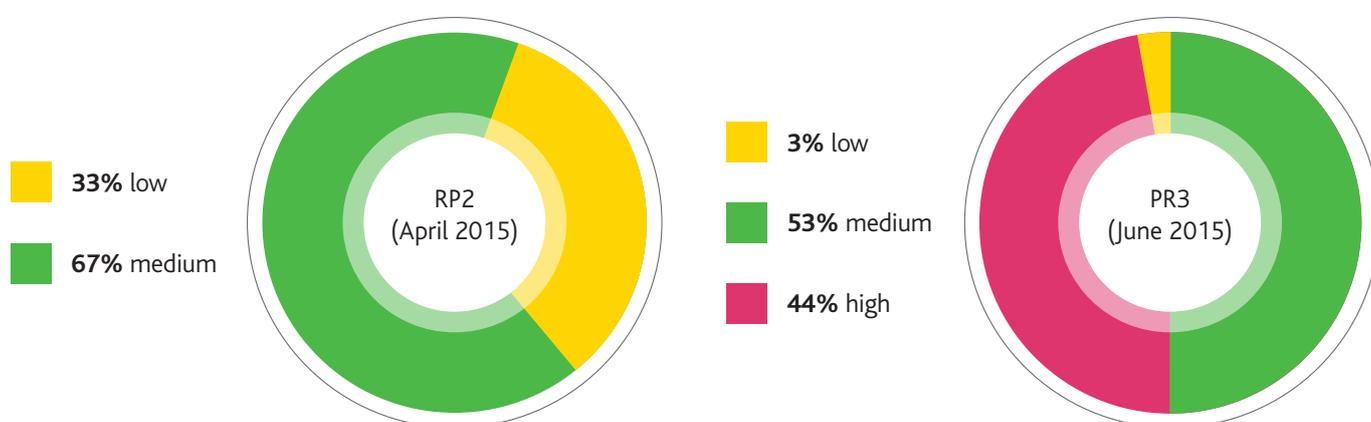


5_2_Impact on pupils

The evidence collected to date shows that the primary science specialist CPD has been very successfully in facilitating significant improvements in the quality of teaching and impact on pupil outcomes for participants and those taught by their colleagues. In both years, the impact on pupils reported by teachers by the end of the CPD training was either medium (50%) or high (50%).

It has been long acknowledged that positive changes in pupil outcomes take significantly longer than changes in personal or even colleagues' teaching practice. This was put to test when we compared impact data collected from the same teachers at two different points during the CPD course. As predicted, impact on pupils reported by the end of the NAPSS14/15 course (June 2015) was noticeably higher than the impact reported by the same teachers in the middle of the training (April 2015). However, it was quite surprising to see that in the space of just two months teachers made a significant leap forward as the qualitative difference in the level of reported impact was staggering. (Figure 13).

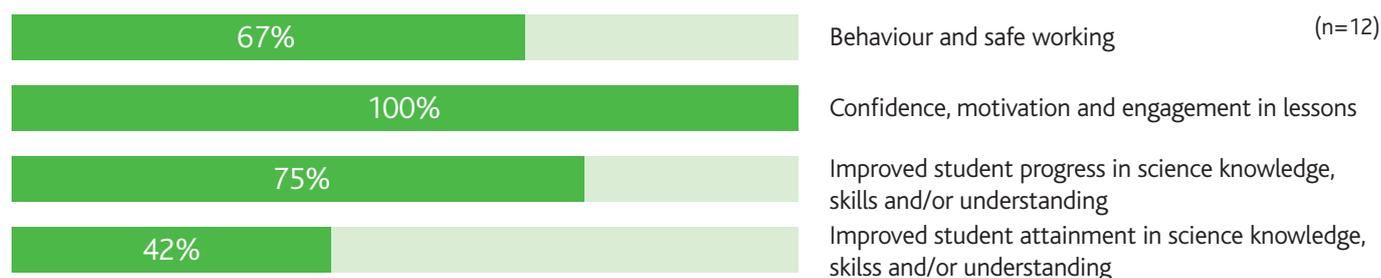
Figure 13 NAPSS 2014-15: Impact on pupils reported at different points of the CPD course



- In the middle of the course (second residential period in April 2015) no teachers described the impact on pupils as high and a third said it was low. Their comments describe the impact as 'emerging' and the evidence as 'forthcoming' or 'anticipated'
- At the end of their training (third residential period in June 2015) four out of ten reported high impact with all but one remaining teachers describing it as medium. Moreover, most were able to substantiate their claims with robust and substantial evidence

The impact data for the PSS 2013/14 course was collected through the standard STEM Learning impact report form, which featured four pre-set options describing pupil outcomes. The findings from the analysis are presented in Figure 14.

Figure 14 PSS 2013-14: detailed impact on pupils



Teachers were most confident to report impact on emotional and motivational aspects of pupil learning (100%), yet were reluctant to identify impact on attainment (42%). However, three quarters of the participants confirmed a positive impact on pupil progress in learning science.

One teacher commented that it was "too early to say if attainment has improved across the whole school but current new assessment data suggests it has", indicating that a modest change in attainment could be at least partially explained by the timing of completing the impact report (March 2015), i.e. well before the end of the academic year.

More rigorous and comprehensive impact data was collected in relation to NAPSS 2014/15. The evidence of impact on pupils consisted of the following sources:

- teacher assessment of pupil attainment and interest in science in the beginning of the academic year (September 2014) and at the end of that year (June 2015). This was measured for all pupils they teach and for different groupings of pupils (e.g. SEN, EAL)
- teachers' general feedback on various impacts of the CPD on pupil outcomes
- individual pupil records showing attainment and progress in science in relation to nationally expected age-related outcomes
- teachers' testimonies (written and oral) describing impact on pupils

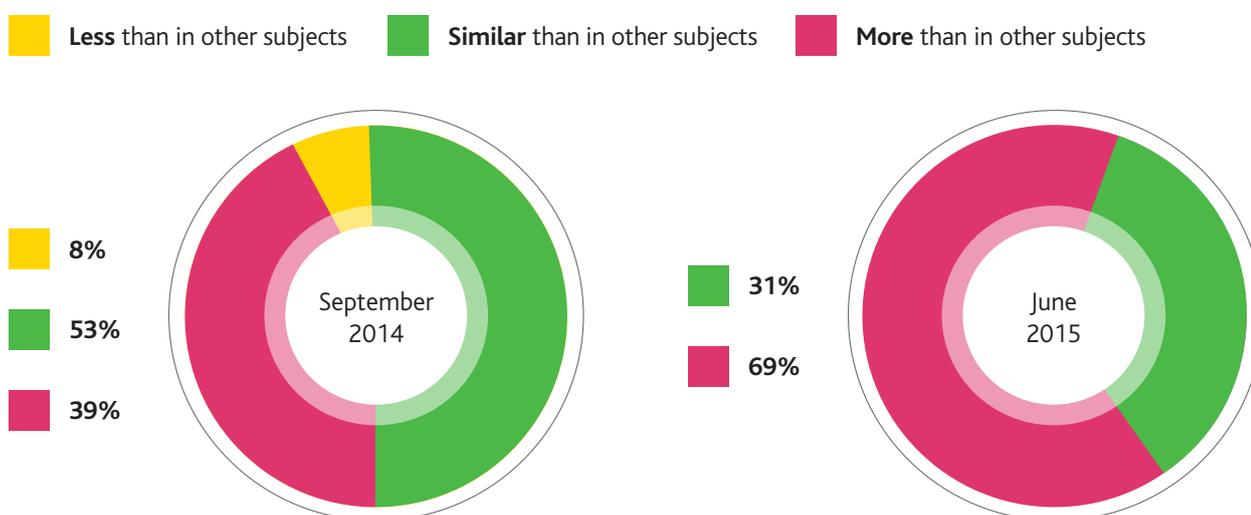
This methodology allowed data and method triangulation, leading to a more robust set of conclusions regarding the achieved impact on pupils.

5_2_1_Impact on pupil motivation and engagement with science

According to the NAPSS14/15 participants, the CPD provided them with new teaching ideas and resources, which were easily applied to classroom teaching and which they were very inspired to implement. This was instrumental in improving teaching of science first in their classrooms and then across the school, leading to a significant increase in pupils' interest and enjoyment of science lessons.

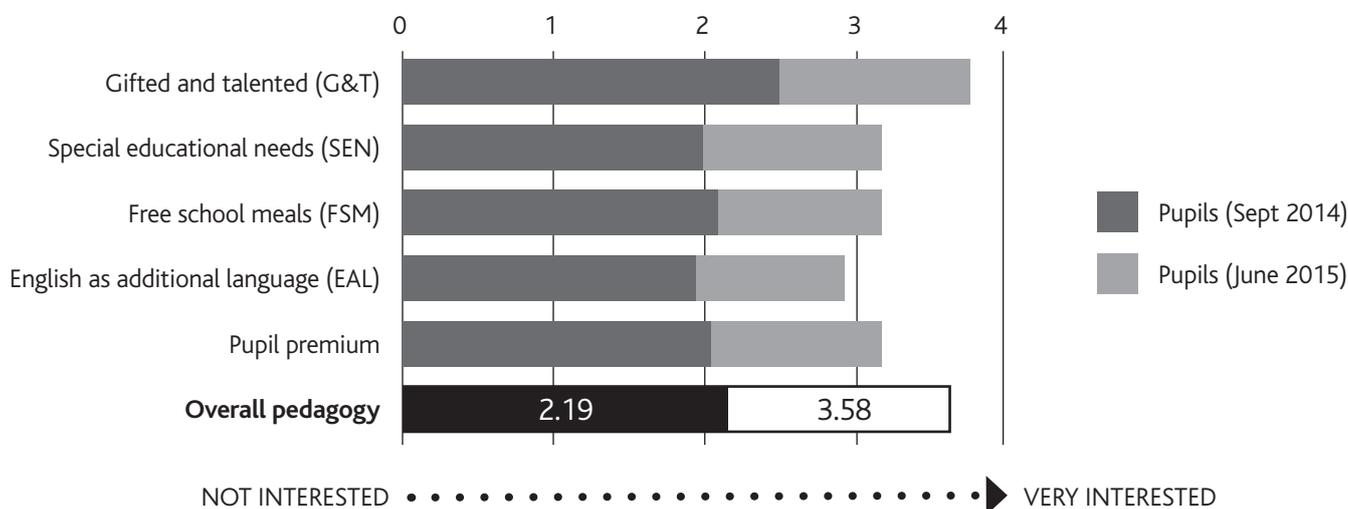
Teachers assessed pupil interest in science lessons relative to their interest in other subjects at two points – at the beginning of the academic year (retrospectively) and at the end of the year (the actual time of the survey). The results are presented in Figure 15 and show a massive increase in pupils' interest in science lessons in comparison to other subjects.

Figure 15 **Pupil interest in science**



Using a similar approach, which combined retrospective and 'present day' assessments, teachers measured the interest towards science demonstrated by different groups of pupils. The findings confirm a significant increase in pupil interest in science across all categories of pupils, particularly benefitting the 'gifted and talented' and all pupils (Figure 16).

Figure 16 **Pupils' interest in science: BEFORE and AFTER teachers' attendance of the NAPSS CPD course** (Average score on a four point scale based on teacher assessment of pupils)



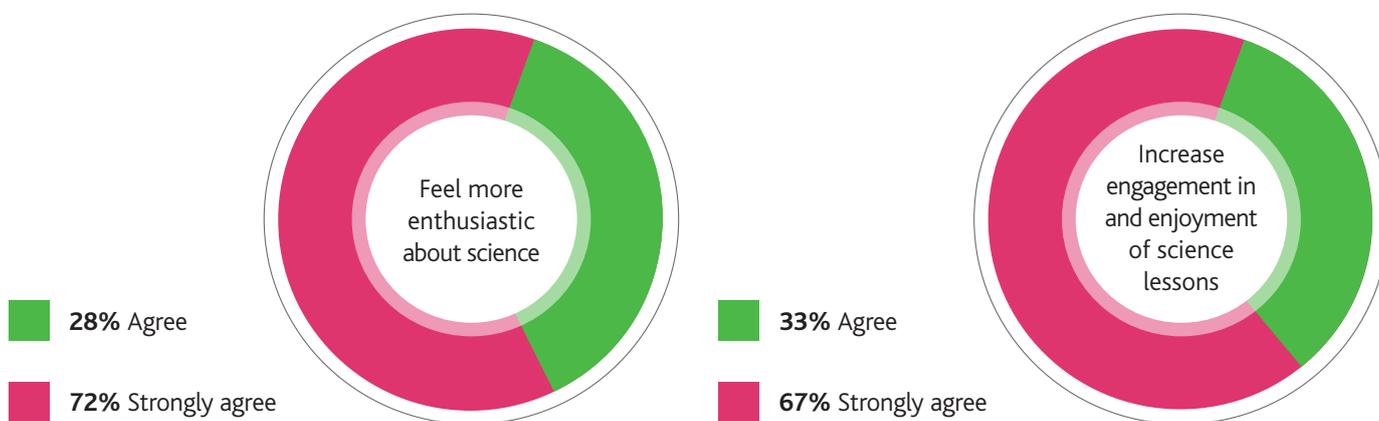
The additional benefit experienced by the 'gifted and talented' is not surprising, given that the main focus of CPD was on improving and stretching teachers' subject knowledge and providing teaching resources that extend beyond the primary science curriculum, thus allowing teachers to set challenging tasks for the most able pupils.

In feedback teachers reasserted how much now pupils enjoy science and some of the respondents directly attributed this positive change to improvements in teachers' subject knowledge and confidence:

To test out the attribution claim, a separate question on impact on pupil outcomes was added to the survey. Teachers were asked to rate impact of CPD on pupils' enthusiasm and engagement in science (Figure 17). All 36 survey respondents agreed that the CPD helped to achieve these outcomes with more than two thirds saying they 'strongly agree' with each statement.

Figure 17 **Impact on pupils' motivation and emotional engagement**

'This CPD course has helped make pupils in my school...'



Buzzing children showing off their science learning in a celebration science week assembly.

Children are enthused particularly with open ended investigations where they have to find the best way...

Children feel more in control of their learning and as a result are more engaged.

Children telling me that their enjoyment has increased and saying that they love science.

More of a positive buzz around children. Pupil voice after science week was amazing!

Planning and resourcing is renewed and improved with a higher practical content which has a positive impact on pupils renewing their interest in science and trying to increase their awe and wonder of the world.

Pupils are now more engaged due to their teachers having a higher enthusiasm and better subject knowledge.

”

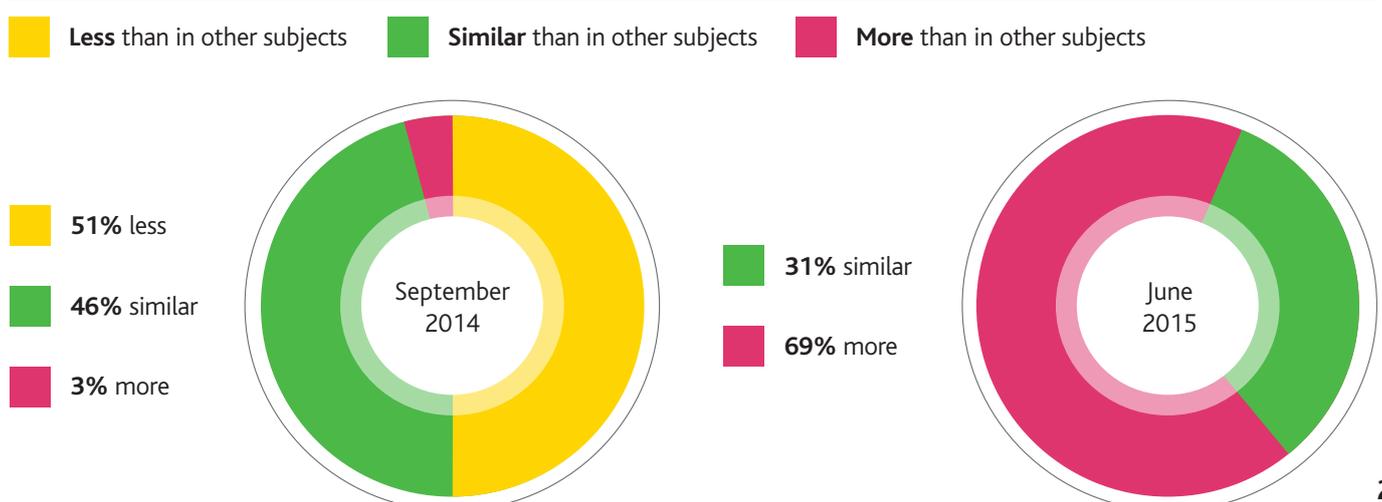
5_2_2_Impact on pupil attainment and progress in science

Obtaining relevant data to assess the impact of CPD on pupils is often very challenging, especially in primary school. When teachers report on impact, quite frequently they say that changes in attainment take long time to register and that at the moment they are not yet able to comment on such impact. However, even when the same teachers are re-approached later, many feel unable to attribute any improvements in pupil outcomes to CPD that they attended long time ago. This is possibly due to teachers' insecurity in undertaking evaluation and/or their concern about claiming causal relationships. To address this issue the NSLN embeds reflective evaluative practices into CPD, so teachers are supported in using techniques to assess pupil outcomes before and after the changes to their practice arising from the CPD (e.g. pupil voice).

As a result of feedback from the PSS 2013/14 course, more practical resources relevant to primary school were embedded in the NAPSS 2014/15 course. Such resources also included tools for measuring attainment and progress in pupil learning. Teachers were asked to provide two estimates of pupil overall attainment in science relative to their attainment in other subjects: the first measure was to rate the level of science attainment at the beginning of the academic year; and the second - to assess the attainment at the end of the school year. This improved teachers' ability to assess pupil attainment and progress and evaluate the impact of using new pedagogies and resources in their science teaching. This helped many teachers to feel more confident in assessing and attributing impact to CPD and their post-CPD actions.

The findings (Figure 18), indicate an increase in pupil attainment in science, similar to increases in pupil interest in science lessons, within the academic year.

Figure 18 Pupil attainment in science



To triangulate the above findings, we collected individual pupil data on science attainment and progress from 13 NAPSS 2014/15 teachers. The data contained science attainment measures for the start of KS, the start of the school year (September 2014), predicted and de facto end-of-the-school-year attainment (Sept and June 2015), as well as teacher assessment of pupil progress. It also contained student background details, including gender, year group and pupil premium categories for 350 pupils, 129 of which were of KS1 and 221 – of KS2 pupils with a ratio of boys to girls being 49:51.

With the removal of attainment levels, schools use a range of different methods and techniques to assess pupil attainment in science. This presented a serious methodological challenge and left no alternative but to reduce the measurement to a very simple three point scale that is based on general national guidelines for assessing attainment in science.

Many teachers reported improvements in pupils’ scientific vocabulary during Interviews:

A very challenging boy ... [now]... loves the practical science sessions; fully cooperates, uses correct vocabulary, can predict and talk about outcomes. He has encourages a lot of my 'boys' to want to investigate and predict and to some extent evaluate their learning.

”

Teachers also reported improvements in pupils’ ability to work independently, ask questions and conduct investigations:

Running a successful science club that is over-subscribed. The questions and discussions are amazing and the children go home and talk about science with parents, who then talk to me in school.

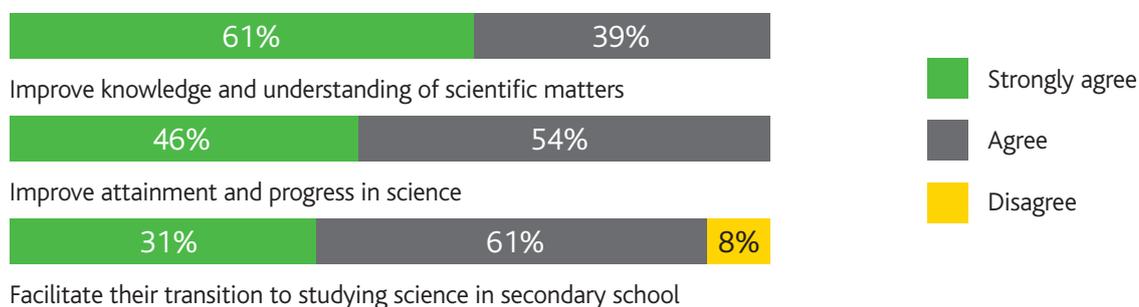
Children now: can think scientifically; can ask scientific questions, can come up with their own investigations.

”

When asked about the attribution, teachers were happy to make an explicit connection between positive changes in pupil learning and the CPD training they received (Figure 19).

Figure 19 **Impact on pupils’ learning**

‘This CPD course has helped pupils in my school...’



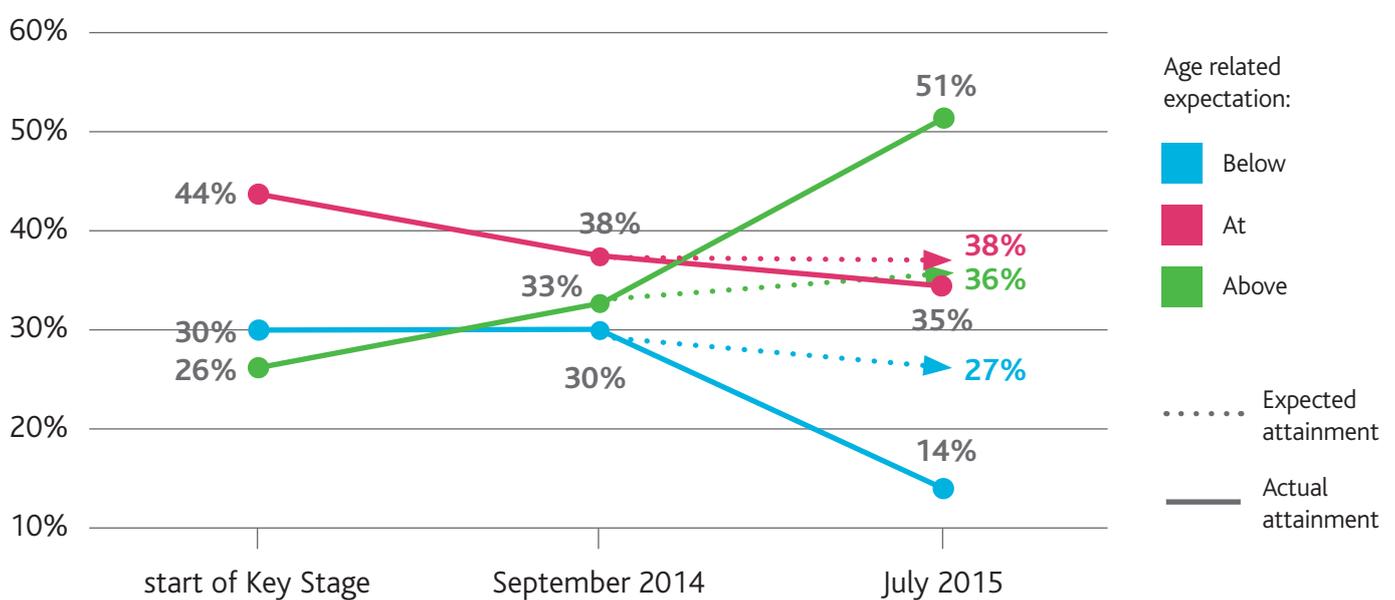
- (+) pupil’s attainment exceeds age-related expectations
- (=) pupil’s attainment meets age-related expectations
- (-) pupil’s attainment is below age-related expectations

The data analysis showed that by the end of the academic year more pupils achieved higher results in science than was expected at the start of the year and that around a third of all pupils showed really good progress, which exceeded teachers' expectations.

In September 2014, 42% of students were predicted to perform above age-related expectations by the end of the academic year, but by June 2015 the actual number of pupils performing above age-related expectations was 51% – a 9% increase above the expected levels.

Even more impressive was the improvement among those, who at the start of the school year were forecasted to perform below age-related expectations (n=52): by June 2015 31% of those pupils were at or above the nationally expected level for their age. Among those, expected to reach the national age-related level (n=147), 26% progressed to 'above expected' level (Figure 20).

Figure 20 NAPSS: Pupil attainment



The three point scale allowed only limited measurement of the attainment of pupils who at the start of the year already were exceeding age-related expectations (n=147). Only nine of such pupils did not meet the forecasted level of 'above expected' and finished the academic year as 'at the expected' level, while 94% of more able pupils retained 'exceeding age-related expectations' status. What this measure could not indicate is whether there was any additional improvement and if so, how great was the change, in the attainment of the top performing pupils.

To overcome this methodological limitation we looked at 'pupil progress', which teachers assessed using a similar three point scale: pupil's progress in this school year has met (=), exceeded (+) or failed to meet (-) the teacher's expectations (Table 1).

Table 1 Progress of pupils of different ability groups (also shown by gender)

PERFORMANCE at the start of the academic year	Gender	N	PROGRESS in relation to teacher expectations:		
			EXCEEDED	AS EXPECTED	BELOW THE EXPECTED
BELOW age-related expectation	girls	47	15%	66%	19%
	boys	55	24%	62%	15%
	overall	102	20%	64%	16%
MEETING age-related expectation	girls	9	25%	68%	6%
	boys	52	31%	63%	6%
	overall	131	27%	66%	7%
ABOVE age-related expectations	girls	53	38%	58%	4%
	boys	61	34%	64%	2%
	overall	114	36%	61%	3%
ALL GROUPS OF PUPILS	girls	179	26%	65%	9%
	boys	168	30%	63%	7%
	overall	347	28%	64%	8%

Overall, 28% of pupils progressed above the expected rate, but for the top performing pupils, i.e. who at the start of the year were performing above the age-related level, this number was higher: 36% of those pupils improved more than their teachers expected them to progress. Interestingly, in the 'below' or 'at expected level' groups there were slightly more boys than girls exceeding teachers' expectations, but in the top-performing group the relationship was reverse as 38% of girls and 34% of boys improved more than was expected.

Also interesting is that more pupils in KS1 ended the year exceeding teacher expectations than in KS2 (Table 2), however this difference was not statistically significant ($p < .05$), so we can't draw further conclusions.

Table 2 Pupils with progress in science in 2014-15 exceeding teacher expectations

Key Stage	Gender	No of all pupils	% progress expected teacher expectations
KS1	Female	66	32%
	Male	63	32%
KS2	Female	114	23%
	Male	107	29%

'My Champagne moment' ⁴ Participants' reflecting on changes in teaching and learning of science

I used 'what if...' strategy to ask "what would happen if water could not change state?" One of the children, who is usually not confident in science, shouted out; "There would be no rainbows". It was then I realised that she had understood about 'changes of state' and the 'water cycle'.

Being on the NAPSS course has really raised the profile of science at our school, which had been very low profile. I have initiated lots of new projects, for example, pupil surveys, joint lesson planning and teaching, winning £1000 from Rolls Royce, improving action planning, more practical hands on experience for children.

It has made me think harder in science lessons to make sure all children have practical experiences of science - moving away completely from using worksheets and taking opportunities whenever they occur, for example, the solar eclipse this year.

”

*"Yes, science!" Realising children who used to find science boring are now excited and engaged
Children all enthusiastically taking part and learn/discover more...*

”

Talking to a visiting Yr. 7 pupil whom I taught in yrs. 5/6. She has just been awarded scientist of the year and said it was because of my teaching. Validated my work and teaching. I felt positive about my teaching.

”

Watching all children engaged in an open-ended investigation including those with challenging behaviour. All learnt something, [showed] enthusiasm for science [and] verbal reasoning.

”

⁴ This was the title of a reflective exercise that the participants of NAPSS 2014/15 performed during the final residential period in June 2015. The tasks included a) recalling the most memorable episode from their teaching practice in the past year ('Champagne Moment'), b) reflecting on the impact and c) reviewing changes in teaching practice

5_3_Impact on colleagues/school

I will now be more willing to lead whole school investigations like science week and make sure that all staff are helping to make great progress in science.

(NAPSS 2014/15)

The primary science specialist course is aimed at supporting subject leaders to develop leadership and management skills and improve science teaching across the school. Impact data collected to date shows that these objectives were successfully met. Participants of both PPS 2013/14 and NAPSS 2014/15 courses reported a range of wider impacts on science teaching and learning with significant impacts on raising the profile of science, increasing the confidence of colleagues to teach science and improving the quality of science teaching.

All participants reported sharing learning with colleagues in school; many said they did it on multiple occasions and in a number of ways and around a third have shared knowledge and resources with other schools (Figure 21 and Table 3).

Figure 21 NAPSS 2014/15 (n=36)

How have you shared the knowledge/skills and resources acquired through this CPD with colleagues?

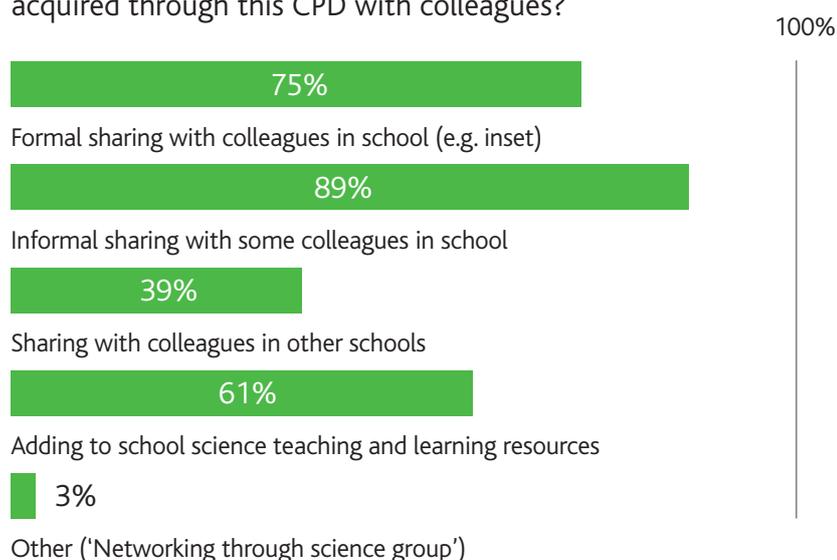


Table 3 Reported methods of shared learning, PSS 2013/14 (n = 12)

Departmental meeting	75%
Shared with small number of colleagues / working group	67%
Coaching / peer mentoring / lesson study	50%
Changes to schemes of work / lesson plans / assessment methods / resources	83%
Notes / slides etc. on VLE	25%
Other	17%

To facilitate this sharing, some of the 'gap tasks' between courses sessions required course participants to organise professional learning for colleagues and implement some of the newly learnt activities in classes other than their own. Here is how one NAPSS 2014/15 teacher described her experience:

Y6 teaching dissecting the heart. Kids buffing with excitement – impacted on 90 kids and whole Y6 team – very, very memorable moment. Y3 – kids pulling cherry blossom off trees, discussing the stigma and stamen in all the different flowers – All the different practicals. All children buffing with excitement. Science profile raised. From discussion with the children they love it.

Detailing wider impact on science teaching, many respondents mentioned the growing 'buzz about science' and all (100%) said that as the result of their work inspired by CPD, they raised the profile of science in the school.

This training has had a huge impact on the school. Science has significantly been raised in its profile and the children have had many more opportunities to learn through experiences, stretching their knowledge without the fear of getting things wrong.

(NAPSS 2014/15)



I have developed the confidence to support colleagues and have implemented a new scheme of work and assessment system for science. I have raised the profile of the subject because of my improved enthusiasm.

...before the Action Plan was implemented, the profile of science was low; mainly because of the delivery. Because of the CPD I now look for more interesting and engaging ways of covering the curriculum.

(PSS 2013/14)



It comes as no surprise that all participants reported a wide range of impacts that they achieved in their schools and beyond as a result of the CPD (Figure 22 and Table 4).

Figure 22 NAPSS 2014/15 (n=36)

Wider impact on school/colleagues This CPD course has helped our school improve in these areas:

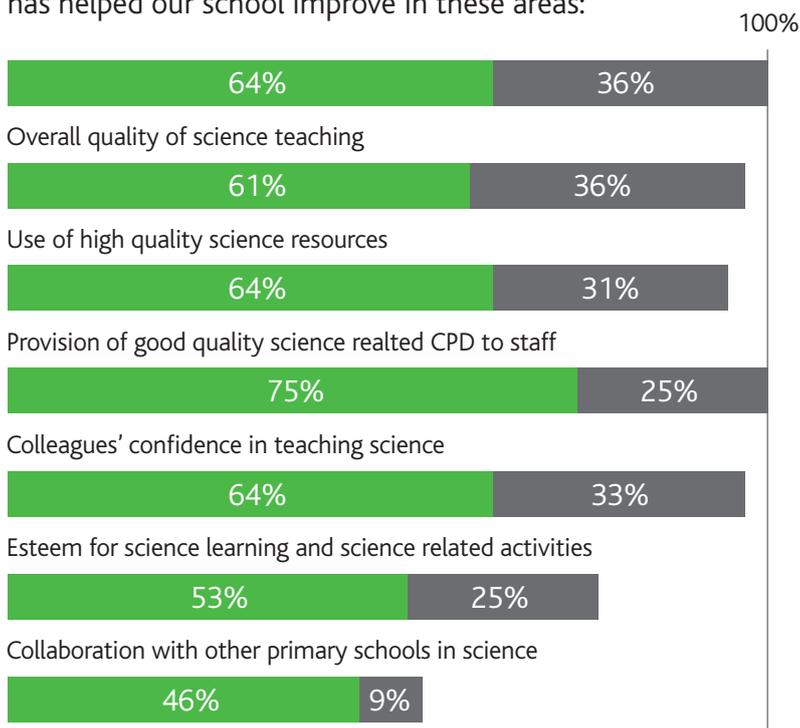


Table 4 Impacts on colleagues and school reported by PSS 2013/14 (n =12)

Improved quality of teaching	58%
Improved student progress and attainment	42%
Raised profile/priority of science	100%
Improved leadership of the science department/science curriculum	75%
Sharing of effective practice and resources	92%

■ Agree
■ Strongly agree

Staff are now more confident to teach the new curriculum for science due to my support with ideas for practical working scientifically- through informal and formal CPD.

Children having sessions from imperial university students, going to the local feeder secondary school for science sessions, having the secondary school children come to us for workshops, going to partner school to share findings from science week projects and lots more enrichment trips organised.

I have felt confident enough to contribute to the development and discussion about science across the cluster.

(NAPSS 2014/15)



5_4_Using evidence to verify the impact

As part of the CPD, teachers learnt how to provide evidence of impact on teaching skills and pupil outcomes. They have also gained knowledge and understanding of how to use data to improve science teaching and learning as well as improved their evaluation and research skills.

In the words of one teacher participant, who was asked about lessons learnt from the CPD and their implication for his future work, he sets himself the following tasks:

...More rigorous baseline data; formalise the way information is shared within school; celebrate the science across the school.

To assess the department initially, discuss strategies to take the department forward and secure the staff agenda as a team, assessing impact at regular intervals through the methods used on this course such as pupil voice, staff surveys.

(NAPSS 2014/15)

”

Teachers were required to provide tangible evidence of the impact of their 'gap tasks', e.g. results of pupil feedback surveys or pupil work, to demonstrate evidence of impact in their schools (Figures 23a and 23b). Some of the evidence was also posted online in the shared community group space on national STEM Centre.

Figure 23A

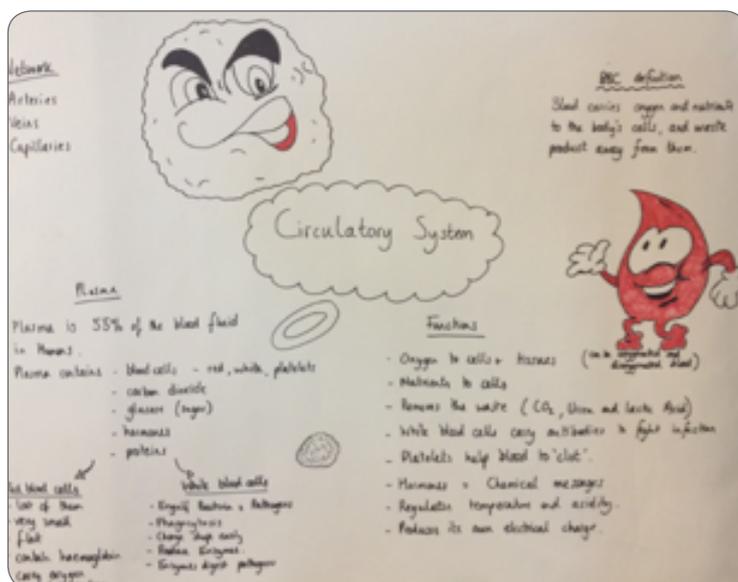
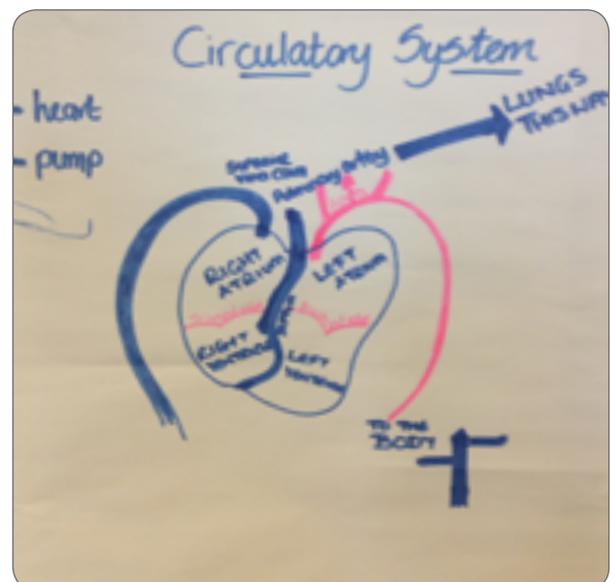


Figure 24B



All teachers cited at least two different types of evidence sources with half of the teachers mentioning four or five types of data to verify the impact of CPD and post-CPD interventions ($M=4.8$). Nine out of ten participants collected feedback from their pupils and even more – from their colleagues (Figures 24 and 25).

Figure 24 PSS, cohort 1 impact reporting, March 2015

Types of evidence cited by participants to support impact claims

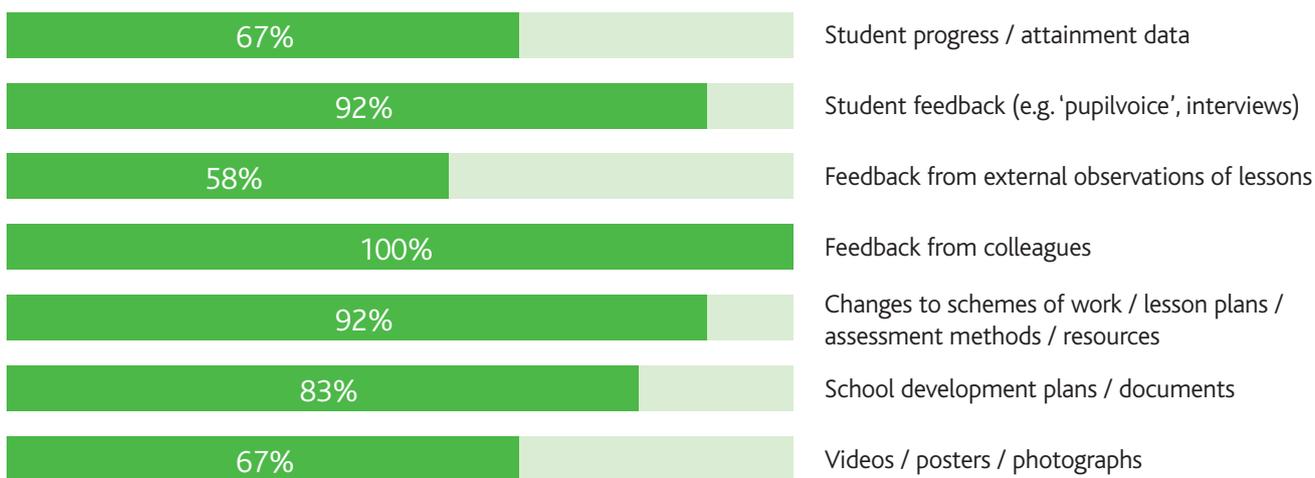
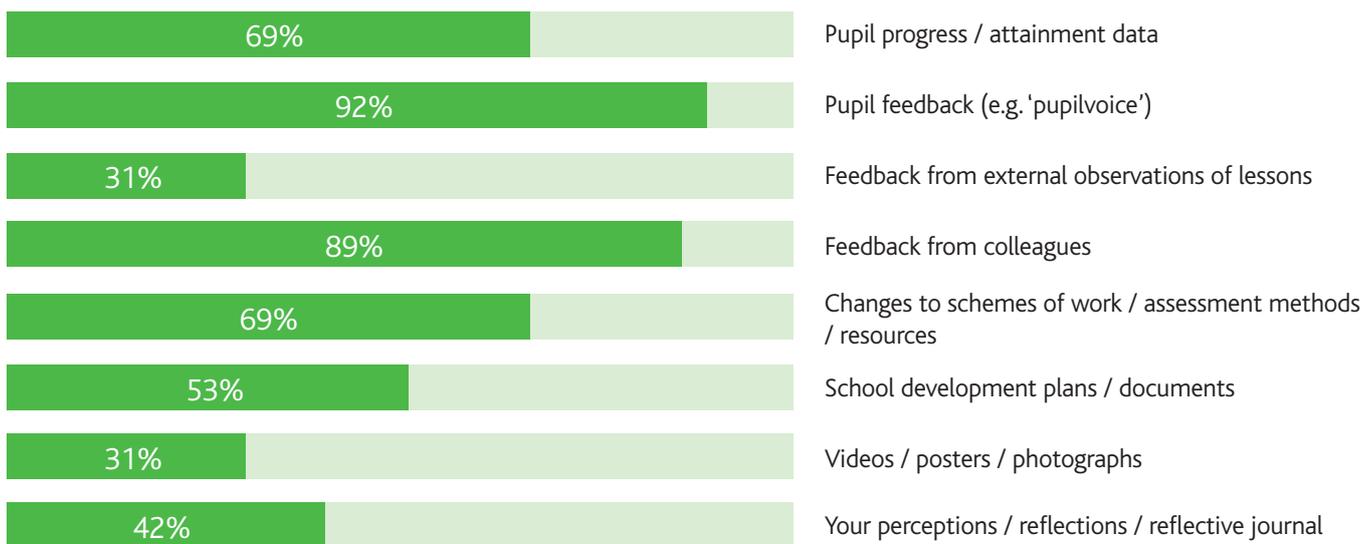


Figure 25 NAPSS 2014/15: Evidence collected by teachers

What kind of evidence do you have to corroborate the CPD impact?
(% of teachers using the following types of evidence):



Other (n=1): Science week book which has examples of working scientifically in each year group (plans and pupil work / photographs).

One of the last CPD sessions of the course was dedicated to teachers' reflections on the impact of the course. Working in groups to discuss the top five 'tips' to share with others, many participants quoted data monitoring, particularly specific data collection tools (e.g. Pupils' voice) as important aspects of effective subject leadership which they learnt during the CPD (Figures 25a and 25b).

Figure 25A

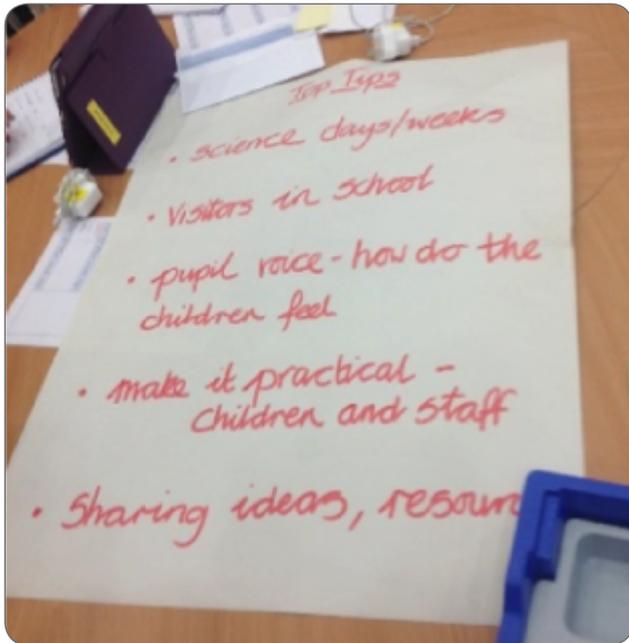
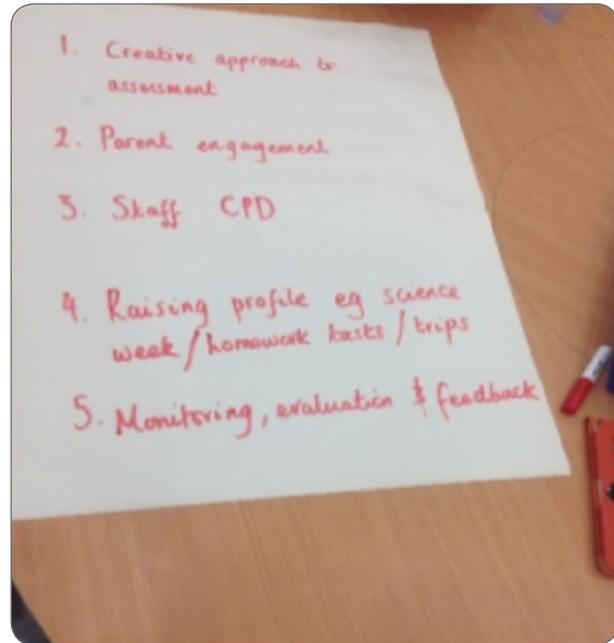


Figure 25B



6_Recommendations

The aim of the primary science specialist course was to develop teacher knowledge and understanding of science and many primary teachers thought the course was challenging. Some teachers, predominantly from the PSS 2013/14 course, found the CPD 'too theoretical' and 'high pitched' and questioned why they had to learn a level of science which was not included in the primary curriculum. They also wanted to see more practical recommendations and primary resources.

Amendments were made to the course in 2014-15 to address these issues. However, further improvement could be addressed by:

- > improving the course information particularly the objectives, intended outcomes and impacts
- > stating clearly the 'theory of change' behind this CPD to explain how the improvement of teacher science knowledge will lead to increased pupil outcomes and support the improvement of science teaching across the school
- > disseminating the findings of this report of how CPD can improve teachers' science knowledge and understanding, boost their confidence and enthusiasm and improve teaching of science across the school
- > keeping the focus of CPD on practical applications relevant to primary school to enable participants to easily build 'portfolio' of actions and resources to be used at school

