Evidence for Excellence in Education

Report

Qualitative Evaluation of the National Science Learning Centre: Final Report

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independent • insights • breadth • connections • outcomes

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Executive Summary

Qualitative Evaluation of the National Science Learning Centre: Final Report

Nalia Thurgood, Matt Walker, Suzanne Straw, Clare Southcott and Marian Sainsbury

June 2013

Report brief

This report presents the findings from a qualitative investigation into the impact on students of the subject-specific continuing professional development (CPD) undertaken by teachers at the National Science Learning Centre ('National Centre'). The report draws on research findings from case-study visits conducted in eleven secondary schools which have had considerable involvement with the National Centre over the last few years and further follow-up interviews with teachers from seven of the eleven schools. The visits were conducted between October 2011 and December 2012.

Scope of the evaluation

- The National Science Learning Centre is an £11 million purpose-built, state of the art facility, providing high quality professional development for everyone involved in the teaching of science, in primary and secondary schools and FE colleges from across the UK.
- The evaluation was commissioned by the National Centre and carried out by a team at the National Foundation for Educational Research (NFER).
- The aim of the study was to explore the impacts on students of the subject-specific CPD undertaken by teachers at the National Centre, with a particular focus on:
  - students' motivation for, and engagement with, science
  - student progress and attainment
  - participation in science subjects at GCSE and progression post-16.
- The findings in this report are drawn from case studies conducted in eleven schools, involving interviews with senior leaders, heads of science, teachers, technicians and students.

Key findings

Benefits and impacts for students

- A range of benefits and impacts on students were identified by teaching staff and technicians, and supported by comments from students themselves. Specific impacts included:
  - **increased enjoyment of, and engagement in, science lessons and extra-curricular activities** – this has been achieved through: increases in teachers' confidence in, and enthusiasm for, teaching science; through teachers keeping up-to-date with new ideas and introducing new content in lessons; and through teachers using, or becoming more expert in using, different approaches to teaching, with practicals featuring most prominently
  - **increased confidence and understanding in learning science, and security in their existing knowledge** – this was a 'knock-on' effect of their teachers' increased confidence in teaching science and delivering practicals and the increased competence of technicians to support teachers
  - **the development of transferable and practical skills** – including a range of skills such as discussion skills, working in pairs and groups, independent learning, study and revision skills, thinking skills, hypothesising and questioning skills, and skills in undertaking practicals. These skills have been developed as a result of teachers using a wider range of teaching approaches
  - **increased awareness of the importance and relevance of science to society** – this has been achieved by more topics being taught within a real life context and field trips e.g. to CERN
  - **increased knowledge of career opportunities in science** – this impact had been achieved in schools where careers in science/STEM have been an element of teacher CPD
  - **improvements in progress and attainment** – although teaching staff were more cautious in reporting impacts on student attainment, many felt that students' increased enjoyment of, and engagement in, science was impacting, or would ultimately impact, on their progress and attainment. A smaller number of teachers (and some students) reported actual improvements in students' grades
  - **increased interest in, and uptake of, science subjects and careers** – again, many teaching staff felt that students' increased enjoyment of, and engagement in, science would ultimately lead to increases in students studying GCSE/BTEC and A-level science subjects. Many schools had already experienced increases in uptake at these levels which National Centre CPD had contributed to, alongside other factors
- All of these impacts were still evident during follow-up interviews with research participants, suggesting the impacts resulting from National Centre CPD were having a lasting benefit.

Schools' experiences of National Centre CPD

- All of the case-study schools had longstanding engagement with the National Centre. There was widespread enthusiasm in pursuing CPD with the National Centre on an ongoing basis and most of the case-study schools had staff who were either currently participating in courses at the National Centre, or had plans to book staff onto training in the future.
- The views of staff regarding National Centre CPD were very positive. They particularly liked the content of courses, the experience and background of the course tutors, and the quality of the National Centre's resources and facilities.

How schools are evaluating CPD

- Most staff reported that their schools had not adopted a systematic approach to evaluating the impact of CPD. Staff who had evaluated CPD had mainly focused on teacher outcomes. Student outcomes were reported to be rarely evaluated, with at least one member of staff in each school saying they were unsure about how to evaluate the impact of CPD on teaching and learning.

Strengths of impacts

- Teaching staff and students identified the strengths, sequence and sustainability of the key impacts of CPD undertaken at the National Centre for teachers and students:
  - **increased enthusiasm in teaching science, new ideas and strategies for effective lesson delivery and increased confidence in teaching science** was ranked as the strongest impacts on teachers
  - for impacts on students, interviewees ranked **increased student engagement, enjoyment and confidence in science** as the strongest impacts.

Sequence of impacts

- Similar to interviewees' perceptions on the strengths of impacts, the impacts most likely to occur first for teachers were increased **enthusiasm in teaching science, new ideas and strategies for effective lesson delivery and increased confidence in teaching science.**
- As with strengths of impacts, the first impacts to occur for students were reported to be **increased student engagement, enjoyment and increased confidence in science.**

Sustainability of impacts

- Interviewees reported that the most sustainable teacher impacts resulting from CPD at the National Centre included the development of **new ideas and strategies, increased subject knowledge and increased confidence in teaching science.**
- The improvement in **transferable and practical skills** was perceived to be the most highly sustained student impact, followed by **increased engagement, enjoyment and confidence in science.**

1. Introduction

This report presents the findings from a qualitative investigation into the impact on students of the subject-specific continuing professional development (CPD) undertaken by teachers at the National Science Learning Centre ('National Centre'). The report draws on research findings from two rounds of case-study visits in secondary schools which have had considerable involvement with the National Centre over the last few years. The first round of visits involved eleven secondary schools and was conducted between October 2011 and June 2012. A second round of follow-up interviews was conducted with participants from seven of the eleven case-study schools and took place between November and December 2012.

1.1 Background and context

Science Learning Centres are a national network for professional development in science teaching. Their aim is to improve science teaching and to inspire students by providing them with a more exciting, intellectually stimulating and relevant science education, enabling them to gain the knowledge and the understanding they need - both as the citizens and as the scientists of the future. There are nine regional centres in England and one National Centre, each with a number of satellite centres to provide additional facilities.

The National Science Learning Centre is an £11 million purpose-built, state of the art facility, situated on the campus at the University of York, providing high quality professional development for everyone involved in the teaching of science, in primary and secondary schools and FE colleges from across the UK.

The National Centre features the highest specification teaching laboratories, multiple teaching rooms, a 291 seat auditorium, and the National STEM Centre, a purpose built resource area holding collections for science, design and technology, engineering and mathematics teaching. The National Centre offers business class accommodation for course participants.

Many courses are supported by the ENTHUSE Award which covers: course fees; travel and supply cover; accommodation and food; and a contribution to support follow-up activities in schools/colleges.

In June 2011, the National Centre commissioned the National Foundation for Educational Research (NFER) to explore the impact on students of the subject-specific CPD undertaken by teachers at the National Centre. This report combines findings from the interim report (published in July 2012) and subsequent follow-up interviews with research participants from seven of the eleven case-study schools and explores whether teachers' and technicians' participation in CPD has had any discernible impact on students' engagement with science, their achievement and attainment and on their intentions regarding further study at GCSE and beyond. The study explores staff and students' views of the impacts in these areas, together with other supporting evidence.

1.2 Models for evaluating CPD practice

The profile of CPD for all staff in schools has been significantly raised in recent years by a range of investment and policy-based initiatives to promote CPD. These include:

- an emphasis on **the role of CPD in enhancing teaching quality**, and ultimately **student outcomes** and **school improvement**
- an increased emphasis on **personalised learning** not only for young people but for staff, including **practitioner ownership of their learning** (e.g. Cordingley *et al*., 2003; 2005a; 2005b; 2007; and GTCE, 2009)
- the introduction of new **professional standards** for teachers and **occupational standards** for staff supporting teaching and learning
- a drive for school improvement, underpinned by **self-evaluation in schools**, a new teacher professionalism, and revised performance management and review arrangements
- **devolved funding arrangements** to schools[1].

The NFER has identified a **policy emphasis on demonstrating impact** as a key driver in recent years[2]. This is important as evaluating the impacts of CPD on practitioners and the consequent impacts on students is a means of **identifying what contributes to improvement** and ensuring that **development work is appropriate and cost effective**[3]. Teachers' new knowledge, skills and attitudes, will, when put into practice, ultimately affect and benefit students' learning and achievements. Therefore, it is important to **recognise teachers' own learning** as part of the outcomes of their professional development.

A number of authors have developed **typologies of impact from CPD.** Joyce and Showers (1980) proposed a model of outcomes focusing around the teacher and their practice, with outcomes on: i) awareness of new skills, ii) ordering knowledge of underlying concepts and theories, iii) development of new skills and iv) application of concepts and skills to practice. Harland and Kinder (1997) developed a **hierarchy** of INSET outcomes where provisionary outcomes, information and new awareness represented the lowest order of change; followed by motivational, affective and knowledge/skills outcomes; through to value congruence, institutional outcomes and changes in practice as the highest order of change. A commonly used model for CPD impact is Guskey's (2000) 'five levels for evaluating professional development'. In this model, Guskey proposes that teachers go through a process of

[1] In 2001, a national strategy for CPD set out the government's commitment to increase the funding available through national initiatives and through money going direct to schools, such as through the Standards Fund (DfES, 2001). In 2005, funding and responsibilities for CPD for teachers were devolved directly to schools: '*Decisions about professional development activity will be taken by schools and teachers themselves, be informed by performance management and be linked to plans for school improvement*' (Secretary of State for Education). The intention was that schools and their workforce became the key drivers for CPD.

[2] E.g. Such evaluation is now expected as part of whole school improvement: http://www.nfer.ac.uk/nfer/publications/TLI01/TLI01.pdf [17 April, 2012]

[3] E.g. the TDA have devised an impact evaluation toolkit for schools' CPD. (http://webarchive.nationalarchives.gov.uk/20111218081624/http://tda.gov.uk/cpd-leader/effective-cpd/~/media/resources/cpd/cpd_impact_evaluation.pdf) [17 April, 2012]. The toolkit provides questions to be considered before, during and after the CPD activity, including, progress made towards outcomes, any unexpected outcomes achieved, and assessment of the cost-effectiveness of CPD in relation to time and finance.

understanding their own reactions, learning and development *en route* to **'higher' levels** of changes to practice and, indeed, to student learning outcomes (see Figure 1 below).

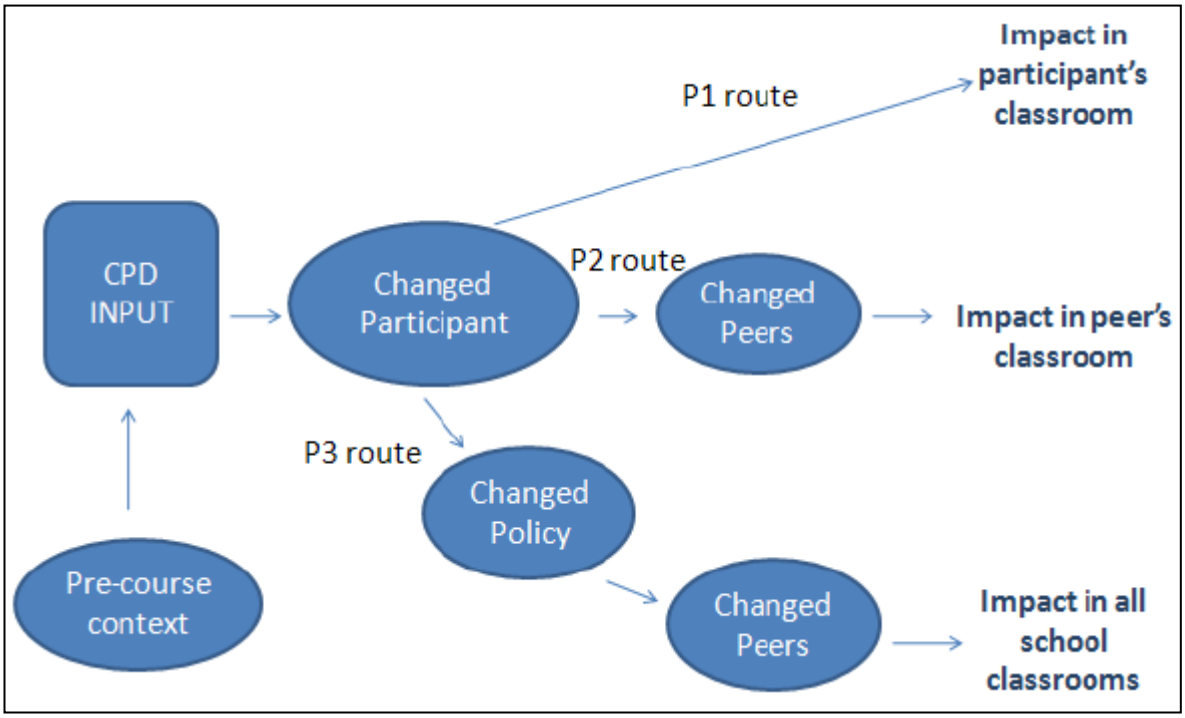
Figure 1: Guskey's 'Five critical levels of evaluation'

Source: Adapted from Guskey (2000)

Guskey argues that, while the relationship between these outcomes is highly complex, there is very often **a sequence in which these outcomes most frequently occur**. The crucial point is that it is not the professional development *per se,* but the experience of successful implementation that changes teachers' attitudes and beliefs (Guskey, 2002), and that it is this that leads to an eventual impact on learners.

More recently, academics from the University of York have developed a model that identifies **additional trajectories for classroom impact.** Bennett *et al.* (2010) propose a model of three impact routes. The three steps become increasingly more elaborate and lead to impacts in: 1) the teacher's own classroom; 2) peers' classrooms; and 3) classroom activities across the school or department respectively (see Figure 2 below).

Figure 2: The classroom routes to impact model



Source: Bennett *et al.* (2010)

The most fundamental difference between Guskey's (2000) and Bennett *et al.'s*, (2010) model is that the latter suggests that impact in a participant's own classroom is possible and independent of organisational and/or policy change in the participant's school.

These competing models for evaluating the impacts of CPD highlight the challenges of attributing outcomes, particularly student learning outcomes, to the particular intervention or activity that teachers have undertaken. Issues in establishing a causal link between CPD provision and outcomes for students include the contribution of other initiatives and activities within the school, and the contribution of other factors such as students' learning with other teachers, and students' maturation over time (TDA, 2007, Coombs *et al*., 2007) Whilst the passage of time is important to achieve change for students (e.g. any changes in teachers' practice are likely to take longer to impact on student outcomes), this emphasises even more the challenges highlighted above (Flecknoe, 2000; Guskey, 2002; Muijs *et al.*, 2004; Robinson and Sebba, 2005).

Recent directives from Ofsted mean that schools will face increased scrutiny on the evaluation of the impact of CPD on school improvement. The new Ofsted framework for inspection (Ofsted, 2012) makes reference to the requirement for schools to evidence the impact of professional development on teaching and learning. Schools will be inspected on the extent to which staff have benefitted from CPD and how effectively senior leaders and managers are linking professional development to school improvement. Similarly, the School Inspection Handbook (Ofsted, 2013) states that senior leaders will be expected to use performance management and self-evaluation to analyse the impact of CPD on teaching and to keep accurate records of CPD and how it is evaluated. This shift emphasises the need for

schools to ensure they can evidence the difference that CPD has made to both staff and students.

Whilst acknowledging these challenges and the changing policy landscape, the aim of this evaluation was to explore the impacts of changes in teachers' and technicians' practices (resulting from undertaking CPD at the National Centre) on their students. It was intended that the evaluation data gathered would enable the National Centre to develop communication and marketing materials to encourage teachers and schools not yet engaged with the National Centre to consider doing so and to highlight the importance and benefits of subject-specific CPD, with a particular emphasis on student impacts. To achieve this, interviews were undertaken with the beneficiaries of CPD delivered at the National Centre, including both science teachers and technicians. Interviews were also undertaken with students and senior leaders, and other school-level data was collected, where available. Full details regarding the methodology can be found in Section 2.2.

1.3 Structure of the report

Chapter 2 provides an overview of the methodology and a summary of the number of interviews undertaken and the characteristics of each school.

Chapter 3 looks at the level of contact the schools have had with the National Centre, their reasons for getting involved, and their views on the quality and usefulness of the CPD undertaken.

Chapter 4 investigates the extent to which schools are evaluating the impact of CPD and the approaches that have been taken.

Chapter 5 explores case-study interviewees' views on the benefits and impacts arising from CPD, focusing specifically on the impacts on teachers, heads of science departments and technicians.

Chapter 6 explores case-study interviewees' views on the benefits and impacts arising from CPD for students.

Chapter 7 looks at case-study interviewees' perceptions on the strengths, sequence and sustainability of teacher impacts, identified through a diamond ranking exercise.

Chapter 8 explores case-study interviewees' perceptions on the strengths, sequence and sustainability of impacts for students, identified through a diamond ranking exercise.

The concluding chapter draws together the key messages from the evaluation and provides an assessment of the impacts on students resulting from the subject-specific CPD undertaken by their teachers. Recommendations are provided for both the National Centre, on how to further target and take forward their programme of subject-specific CPD, and for schools to enable them to fully benefit from all aspects of CPD.

2. About the evaluation

This chapter provides further details about the aims of the evaluation and the methodology used, in addition to the challenges the evaluation team encountered and how they were tackled.

2.1 Aim of the evaluation

The aim of the study was to explore the impacts on students of the subject-specific CPD undertaken by teachers at the National Centre, with a particular focus on:

- students' motivation for, and engagement with, science
- student progress and attainment
- participation in science subjects at GCSE and progression post-16 (into KS5 and higher education).

2.2 Methodology

The methodology was designed to provide in-depth qualitative insights from participating teachers, heads of science departments, technicians and students on National Centre-delivered CPD, with a particular focus on the impact of CPD on students. The first round of case-study visits were undertaken with eleven schools between October 2011 and June 2012. The aim was to then conduct follow-up visits to schools in the autumn term of 2012 to explore any additional impacts. In the first round of visits, ten of the case studies involved visits to schools, while one case study was undertaken over the telephone. Follow-up interviews were undertaken with respondents from seven of the original eleven schools between November and December 2012. Three of the interviews were undertaken in person, while four were undertaken over the telephone. The fact that it was not possible to secure the involvement of all of the eleven schools in the follow-up interviews is symptomatic of how busy they were, but it perhaps also reflects the relatively short period of time available between the initial and follow-up interviews. Non-participating schools said they had little additional information to report and had other internal commitments which prevented participation. For both rounds of interviews, supporting evidence, such as schemes of work and student attainment data was collected, where available.

2.2.1 Sample design and sampling procedures

The first part of the sampling process involved identifying a long-list of schools whose staff had undertaken training at the National Centre. A list was compiled of schools which had engaged in subject-specific CPD over a five year period (2007-12). Schools were ranked in order so that those schools that had had the most contact with the National Centre were at the top of the list. This list was then merged with the NFER's Register of Schools, which provides up-to-date information about each school in England, including information such as size, governance and location, as

well as information about schools' overall levels of attainment and entitlement to free school meals. By combining the Register with the National Centre's information, the research team were able to ensure that a short-list of schools with a range of characteristics could be identified. Schools were selected to ensure:

- a geographical spread
- a range of different courses were included
- the sample of schools had recent, as well as long-standing, engagement with the National Centre
- schools with a range of characteristics were included, including schools with different proportions of students claiming free school meals (FSM) and with special educational needs (SEN).

To minimise burden on schools, those known to be involved in other extensive research activity with the NFER and/or with the National Centre were excluded from the sample. An approach letter was sent to the headteacher and head of science in a total of 70 schools, inviting them to participate in the research. The letters were followed up by telephone and email contact. From this sample, a total of eleven schools agreed to participate in the research. The characteristics of these schools are presented in Table 2.1 below (the school names have been removed to maintain anonymity). The table also indicates the seven schools that took part in follow-up interviews.

Table 2.1: Characteristics of the eleven schools involved in the evaluation

School	School type and gender	Main specialism	Age range	Number on roll	% SEN (with statements or on School Action Plus)	% FSM	% achieving 5 GCSE A*-C inc English and mathematics (2011)	% KS4 students gaining 2 Ebacc GCSEs A*-C in science (2011)	Participation in follow-up visit
1.	Voluntary Aided, mixed	Arts	11-18	1700	2.2	8.1	74	55	
2.	Community, mixed	Science	11-16	1300	8.3	15.4	53	54	✓
3.	Community, mixed	Sports	11-18	1500	18.9	21.3	41	8	
4.	Academy, mixed	Language	11-18	1600	2.4	3.8	89	65	✓
5.	Academy, mixed	Language, Mathematics and Computing	11-18	1200	6.0	5.9	79	63	✓
6.	Academy, mixed	Mathematics and Computing	11-18	1700	5.6	7.1	65	60	
7.	Community, mixed	Mathematics and Computing	11-16	1300	7.2	6.4	73	76	✓
8.	Community, mixed	Language	13-18	1100	2.8	4.0	70	55	✓
9.	Community, mixed	Mathematics and Computing	11-18	1000	7.6	15.4	45	41	✓
10.	Foundation, mixed	Science	3-18	1300	15.6	37.2	44	41	
11.	Community, mixed	Arts	11-18	1400	11.9	29.8	63	41	✓
National (English) Average state funded schools only							58.2	47.4	

2.2.2 Consultees

Within the case-study schools, we consulted with heads of science departments, science teachers and technicians who had undertaken CPD at the National Centre, as well as with students who were identified by the schools as benefiting from the training. The interviews followed semi-structured interview schedules and were recorded with the interviewees' permission.

A diamond ranking exercise (see Appendix) was used during the follow-up interviews to elicit the views of senior leaders, teachers and students on the strengths, sequence and sustainability of the impacts identified during the initial visits to the case-study schools. Nine senior leaders, two teachers and one group of students participated in this exercise. While exploring the same things, the language used in the ranking exercise was adapted when used with middle leaders, teachers and students.

Table 2.2 below provides details of the numbers of each type of consultee involved in the evaluation by school and the courses that staff had recently attended at the National Centre.

Table 2.2:

List of people consulted and recent courses attended by staff in both rounds of case-study visits to schools involved in the evaluation

School (Year 1)	Senior leader	Head of science	Science teachers	Science technicians	Students							Sample of recent courses
					Y7	Y8	Y9	Y10	Y11	Y12	Y13	
1.		1	3	1			3	6			2	• How Science Works: Contemporary Science Conference • Promoting STEM Careers in Your Classroom • Inspiring Post-16 Chemistry • CERN Visits and Follow-up Conference
2.		1	1	2					6			• Science AST Conference • Summer School for Newly and Recently Qualified Teachers • Success in Teaching 11-16 Chemistry
3.		1	3					4				• Inspiring Post-16 Physics • Aspiring Head of Science • CERN Visits and Follow-up Conference • Post-16 Biology Follow Up: Inspiration Again
4.		1	2							2		• New and Aspiring Heads of Science • How Science Works: Contemporary Science Conference • Physics for Non-specialists (11-16)
5.		1	1			6						• Physics for Non-specialists (11-16) • Success in Teaching 11-16 Chemistry • Inspiring Post-16 Biology
6.		1	1	2				3		6		• Summer School for Newly and Recently Qualified Science Teachers • How Science Works: Contemporary Science Conference • Inspiring Post-16 Biology
7.		1	2						3			• Teaching Science using Thinking Skills • Bring Science to Life: CSI Forensics
8.	1	1	4	2				8		2	5	• New and Aspiring Heads of Science • ICT Innovations in Science Teaching and Learning • Going Further with Post-16 Psychology • Inspiring Post-16 Chemistry
9.	1	1	2	2								• Stimulating Physics Network: York Summer School • CERN Visits and Follow-up Conference • Inspiring Science Learning through Demonstrations
10.		1	2	1	3	3						• Summer School for Newly and Recently Qualified Science Teachers
11			2									• Stimulating Physics Network: York Summer School

School (Year 2)	Senior leader	Head of science	Science teachers	Science technicians	Students							Sample of recent courses
					Y7	Y8	Y9	Y10	Y11	Y12	Y13	
2.		1		1				3				• Chemistry for Non-specialists (11-16)
4.	1											• Active Approaches in A-Level Science
5.	2	1	1	3								• Inspiring Post-16 Biology • CERN Visit • Skills for New Technicians
7.		1										• New and Aspiring Heads of Science
8.		1										• Contemporary Science Conference
9.		1										• Physics for Non-specialists (11-16)
11		1	1									• Physics for Non-specialists – Physics Summer School

3. Schools' experiences of CPD

Key findings

Nature of contact

- **All of the case-study schools had longstanding engagement with the National Centre.** Schools reported regularly receiving marketing material from the National Centre, while recommendations regarding the quality of the National Centre's CPD offer were mainly spread by word of mouth.
- Staff from **half of the schools said they had also attended training at one or more of the regional science learning centres (SLCs).** Where staff had not attended training at a regional SLC, this tended be due to its long distance away from the school.

Reasons for getting involved

- **Interviewees were motivated to access CPD with the National Centre** for a range of reasons, including to: improve their confidence and practice; prepare for courses being taught in school; and to access specific courses of interest.
- There was unanimous agreement amongst interviewees regarding the **high level of quality of the courses** on offer at the National Centre and their excellent reputation, both key drivers in staff wanting to pursue CPD with the National Centre.
- The **availability of the ENTHUSE Award** was one of the key reasons staff became involved, while recommendations from colleagues were also important.

Views on CPD

- The **course content** was reported to be particularly useful and relevant and allowed interviewees to both refresh their practice and help challenge the most able students. The mixture of theory and practice, and the practical nature of the courses were particularly valued.
- The **experience and background of the course tutors** was noted as an important part of the success of the National Centre's CPD offer. Course tutors with experience of working in schools were felt to be key to the delivery of CPD within context.
- Interviewees were very impressed with the **resources and facilities** at their disposal at the National Centre and there was a consensus on the **high quality** of the resources and materials used.
- **The opportunity to network and share practice with colleagues** from other schools was felt to enrich the CPD experience, and courses that allowed such opportunities were particularly praised and valued.

Changes to the educational and CPD landscape

- **In follow-up interviews some heads of science reported that they had sent fewer staff on courses compared to the last academic year due to uncertainties around changes to the science curriculum and new priorities for schools.** Staff said that, following further guidance on curriculum changes, they would be in a better position to identify relevant CPD courses. Schools were very keen to continue undertaking CPD at the National Centre in the future.
- In some cases, **schools have valued the consistency of internal rather than out-of-school CPD** and the benefits of being able to better align internal CPD with their school development plans.

Barriers to accessing CPD

- The primary barrier to accessing CPD has been teaching commitments and challenges related to attending CPD during term-time.

3.1 Introduction

This chapter explores the level of contact the case-study schools have had with the National Centre, their reasons for getting involved, their views on the quality and usefulness of the CPD undertaken and barriers to accessing CPD.

3.2 Nature of contact

All of the case-study schools had been sending staff to the National Centre for a number of years. However, most interviewees could not recall how contact was initially established, a view reflected by a head of science who explained that he had always been aware of the National Centre: 'I'm not sure [how the school got involved with the National Centre] it would be going back a bit, they [the National Centre] have been there a while'. Schools reported regularly receiving marketing material from the National Centre, while recommendations regarding the quality of the National Centre's CPD offer were mainly spread by word of mouth.

A range of courses at the National Centre had been accessed by heads of science, teachers and technicians (see chapter 2 for a summary of some of the recent courses attended). While most staff reported coming into contact with the National Centre through their schools, a teacher and a technician from two different schools reported participating in CPD with the National Centre through academic courses; the former through a Masters degree and the latter through an apprenticeship course. Interviewees reported accessing CPD courses as recently as 2013, whilst some participated in courses up to ten years ago.

Staff from half of the case-study schools reported that they had also attended courses at the regional science learning centres (SLCs). Examples included an NQT conference and courses aimed at science for non-specialists and science as an additional specialism. Of those schools that had not been engaged with the regional centres, the main reason for this appeared to be that, in their view, the duration of the course did not warrant the travel time required to get to and from the closest SLC.

As previously mentioned, interviewees reported regularly receiving marketing material from the National Centre and thought this was helpful for keeping up-to-date with new courses. One interviewee commented about the large amount of information on the National Centre website, which was felt to be unwieldy to navigate.

3.2.1 Future contact with the National Centre

There was **widespread enthusiasm** for pursuing CPD with the National Centre on an ongoing basis and most of the case-study schools had staff who were either currently participating in courses at the National Centre, or they had plans to book staff onto training in the future. Typical courses that staff were currently attending included mentoring and coaching and the leadership course for New and Aspiring Heads of Science.

A physics teacher at one case-study school explained that the head of science encouraged staff to participate in at least two CPD courses a year and that all science CPD at the school

was accessed through the National Centre. Similarly, a biology teacher planned to pursue more courses with the National Centre. However, this was with the caveat that the school would only be able to do so if the courses were supported by the ENTHUSE Award:

> *At the moment most of our CPD is in-house, as we don't have the money to do external CPD…so the* [National Centre], *certainly for the science department, is the only external CPD we have access to* (Science teacher, case-study 6)

A head of science explained that, although staff would only be in a position to access courses with the support of the ENTHUSE Award, they would still initially struggle to cover the costs of courses despite being later reimbursed.

During the first round of visits, the minority of case-study schools with no current plans to pursue CPD with the National Centre were in the midst of performance management reviews and expected to identify CPD needs once these had been completed. Of the small number of interviewees who reported no further plans to pursue CPD, this was either due to pressure of role responsibilities at school or because teachers thought that at present they had attended all the relevant courses. One teacher explained: 'There isn't anything new this year. We have been on the courses, so there is no point in us going…as they are quite similar' (Science teacher, case study 8). Another teacher wanted to attend a course that was fully booked. Interestingly, although the National Centre website contains a link to inform attendees when a place becomes available on a fully booked course, the teacher decided not to use this option and did not pursue the course. In a few cases, interviewees involved in follow-up visits reported no current plans for staff to attend CPD in the 2014 academic year; however, these schools were poised to address training needs following the anticipated changes to the science curriculum (further detailed in section 3.5 below).

3.3 Reasons for getting involved

Interviewees across the eleven case-study schools were motivated to access CPD with the National Centre for a range of reasons, discussed below.

A number of interviewees reported attending training with the National Centre in order to improve their confidence and practice. This was commonly cited by teachers who were either newly qualified and/or delivering non-subject specialist classes, and wanted to extend their expertise. For example, a newly qualified biology teacher had recently become responsible for teaching chemistry, which she had previously studied at A-level. She explained: 'It had been a while since I'd done chemistry and I just wanted my chemistry knowledge to improve'. She therefore decided to attend the Success in Teaching Chemistry to 11-16 Year Olds course. Similarly, a former science technician, who later became a chemistry teacher, reported that, after having to teach an A-level chemistry class in the absence of a sick colleague, he wanted to improve his confidence and find out more about the course, so attended the Inspiring Post-16 Chemistry course. Experienced teachers were more inclined to attend refresher courses to update their practice or to pursue leadership courses.

Heads of science in two case-study schools had attended courses at the National Centre **in order to prepare for running new courses in schools**, for example the BTEC and Salters'

Nuffield Advanced Biology courses (SNAB). One interviewee was particularly confident about the National Centre's ability to help him implement the SNAB course at his school and commented: '*You know it's going to be a good course…it* [the National Centre] *is something that we always look to'* (Head of science, case study 5).

Some interviewees also took up the National Centre's CPD offer in order to access specific courses of interest. The CERN courses, based in Switzerland, offer CPD study trips for physics education and can be accessed through the National Centre. This course appeared to be particularly popular amongst interviewees due to the opportunity to conduct fieldwork and experiments. In one case-study school, where a number of science subject teachers had attended the course, it was felt to be successful for the department because physics teachers gained specialist subject knowledge, non-physics specialists found it interesting and fulfilling and students were engaged with learning.

There was **unanimous agreement amongst interviewees about the high level of quality of the courses on offer at the National Centre** and their excellent reputation, both key drivers in wanting to pursue CPD with the National Centre. A head of science effectively highlighted this point below:

> *We get bombarded – perhaps ten offers a week for different courses. Its* [The National Centre's] *reputation, to me, is paramount. I know that if I send anyone to a* [National Centre] *course, it's not going to let me down and that's why I do it* (Head of science department, case study 4)

Positive recommendations and feedback from colleagues about attendance at the National Centre's courses have also been an important factor in encouraging interviewees to pursue CPD at the National Centre. This endorsement by heads of science was particularly effective in encouraging staff, reinforced by a physics teacher who said that if a course received good feedback, 'our head of science will say, 'Look, get yourself on one of these! They look really good''.

Whilst staff praised the reputation and positive experiences of courses at the National Centre, they reported that **the availability of the ENTHUSE Awards had been a key factor in CPD being accessed.** The value of the award varies per course and it can be used to cover course fees, supply cover, travel and accommodation, or to fund resources for improving teaching practice. Reduced school budgets have resulted in fewer schools accessing external CPD and therefore the additional funding provided by the award is particularly beneficial for schools. Most interviewees agreed that **schools would be unable to provide funding for CPD, particularly residential courses, without the availability of the funding the ENTHUSE Award provides**, a point highlighted by several interviewees below:

> *It's always, number one, very difficult to get out of schools, because you've got your cover costs etc. and money is getting tighter and tighter every single year…I know then, if I say to SMT that I would like* [a member of the department] *to go on a course…I can cover all the course fees because I've got the ENTHUSE Award – instant 'yes'. The courses are fantastic and I've got support financially, which makes a massive difference* (Head of science department, case study 4)

It's the ENTHUSE Award that allows us to go. If the funding ran out I don't think the school would let us go. I get emailed about CPD courses from other providers all the time, but because it [the National Centre] *has these ENTHUSE Awards and these other providers don't, the school won't let us go on them* (Head of science department, case study 7)

If we can't cover the cost, we can't go. We don't have much in our budget for it (Science teacher, case study 6)

3.4 Views on CPD

As previously mentioned, there was **widespread positive feedback regarding the high quality and fitness for purpose of the National Centre's CPD courses.** Interviewees, particularly those who had attended several courses at the National Centre, frequently reinforced the comments of one technician, who said: 'I think that everyone knows that the quality is really high in what we are bringing back, that it's going to be good'. A head of science further commented that: 'from a learner's point of view you get so much information crammed in and you go away with so much!' Interviewees commented that the courses were extremely well planned and organised and represented some of the 'best training' they had ever attended. Encouragingly, interviewees remained extremely enthusiastic about National Centre CPD during follow-up interviews and most outlined their ongoing plans to continue pursuing CPD with the National Centre. For example, one senior leader said: 'whenever people go out to the National Science Learning Centre, they always come back inspired and energised' (case study 2).Interviewees' views on particular aspects of the courses are presented below.

3.4.1 Content

The course content was reported to be particularly useful and relevant and allowed interviewees to both refresh their practice and help challenge the most able students. There was thought to be a good mix of theory and practice in courses, and the practical nature of the courses was particularly valued amongst interviewees. Interviewees valued the number of demonstrations and experiments carried out and, in particular, felt the expertise and skills that they had acquired had increased their confidence and were transferable to day-to-day teaching practice.

A science teacher who was teaching a module on Crime Scene Investigation (CSI)/forensics explained that she wanted to develop stimulating and engaging practical lessons for students. She attended a CSI/forensics course at the National Centre, where the first day of the course was spent learning techniques. On the second day, the room was set up like a real crime scene and attendees had to use their new skills to analyse the scene. She was particularly impressed with her experience and commented: 'It gave me lots of ideas and made me think about setting lessons around particular crime scenes and putting it into context'.

Similarly, technicians had also found the practical aspect of the courses helpful. Although technicians are responsible for setting up equipment to support lessons, they reported that

they found it difficult to find opportunities to practise experiments, and outside of attending National Centre CPD, were only able to do so when preparing for examinations.

A physics teacher, who attended an 'Extreme Physics' residential course, described the course content as 'absolutely fantastic, engaging and stimulating… [the course] was three years ago and I'm still using material now'. The course included the use of practical demonstrations and video clips, which he explained had successfully 'captivated' students and been shared with the rest of the department.

At the end of every course, participants are expected to develop and submit an action plan, identifying ways in which they can implement their ideas on their return to school. Of those interviewees who commented on the action plan, there were mixed views. Interviewees in one case-study school felt the plan was more for the use of the National Centre rather than teachers and was not used in schools, as teachers tended to create their own schemes of work and lesson plans. However, most other interviewees found the plan and pre-course tasks useful in exploring what they wanted to achieve with students and valued having an approach where actions had to be taken during and following courses, rather than attending one off courses with no preparation or follow-up. In most cases, writing an action plan ensured that teachers acted on what they had learnt and embedded new learning and strategies within the classroom:

> *It* [the action plan] *meant that I could prioritise after however many sessions that we had seen that week. I had pages and pages of things I wanted to try in the classroom and it meant that there was the opportunity to look at them and say: 'what is the most important thing for my development and what am I going to want to use in the classroom most?'* (Teacher, case study 10)

3.4.2 Delivery

The experience and background of the course tutors was noted as an important part of the success of the National Centre's CPD offer. Interviewees explained that effective course delivery was reliant on having good, enthusiastic tutors who do not 'just talk at you', but rather interact with attendees and encourage attendees to actively engage with the CPD. A head of science described his experience of effective delivery on a National Centre course as 'experiencing what it would be like for the student'.

The professional background of tutors was felt to be very important. Course tutors with experience of working in schools were felt to be key to the delivery of CPD within context. A head of science praised the National Centre for this:

> *I've very rarely seen good delivery from people that are not involved in schools themselves and I've never, ever been to a poor course* [at the National Centre]. *Every single one I've been on has been engaging, direct, relevant, the trainers have been fantastic and I've come back with a buzz* (Head of science department, case study 4)

The flexibility of delivery was also highlighted as a positive feature of the National Centre's courses. Interviewees commented that course agendas were adaptable, depending on the needs of attendees, and felt that tutors were open to changing courses

where needed. A biology teacher said the National Centre 'did really well at pitching [courses] at everybody and trying to respond to everybody's needs'.

Group size was felt to be dependent on the context of the course. For example, small group delivery was praised for being 'really intimate, [with] lots of time with tutors', while larger delivery to groups of between 30 to 50 people was also said to work well, allowing the opportunity for multiple perspectives.

3.4.3 Resources and facilities

Interviewees were very impressed with the resources and facilities at their disposal at the National Centre and there was a consensus on the high quality of the resources and materials used at the National Centre. The 'well equipped, purpose built building' and resources were seen as well matched to course content. As one interviewee commented:

> *The quality of the notes and things you bring back are absolutely excellent…They are some of the best resources I think I have come across* (Technician, case study 2)

Interviewees frequently described the National STEM Centre resources as 'amazing' and valued its availability to provide quick access to information during residential courses. A biology teacher said that because her school could not afford to purchase any resources, she was able to pick up useful ideas from resources in the library and subsequently went back to school and made her own resources.

The facilities at the National Centre were regarded as providing an environment which helped to foster learning. Two teachers who were particularly impressed commented:

> *It* [The National Centre] *is a sort of halfway house between a school and a hotel. At the Centre you have got education all around you, you have the resources and it feels a bit like school and you are fully focused on education* (Teacher, case study 8)

3.4.4 Networking

The opportunity to network and share practice with colleagues from other schools was felt to enrich the CPD experience, and courses that allowed such opportunities were particularly praised and valued. Interviewees welcomed the opportunity to meet new people, hear new ideas and gain others' insights on how to help children progress. A chemistry teacher found the chance to speak to other teachers extremely useful and valued being able to 'learn from them'. A biology teacher, in explaining how the experience put her at ease, said 'it was nice to meet people, get ideas and just a bit of reassurance that it's okay to not really know how to address certain issues'.

Many interviewees reported that they kept in touch with other course participants by communicating through course blog sites and through informal networking, such as emails, both during and after courses.

3.4.5 Particularly beneficial CPD

There was a variety of views about what type of CPD was felt to be particularly helpful, due to the differing nature of interviewees' professional backgrounds, skills and reasons for undertaking CPD. However, a number of key features of effective CPD did become apparent, as detailed below.

- **Practical courses** – all interviewees, especially those who were teaching non-specialist subjects or who were less confident in carrying out practical demonstrations, welcomed the opportunity to try out new demonstrations which would challenge and engage students. Interactive courses which promote active learning were seen as particularly important.
- **Breadth of courses** – the sheer availability of courses to choose from was seen as useful in ensuring differing needs of science staff were met, particularly the needs of technicians. There was a sense amongst some technicians of being undervalued, as CPD opportunities for them are limited. However, the range of courses offered by the National Centre were felt to cover a vast number of personnel, from newly qualified teachers and experienced but non-subject specialists to aspiring subject leaders.
- **Residential CPD** – teachers appreciated the opportunity to participate in CPD activity outside of school, particularly on residential courses, which allowed interviewees to focus solely on the course, rather than school commitments. The professional expertise of tutors, high course quality and the resources available outweighed any concerns about travelling to the National Centre.

3.5 Changes to the educational and CPD landscape

As a result of the anticipated changes to the science curriculum in 2014, senior leaders in some of the case-study schools explained during the follow-up interviews that they had sent fewer staff on CPD courses compared to the previous academic year. Interviewees explained that, to some extent, out-of-school CPD was being cut back until further clarity about changes to the science curriculum and assessments was received from the government. Across case-study schools, teachers intended to align any CPD undertaken with school priorities, following changes to the curriculum. Two senior leaders said they had not made any CPD plans for the 2014 academic year because they were awaiting further information on curriculum changes, particularly in relation to scientific literacy.

Some schools were focusing on improving the links between CPD and their school development plans. Schools were therefore increasingly valuing internal rather than external CPD, in an effort to achieve consistency in teaching practice and improvements across the science department and the whole school. Interviewees explained that they were making more use of external consultants and partnership activities with other schools to address their specific needs.

3.6 Barriers to accessing CPD

Interviewees across most of the case-study schools identified teaching commitments as becoming a bigger barrier to accessing out-of-school CPD. There were challenges associated with the time required to release staff from the classroom, particularly where staff were responsible for exam classes, despite schools receiving cover for staff absences. One senior leader said that growing school improvement pressures meant that teachers were reluctant to leave their classes to undertake CPD activities, while also acknowledging that CPD formed an integral aspect of school improvement. Despite some interviewees reporting during the first round of visits that regional centres were too far away, a minority of interviewees reported during follow-up interviewees that the proximity of the regional centres to schools has helped to address the issue of extended travel to attend courses at the National Centre. Many interviewees suggested it would be easier for them to attend National Centre CPD if more courses were delivered outside of term time.

4. How schools are evaluating CPD

Key findings

The extent to which CPD is evaluated

- **Staff were extremely positive about the impact of National Centre CPD and the differences this has made to both staff and students.** However, most staff reported that their schools have not adopted a systematic approach to evaluating the impact of CPD; there were also inconsistent approaches to evaluation within schools.
- **Where staff reported that they were evaluating the impact of CPD, this appeared to primarily involve capturing teachers' perceptions of its impact on their self-efficacy.** The focus of evaluation has mainly been on increases in teacher confidence and enjoyment, with some evaluation of changes in teaching delivery following the introduction of new approaches and practical work. **Staff reported that efforts to evaluate the impact of CPD on student outcomes happened rarely, if at all.**
- There was confusion amongst some interviewees between dissemination and evaluation. Most described practices that focused on cascading learning from CPD as evaluation rather than trying to evaluate impacts on teaching and learning.
- Key barriers to evaluating CPD were uncertainty about how to undertake effective evaluation and lack of time, due to workload pressures.

Evaluation processes

- **Staff were using a combination of performance reviews, observations and student voice surveys to evaluate impact.** Where schools have been successful in evaluating impact, evaluation outcomes have been defined during the CPD planning process and evaluating the impact of CPD has been a key aspect of undertaking CPD.

4.1 Introduction

This chapter covers the extent to which schools have been evaluating the impact of CPD on teaching and learning, the outcome measures used and the processes used to evaluate CPD.

4.2 The extent to which CPD is evaluated

Schools were extremely positive about the impact of National Centre CPD and the differences this had made to both staff and students. However, there was widespread agreement from interviewees that approaches to evaluating the impacts of CPD on teaching and learning were not systematic. In many cases, evaluation was informal or anecdotal and schools were not routinely collecting evidence of impact. As a result of inconsistent approaches to evaluation by individual teachers, there were examples of both good practice and absences of any evaluation taking place within the same schools.

Most interviewees recognised that they had to 'be smarter' about evidencing the effectiveness of CPD and ensuring it was closely linked with their school development plan in order to demonstrate school improvement. Despite this acknowledgement, the majority of schools had not developed formal evaluation processes, were **not always measuring the impact of CPD and were unsure about how to do this**. This is illustrated by the following comments from interviewees:

> *People just say the usual things, I am going to try this out in class, I am going to modify the model plan, but really what is the long term effect of that? I don't think that the outcome really matches the amount of time spent on the actual course (*Head of science, case study 8)

> *We found out* [after attending National Centre CPD] *that we can access the schemes of work which have the whole year's practical and equipment, so we are more aware of equipment needs. Before we had to guess, the teachers never tell us what apparatus to put out and the quantity, so students can get confused. Suddenly we knew what to order, rather than finding out you're out of stock in nitrates and you need it for next week! I think it's helpful* [for students], *I don't know really, we haven't had any direct feedback from the pupils* (Technician, case study 11)

These comments show, that while in some cases interviewees had identified outcomes they would like to measure from evaluating the impacts of CPD, they were not always effective at actually capturing these outcomes because they were unsure about how to do so.

The requirement placed on those in receipt of the ENTHUSE Award - to outline the intended impact of CPD - appears to have been successful in encouraging some staff to consider how they will evaluate the impact of CPD. However, interviewees in two case-study schools viewed the development of their impact statements as merely a formality in applying for CPD, rather than regarding it as a genuine opportunity to seek out opportunities to evaluate the impact of their CPD.

Interviewees highlighted some of the challenges related to evidencing impact, one of which was a perceived limited '*window of time'* in which teachers had to implement new learning or knowledge in order to avoid the impact of CPD being minimised or lost. A head of science explained:

> [Implementation] *can sometimes take up to a year. You know that* [teachers] *will try things and we do share them as best as we can but it is not always immediate. I would say that you need to* [implement CPD] *in six months to a year for it to be most useful but it can't often be the immediate weeks following it* (Head of science, case-study 7)

Workload pressures were also cited as the main reason that evaluation was not always prioritised. Some interviewees explained that, after attending CPD, they had then subsequently started teaching new year groups and/or different subjects, resulting in difficulties in tracking or evidencing impact. However, there was little to suggest that schools were attempting to evaluate short-term impacts.

Most schools were assessing staff satisfaction and the value for money aspect of CPD. This has mainly been carried out through the use of evaluation forms, to determine whether or not to use providers again or to recommend particular courses to colleagues.

4.4 Outcome measures

The minority of interviewees who had attempted to evaluate CPD had primarily focussed on **measuring impacts on teaching practice,** limiting evaluation to the first two levels of Guskey's model of evaluating CPD. Impacts had mainly been evidenced in relation to increases in teacher confidence, enthusiasm and enjoyment, in addition to changes in teaching delivery, such as the introduction of new teaching approaches or practicals.

Student outcomes were rarely, if at all, measured across case-study schools. Most schools attributed positive changes to teaching outcomes as indicative of positive impacts on students. Where interviewees had measured student impact, they had largely explored changes in students' attitudes to learning such as increased enjoyment and confidence. There was evidence that one interviewee had measured the impact of National Centre CPD on student attainment (further details in section 4.3 below).

4.3 Evaluation processes

Interviewees appear to have been most successful in evaluating the impacts of CPD where they have used a combination of the evaluation processes outlined below.

When asked how they were evaluating CPD, most staff reported using **dissemination** as their main method of evaluating the impact of CPD. This response suggests that, in some cases, interviewees were confusing dissemination with evaluation, as demonstrated by the following comment made by an interviewee, who provided an example of evaluation:

> *My Action Plan focussed on improving the confidence of teachers in physics. I did PowerPoints with teacher notes that could be used across the department and incorporated practicals and lesson plans* (Chemistry teacher, case study 11)

The minority of staff who appeared to make the appropriate distinctions between dissemination and evaluation had used dissemination as a way of cascading good and effective CPD practice after evidencing its impact on positive changes to teaching. The following comment demonstrates how a head of science, **who has attributed some of their school's success to National Centre CPD**, has approached dissemination across the science department after evidencing outstanding teacher practice:

> *We meet an hour after school once every two weeks on a Monday, but the philosophy is more, in science there are three or four teachers who have been consistently graded as outstanding. My argument is we are getting these outstanding gradings because of the quality of training that we have had at the National Science Learning Centre. We have got a good way of implanting new ideas into our shared scheme of work to ensure that the teachers all benefit* (Head of science, case study 8)

All schools were routinely carrying out **performance reviews/staff appraisals,** but not all interviewees reported using the performance management system to evaluate CPD. In one

school where performance reviews formed a key aspect of evaluation, interviewees explained they proactively reflected on and reviewed training objectives during performance management meetings, highlighted any areas for development and recorded evidence of any changes before and after undertaking CPD.

Observations have been used to evidence changes in teaching and learning, for example after the introduction of new teaching approaches or practicals. A head of science explained that, by using observations, the department could evidence that '[teachers are] *not doing practicals for the sake of it, but understanding what benefit a practical can have and identifying why a particular practical should be carried out, to teach a specific skill'.* In one of the case-study schools where observations have frequently been used to evaluate teaching practice, teachers are graded on new approaches following CPD. Some interviewees commented that observations were most effective for evaluating tangible differences in practice, for example new teaching strategies or practicals**.**

In one school, **an interviewee explained how the impact of National Centre CPD on student attainment** had been measured:

> *My gap task focused on breaking down exam techniques in order to improve attainment. This involved students breaking down exam questions and creating their own mark schemes and questions. I did an analysis of students' results and looked at their progress before and after the task and also compared the treatment group with a control group I was teaching at the same time, with whom I didn't use the same methods. Attainment was better* [in the treatment group]. *The more practicals that you can build into lessons or improve the way that they do tackle exam questions, that's had a big impact* (Biology teacher, case study 5)

Interviewees in half of the case-study schools reported using **student voice surveys** and **questioning techniques** to explore students' views on impact. A teacher gave an example of how evidence has been collected:

> *I spoke to Year 12 A-level physics students and they were really enthusiastic about what they had learned. They said 'Physics is so much fun, remember when we did the experiment with the Van der Graaf and the parabolic'…they were giving all these different examples that really helped them and made* [Physics] *a lot more memorable for them* (Chemistry teacher, case study 11)

There were also examples where some interviewees had used student surveys less successfully by aligning them not to a particular CPD intervention but to students' general views on the teaching of science. Hence, some interviewees found that although students were '*very, very positive'* about science in their schools, it was difficult to then attribute any increases in enjoyment or enthusiasm to CPD and to therefore effectively evaluate the impact of CPD.

5. Benefits and impacts for teachers, heads of science departments and technicians

Key findings

The **key impacts identified for teachers** were:

- increased **enthusiasm for, and confidence** in, teaching science
- **increased and more secure subject knowledge**
- increased **confidence and skills in practical work**
- **new ideas, resources and strategies** for delivering lessons in a more engaging and effective way.

These findings were reflected across both rounds of case-study visits, demonstrating their sustainability over time.

Impacts were realised as a result of teachers both engaging with the taught content of courses as well as networking with other teachers. In addition, teachers valued time away from the classroom to reflect on their teaching.

Where heads of science departments had undertaken leadership CPD, they had gained **increased confidence in leading their department and had further developed their leadership and management skills.** The development of their confidence and skills had also resulted in a **'knock-on' effect on teachers within the science department** in terms of improved support to help them work more effectively and efficiently.

Technicians had acquired increased confidence in their role in terms of setting up equipment and improving the experiments they already supported. They had **also gained ideas for new experiments**, which had allowed them to suggest practicals to their teacher colleagues and to be more experimental.

Many teachers had shared their learning with colleagues in their school, thus ensuring a wider impact.

Factors that increased the impact of CPD were seen to include:

- **senior leader commitment to staff undertaking National Centre CPD**
- **funding for new resources and time for staff to follow-up their learning back in school** e.g. via the ENTHUSE Award
- the focus of the courses on **action planning and follow up work**
- **the practical slant of courses**
- coming back to school with **materials and resources**
- **sharing learning and good practice** at departmental meetings and sharing resources on the science department's shared area
- **accreditation**.

Some of the issues and challenges faced by schools/staff in accessing CPD include: lack of support from senior leaders for external CPD; the length of some courses – courses of 3 days or more impact on teachers' classes; cost; accessibility and travel time; timing; the application process and time delay in receiving funding; relevance; and the lack of time to follow-up on CPD when staff returned to school.

5.1 Introduction

Drawing on evidence from consultations with science teachers, heads of science departments and technicians, in addition to other supporting evidence, this chapter focuses on the benefits and impacts for school staff arising from National Centre CPD. It presents:

- benefits and impacts for teachers, in addition to case-study examples of changes in classroom practice
- benefits and impacts for heads of science departments
- benefits and impacts for technicians
- wider impacts on schools.

It also looks at how to maximise the impact of CPD and what issues schools/staff face in accessing CPD.

5.2 Benefits and impacts for teachers undertaking National Centre CPD

The science teachers, heads of science departments and deputy headteacher involved in the research reported a range of impacts that had been realised for teachers as a result of their attendance at National Centre CPD. The key impacts identified for teachers were:

- increased enthusiasm for, and confidence in, teaching science
- increased and more secure subject knowledge
- increased confidence and skills in practical work
- new ideas, strategies and materials for delivering lessons in a more engaging and effective way.

Interviewees reported the same range of impacts during follow-up visits, suggesting these impacts have been sustainable over time. For example, a head of science said that National Centre CPD had continued to 'develop teacher confidence' and that teachers brought back all the learning elements of CPD which were 'crucial to running a successful department' (case study 5).

Impacts were reported to have been realised as a result of teachers both engaging with the taught content of courses as well as taking advantage of the opportunity to network with other teachers and exchange ideas, learning and good practice. In addition, teachers valued time away from the classroom to reflect on their teaching.

What was seen to be a positive aspect of National Centre courses that ensured an impact in schools was **the requirement for teachers to make a commitment to what they would do differently when they returned to school:**

> *The courses are not passive, and actually that's quite an attractive part of it, that they do try to make you think, and think about how you're going to use those ideas*
> (Teacher, case study 4)

> *…so, anything where you introduce a particular teaching and learning style, a particular approach and then go on to say, right this is how it is used, go away and try it and then come back and follow it up. Anything that has that structure to it in my experience is more effective than a one- off course. Yes, and people arrive as active rather than passive participants and I think that makes a very big difference* (Deputy headteacher, case study 8)

In some cases, teachers had committed to undertaking action research between the different days of the course. The luxury of longer courses at the National Centre combined with the opportunity to network allowed teachers the time to analyse their teaching and come back refreshed with ideas to do things differently, which benefited their students:

> *…you've got time to relax, you start talking to people like you never did before, which makes you think about and analyse your teaching. And when you come back you feel more refreshed, and you start doing things you never did before…and the students get a different dimension to a teacher* (Head of science department, case study 4)

As one head of science pointed out, the **National Centre courses were resulting in 'better and more effective teachers after the training**' (Head of science department, case study 2).

5.2.1 Increased enthusiasm for, and confidence in, teaching science

Most consultees commented on how the courses had **increased teachers' enthusiasm for, and confidence in, teaching science**. This was related to their more secure and/or increased subject knowledge, new ideas for practicals and strategies for engaging students, and access to a wider range of resources. Making contact with teachers in other schools was also seen to be beneficial, particularly when teachers were the sole teacher of a science subject within their school.

You actually feel really enthusiastic once you have come away from a course there and you actually go and do it…I think it gives teachers more confidence… I have got the enthusiasm and because of the courses I have been on it is easy to identify how to cheer your kids up a bit. Being more aware of different things and conscious of them in the lesson and then you are more likely to use it and get them developing those skills (Head of science department, case study 2)

Teachers are more inspired to teach, it widens their thinking and provides support for implementation both financially and through networking and blog sites (Teacher, case study 3)

… and I think that one of the things that happened to me as a result of going on that course last year, was in a way I sort of rediscovered my enthusiasm for it again, and it's about trying to get kids interested in your subject and asking questions… (Teacher, case study 4)

I think it helps to get the enthusiasm back… (Head of science department, case study 9)

…especially the session where they showed us lots of science demonstrations. Most of them I hadn't seen before and stuff like that really helps you get more

excited and thinking when I go back to school I will try this (Teacher, case study 10)

Staff are coming back (from these training experiences) feeling invigorated, they get their passion back. Sometimes in the day-to-day job it's hard to keep that going, but when they come back, they want to try this and that; they come back with a real fire in their belly to want to make a difference and try new things (Senior leader, case study 2)

There was also some evidence that teachers were benefiting from the school's technician(s) undertaking National Centre CPD. For example, knowing that their technician was available to help them deliver experiments that were not in their specialist subject was a big source of confidence for teachers:

> *Teachers are getting the confidence knowing the technicians are available to help them deliver experiments that aren't in their specialist subject* (Head of science department, case study 5)

A head of physics said that following training, the technicians had carried out a workshop for teachers to demonstrate and share what they had learnt on their course and how they felt it would benefit practice in the department.

5.2.2 Increased and more secure subject knowledge

Teachers **had acquired new and updated subject knowledge in all of the three main sciences** (biology, physics and chemistry) as a result of attending National Centre CPD. This was recognised as being important given the ongoing developments in science and the need for knowledge to be kept up-to-date.

Experienced teachers felt that they had acquired new/updated subject knowledge, particularly for teaching at higher levels:

> *I think I got a great understanding of physics, a current understanding of physics. There's a basic level of physics but getting beyond that on your own can be quite tricky so having the guidance from the people in the field is very, very useful (*Teacher, case study 9)

> *I understand more, it* [physics] *is more interesting and accessible. I actually promote* [physics] *and encourage children to take it* (Teacher, case study 11)

It was commented that teachers' improved subject knowledge had an impact not just on the subject content of their lessons but also on pedagogy as it meant that teachers were more confident using, and being creative with, different approaches to teaching and using techniques such as open and big questions (see section 4.2.4 for further details):

> *The general benefits of these courses are that you are refreshing your own knowledge…Just talking with other colleagues and the course leader you get a complete update…even if you take back one or two activities you can incorporate into your schemes of work, it's worth it* (Head of science department, case study 7)

> *Anything that improves staff subject knowledge is going to have a positive impact on teaching and learning and the different strategies that they are going to use in teaching*

because if you are confident with subject knowledge then you are more likely to be creative and pose more open questions and invite more questions back from students…that can only help with the teaching side of things and student learning (Deputy headteacher, case study 8)

Overall, I would say my knowledge and understanding has increased…For me the point is how to make it interesting for the kids so they like it (Teacher, case study 11)

Courses had also increased the subject knowledge of non-specialists teaching outside of their specialist area and impacts in this area were particularly noted. For example, a non-specialist teacher of chemistry felt that, with her increased subject knowledge in chemistry following National Centre CPD, she had now learnt how to 'stretch' the brighter students. In addition, teachers new to the profession had acquired additional subject knowledge very quickly which stood them in good stead as a new teacher:

I learnt a lot of the basics, I covered some of it in-house but they were able to go into a lot more depth with it and spend more time on it at the centre (Teacher, case study 2)

CPD for teachers in their second year of teaching was seen to be particularly beneficial as this was when they had passed all their NQT assessments and they were no longer receiving the support that they had received in their NQT year. As two teachers commented:

Going into your second year can be a bit funny. You have passed all your assessments and they suddenly take away all of your support and then you are sort of left to it so it gave them a focus for their second year which I think was incredibly beneficial but very hard to measure (Head of science department, case study 10)

I think it was a really positive experience…I really enjoyed the course and I found it helpful and it was at an excellent time in my professional development at the end of my NQT year when I had learnt so many things but was so distant from the PGCE year when you are given so many ideas. To have this aimed specifically at our level and to have so much time to discuss with other NQTs… (Teacher, case study 10)

One school had fairly recently introduced Applied Science at GCSE and the National Centre CPD had been instrumental in supporting teachers to deliver the new course content and in giving them the confidence to seek support from outsiders (e.g. business and universities) in delivering the course:

It is a difficult course because it is not something you are trained to teach because it requires a lot of outside involvement and you need the confidence to seek this involvement (Head of science department, case study 8)

One teacher commented that gaining additional subject knowledge had led to a change in the way that topics were taught – for example the school were now teaching ionic and covalent bonding together rather than as two distinct topics. A teacher also commented on how complex materials from CERN were being used in lessons. Another teacher was now using A-level material at Key Stage 3 so that students had an awareness of what to expect. Other teachers were now more effectively including sessions on careers in science in lessons. As one teacher summed up: 'Anything we bring back from the Science Learning Centre the department tries to fit into the curriculum and the staff change their schemes of work quite regularly so that it can be fitted into what they are doing (case study 10).

The fact that courses were built around teachers' requirements meant that their particular needs were met. In many cases, teachers felt able to immediately impart their new learning to students and to disseminate it to other teachers in school. As one teacher commented: 'They [students] get more in-depth instruction about a topic, rather than the basics' (Teacher, case study 3). Teachers commented that having more in-depth and up-to-date subject knowledge meant that they were able to create better lessons which were more engaging for students.

5.2.3 Increased confidence and skills in practical work

Teachers **had gained increased confidence and skills in undertaking practical work, a variety of new ideas for demonstrations and practicals and ideas for new resources and equipment**. This had led to teachers being able to teach science within context, incorporate more practicals into lessons and give more relevant, real life examples. This made lessons more engaging for students. Teachers were also putting on science shows inspired by ideas from National Centre CPD.

So a big thing for me [at the National Centre] *was getting the experience in how to do practical work. That was brilliant. I got a lot out of that...It was nice to play around in a lab with people who knew what they were doing...I'm certainly a lot more confident, particularly with things like practical work. I wouldn't be doing so many practicals if I hadn't had the chance* [to go on the course]. *It's things like the little ideas, the time fillers, the plenaries. All these little things...we don't do it for the sake of it, but we always try to do demos and practicals* (Teacher, case study 6)

…fantastic, because it's [the CPD] *practical based, lots of clips, experiments I could then introduce into the school* (Teacher, case study 1)

It is having new ideas and widening the range of things we do. Practicals that maybe we weren't aware of that are really whiz bang… (Teacher, case study 2)

…it opened up more ideas, more avenues - and we got video clips of things we did - stuff like that which I've used in lessons…the board breaking, they [students] *love it, and they think it's really death defying and dangerous when it's not at all, it's easy, but it's something I never even thought about…And other teachers have been on chemistry courses and done chemistry practicals and come back and we've used those. We keep using them again and again* (Head of science department, case study 4)

Although I don't do chemistry as much because I'm doing more biology, I think I have become more confident and I have done more practicals than I used to. Again, that's engaging for the pupils (Teacher, case study 5)

You always come away with 3 or 4 new demonstrations from these courses (Teacher, case study 8)

I came back with new ideas and lots of innovation and experiments. We are quite ideas-rich as a department… (Teacher, case study 9)

There were some fantastic, wonderful smells and bangs and explosions coming out of the prep room for about a week later! (Deputy lead teacher of science, case study 9)

One head of science commented that, when teachers were not confident in undertaking practicals, they would look for any reason to get out of doing them but that that attitude had now completely changed: 'But now I don't think we have that attitude, it's completely changed and **people are far more willing to try things out**' (Head of science department, case study 6). However, she still felt that there was some way to go in developing higher level skills amongst students and more accuracy in their handling of equipment: 'Now that we've got started, I'd like to get them [practicals] to be better quality, rather than quantity only'. So National Centre CPD was 'raising the bar' in terms of teachers' ability in undertaking practicals and schools still had aspirations to further improve the way that they were delivered.

Another head of science commented that the Getting Practical CPD had meant that teachers weren't 'doing practicals for practicals' sake' and that that the school were now thinking more about the impact of practicals on students' learning and that this had resulted in a change in school policy which had, in some cases, led to a reduction in practicals and a focus on those which were most effective and impactful:

> *That's* [the CPD] *had a direct impact on our policy. We've got to look at exactly what practicals people want to do in units, are they worth doing, what is the impact and almost reducing what we do but making them have a bigger impact and making them more effective* (Head of science department, case study 9).

Examples of new experiments/practicals that teachers had found out about included: electrophoresis, polymerase chain reaction (PCR), using different types of plant when measuring photosynthesis, genie in a bottle, hydrogen balloon, jelly baby wave, firefly, slime practical, Crime Scene Investigation (CSI)/forensics, conductive door, board breaking, fire walking, combustion, walking on glass experiment, microwave experiment using a light bulb, UV lamps being lit using plasma balls, DNA extracting, pyrotechnics, Van der Graaf generator, making a paper mache volcano, liquid crossing a membrane, superglue fuming and heat transfer practical.

One teacher commented that not only was he now delivering more practical sessions but that **he was making the practicals more valuable**. This was through making sure that practicals were not undertaken in isolation by effectively leading up to them and following up on the learning:

> *For me, it has definitely raised practicals up the agenda, so a greater number of my lessons are practicals and investigations than they were before. I think it was the idea that a practical isn't just a stand-alone thing and a practical might be very simple…the emphasis was very much on that particular course on thinking about how you are going to get them* [the students] *ready for the practical, what you're going to do beforehand – and the idea of rather than just having one practical, having a series…and then talking about it afterwards, rather than trying to use one practical to answer all the questions that they might have on a topic. And that has significantly changed my teaching* (Teacher, case study 4)

One teacher commented that it had been useful to be introduced to simple experiments and that sometimes 'less is more'. **Some of the most powerful practicals were very straight forward**, such as putting a splint in a test tube and taking it out again and adding some

indicator solution or showing materials crossing a liquid membrane by floating oil on top of water, colouring the water so you can see it and adding salt. These experiments were simple and very cost effective. He commented that experiments that used more complicated and expensive equipment were less likely to happen in the current financial climate. Some of the 'whiz, bang, pop' experiments also required long explanations which teachers did not always feel they had the time or expertise to provide. This teacher felt that using day to day things when 'something weird' happened was much more effective and could help teachers explain complicated things: '…if you just take two seemingly innocuous things, and have an interesting effect, that's far more startling' (Teacher, case study 4).

Through courses, teachers gained **an increased awareness of what equipment and resources they could purchase to support their practical work**, many of which were inexpensive. Some schools had used part of the ENTHUSE Award to purchase resources for the school (for example one school had purchased materials to set up a cloud chamber following a CERN course).

During the follow-up visits, a head of science reported an additional impact of training undertaken by one of the teachers during the first round of visits. Following CPD, the teacher had developed increased confidence and skills in carrying out practical work and as a direct result had started up a science club for Year 7 students, enabling them to carry out experiments and extra-curricular activities. The science club was said to be very successful and has allowed both the teacher and students to extend their learning.

5.2.4 New ideas, strategies and materials for delivering lessons in a more engaging and effective way

As well as ideas for practicals, teachers were coming back from National Centre CPD with a large range of other ideas, strategies and materials for use in the classroom. Some ideas came directly from the course whilst others came from contacts made with other teachers:

> *You do come back with things to do, so it does encourage you to use the information and skills, whereas a lot of courses you come back full of ideas but it just gets swept away in the stream of every day* (Teacher, case study 1)

> *You're bombarded with a million ideas, a million resources, which is a very good part of going to these National Centre* [events] (Teacher, case study 4)

> *It gives you so many more ideas. Once you go for a couple of days you get loads of ideas and information and you can think about how you can apply it back at school* (Teacher, case study 8)

> [The courses] *provide lots of tricks you wouldn't normally think about that you can include* (Head of science, case study 9)

> *I was always enthusiastic, but I think I've got more ideas now and I put them out there* (Chemistry teacher, case study 11)

Many teachers reported that they were using the ideas and materials that they had acquired on an ongoing basis and embedding them in the curriculum:

> *I keep using them* [materials] *all the time and when I'm doing my SEF, I still refer back to my folder to get ideas from that* (Head of science department, case study 4)

> *The feedback I get from the department is that when they come back, after they've experienced good training, they tend to be quite experimental in their teaching. Initially you get that flurry of good ideas coming out which may diminish as time goes on, but even if only one or two ideas get embedded into their practice, it's still an improvement on where the department was beforehand* (Head of science department, case study 6)

This was particularly the case when teachers had developed their own materials, adapting those provided by the course or developed from ideas gained at the National STEM Centre. In some cases, schools were using the ENTHUSE Award to pay for cover to allow staff time to develop teaching materials, but some teachers reported that they had done this in their own time and commented on the limited time available to develop their own resources.

Teachers had gained an **understanding of useful strategies such as using 'big questions'** or making more use of questioning, and open questions, in general:

> *There was a session where we all came up with open questions and I now quite often use that as a starter, particularly with my year 7s to get them thinking in a scientific way but also not necessarily 100% related to the topic that we are doing but just developing their science thinking skills* (Teacher, case study 10)

One teacher reported that, after attending a longer course, he changed the format of his lessons to include 'big questions' at the start of the lesson:

> *At the start of the lesson there would be either a question, or an object, or a picture of some sort, related in some way to the work you're doing and the children have to basically explain, or discuss, what it is… (*Teacher, case study 4)

Another teacher in the same school and a teacher in a different school reported that a key impact of the National Centre CPD that they had attended was an increase in their use of questioning in lessons:

> *…if there is one thing I do measure more than before, it's 'Are they asking questions in my class?' Because, if they're not, I haven't really got them. So, I am seeing more questions…for me that's a measure that shows they've actually linked in and want to learn (*Teacher, case study 4)

> *I have learnt to develop their ability to answer questions and communicate better in science that is particularly how the course has impacted them. It allows thinking time and the development of their ideas rather than teacher question answer* (Teacher, case study 10)

Teachers also mentioned a wide range of other interactive learning strategies and activities that they were now using such as effective use of group work (structuring group work so that students gain experience of interacting with a range of different class members and all students contribute rather than just the more dominant ones), starter plenary games, word play exercises, literacy and questioning resources (which one teacher had developed following a course), revision exercises, peer marking, final thought slides and post-it notes to collect student feedback in lessons. Teachers were also making more use of

PowerPoint slides, mini whiteboards, displays, videos, podcasts, webcams to show practicals on a big screen, and blogs. In addition, teachers commented that they were making the learning objectives and targets for each lesson clearer to students. Some teachers reported that they had acquired useful strategies for classroom management.

Schools were also placing a greater emphasis on delivering enrichment activities with the aim of raising attainment in class and were, for example setting up/further developing Science/STEM Clubs, delivering science activities in breakfast clubs, arranging visits to Science Museums and becoming further involved in Science Week through, for example, running competitions: 'We normally do some kind of competition but this year it was every single year group, there was the tutor group challenge, it was in assemblies and down to the primary phase. It was big news! Whereas, previously, it was on a very small scale' (Teacher, case study 10).

Teachers reported that they were now **relying less on teaching facts and students answering questions from text books and were, instead, undertaking more problem based activities**. This was leading to students' increased understanding of topics.

One head of science and a teacher commented that **courses that focused on developing teachers' skills in Assessment for Learning were very impactful**: 'That has a great influence on student impact because the processes that they use, particularly through things like Assessment for Learning, that carries the kids through' (Head of science department, case study 6). The teacher who had effectively used Assessment for Learning strategies now routinely asked her students to give feedback as to where they were at and their next steps.

Another head of science discussed how **the school had increased its focus on regularly checking students' work and understanding** as a result of National Centre CPD. It had also **run a number of sessions on data intervention** that was covered on the New and Aspiring Heads of Science course which has led to the better identification of performance issues amongst different groups of students and the putting in place of strategies to boost performance, such as target setting. Teachers were also collaborating more on lesson planning and delivery and teaching other teachers' lessons to share learning and best practice.

One head of science felt that developments in the teaching of science had moved much faster in his school as a result of staff attending National Centre CPD than would have occurred otherwise: '…we have been able to move faster than we would have done without the National Centre because there is that influx of ideas that have come from the centre' (Head of science department, case study 8).

5.3 Case-study examples of changes in classroom practice

A range of examples were provided of new schemes of work (e.g. wicked science) and lessons (e.g. on CSI/forensics), as well as activity weeks, assembly sessions, practical sessions, revision sessions, field trips (e.g. to CERN), visits (e.g. to universities) and other

extra-curricular activities, such as STEM Clubs and work experience, that had been delivered or run as a result of National Centre courses.

As explored above in section 5.2.3, all schools reported that they had increased the delivery of practical sessions as a result of National Centre CPD and, where technicians had benefitted from CPD, they were more involved in suggesting and setting up experiments where their role included this. All of the schools had tried out and embedded some of the practical sessions that they had found out about at the National Centre.

A number of schools had developed and introduced new courses such as BTEC or Applied Science GCSE and one school, following advice during CPD, had changed a post-16 biology course from OCR to Salters' Nuffield Advanced Biology (SNAB). Another school had introduced CREST Awards which were proving very popular with students. As mentioned above in section 5.2.4, schools had also started to embed a range of ideas, materials and strategies that they were introduced to during their CPD.

The box below details some of the changes in classroom practice that have occurred in each of the case-study schools[4].

Case study 1

This school has:

- developed an imaging course which has resulted in more practical work in year 12 biology
- developed a 'science in the news' course with teachers encouraging students to bring in news stories as they occur
- developed and introduced a week's scheme of work for year 8 based on CERN
- developed and delivered a discussion lesson on polymers for year 10
- changed teaching styles at A-level to become less didactic with more fun activities being used such as starter plenary games and revision exercises
- delivered a range of new practicals including: electrophoresis, PCR, using different types of plant to measure photosynthesis
- more fully involved technicians in suggesting and supporting practical activities.

Case study 2

This school has:

- developed a cross-curricular 'wicked science' scheme of work for all of the sciences targeted at years 7 to 9
- developed context-based investigations around forensics (like CSI) and accident and emergency
- started delivering a wider range and number of practicals such as the jelly baby wave, genie in a bottle, firefly, hydrogen balloons and slime practical and plans to deliver the conductive door experiment in future
- ordered new resources which have led to changes in the content of practicals and enriched students' learning experience
- started to use a strategy picked up on the course for supporting students with revision which includes putting things on the wall for students to look at, think about and then discuss.

[4] Please see Chapter 2 for a summary of the characteristics of the eleven schools involved in the evaluation.

Case study 3

This school has:

- introduced a BTEC science course and the National Centre CPD was 'instrumental' in how the course was set up and the course has led to an improvement in students' grades
- changed a post-16 biology course from OCR to Salters' Nuffield and the course is proving more popular with fewer drop outs
- introduced CREST Awards which the school were in the national final for
- delivered an assembly series based on the CERN visit with a blog on the school website
- started to provide better STEM careers advice to students using information and advice gained from National Centre CPD
- begun to use material from A-level with KS4 students to show them how what they are learning will feed into later study and giving students a deeper understanding of topics
- wherever possible, taught topics within a real life context, with practicals being used where appropriate and a wider range of resources being used
- reduced the emphasis in lessons on answering questions from a book 'we look at how things work and don't just learn facts about a topic' (Student).

Case study 4

This school has:

- started to listen to students more, uncovering any issues and tackling them in order to improve the teaching and learning of science (the A-level physics intake has doubled in the last three years)
- placed a greater emphasis on practical and investigative work using a range of video clips, demonstrations and practicals in physics and chemistry (e.g. board breaking; fire walking; walking on glass; exploring combustion using a test tube, a splint and indicator solution; and demonstrating materials crossing a liquid membrane using oil, water and salt)
- used a range of materials from CERN CPD in physics lessons and run a related field trip to CERN for students
- delivered practicals differently ensuring that they are introduced properly and followed up; in some cases a series of practicals are delivered on a particular topic and in many cases practicals are very simple yet effective
- run a wide range of extra-curricular visits and trips (e.g. regular visits from Institute of Physics (IoP) staff, trips to Manchester University to hear Professor Brian Cox give a lecture, Starchaser, visit from Rock Doctor etc.)
- undertaken more cooperative work in class
- encouraged students to ask more questions in class: 'Are they asking more questions in class? Because if they're not, then I haven't really got them' (Teacher)
- made more use of peer marking – students marking the work of other students
- made more use of 'big questions' at the start of classes to introduce a topic and get students talking about it
- made more use of displays in class
- used data and resources from the National Centre on the uptake of physics, the use of physics, physics careers and financial rewards in jobs to run a project to encourage more students, and more of the right students, to study physics at A-level
- reviewed and introduced more effective ways of carrying out exam revision, for example by getting students to do more group work and marking each other's work in order to improve their knowledge and support them in improving the way

they tackle exam questions.

Case study 5

This school has:

- increased the number of demonstrations and practicals used in science lessons (e.g. chemistry lessons delivered by a non-specialist) and has used experiments in open evenings to show parents and prospective students what science involves. New experiments include a microwave experiment with a light bulb, UV lamps being lit using plasma balls, hypothesising on the effects of mixing different solutions, and demonstrations on combustion reaction
- used a range of new resources in lessons and in the Science Club
- begun to consider undertaking some cross curricular work linking chemistry with art, in line with the school's increased emphasis on cross curricular activities
- developed and shared revision packs.

Case study 6

This school has:

- developed new resources from ideas gathered from the National STEM Centre which was visited during National Centre CPD
- introduced a range of new demonstrations and practicals into lessons (e.g. making a paper mache volcano) and disseminated learning amongst staff (e.g. the use of a Van der Graaf generator)
- developed a new scheme of work for chemistry which includes demonstrations and/or practicals in most lessons
- made more use of technology in lessons (e.g. through the use of video and podcasts) and placed more focus on engaging students outside of the classroom (e.g. through their own research using ICT).

Case study 7

This school has:

- introduced a new Applied Science course which has drawn on knowledge and materials gained from a CSI/forensics CPD course
- rewritten a new scheme of work on alloys
- used a range of new ideas for demonstrations and practicals in both lessons and enrichment classes, for example a practical demonstration on a technique called superglue fuming which was very cheap and effective
- built in more careers lessons and discussions in science to encourage students to consider careers in science.

Case study 8

This school has:

- used a range of tools and techniques such as PowerPoint presentations, mini whiteboards, webcams to show practicals on a big screen so that all students can see the experiment, final thought slides, post-it notes to collect student feedback in lessons, and use of learning objectives/targets at the start of the lesson
- picked up new ideas and delivered a range of new demonstrations and experiments
- broadened the range of extra-curricular activities offered which now include visits to universities, work experience with universities, STEM Clubs and after-school revision sessions, which are all perceived to make a big difference to students
- increased its focus on regularly checking students' work and understanding and more rigorous assessment
- linked to more rigorous assessment, run a number of sessions on data

intervention that was covered on the New and Aspiring Heads of Science course which has led to the better identification of performance issues amongst different groups of students and the putting in place of strategies to boost performance (e.g. target setting)

- carried out a project with the aim of improving the grades for controlled assessment - the timing of CPD meant that ideas from the CPD were drawn on in developing the project and a strict deadline provided focus and the results were, consequently 'amazing' and students' grades increased (Teacher)
- moved faster in terms of developments in teaching science as a result of the 'influx of ideas' (Head of science department) gained from the National Centre than it would have done otherwise. This includes teachers teaching in another teacher's lesson to share learning and best practice
- demonstrated experiments usually delivered at A-level with GCSE students - this was suggested during CPD and the year 11 students found them very engaging
- introduced a new Applied Science course which was the idea of the headteacher but the National Centre CPD supported its implementation and 'it is a testament to that training that it is still running and there is an increased uptake' (Head of science department).

Case study 9

This school has:

- embedded a large number of practicals into classrooms 'as a permanent fixture' and say that 90% of their practicals have come directly from courses that staff have attended
- embedded practicals such as elephant tooth paste and exploding eggs and other practicals from the Chemistry for non-specialists and Getting Practical courses
- used a variety of 'Hands on, Minds on' practicals with GCSE chemistry students, for example: calculating how much ethanoic acid is in vinegar, a dry ice task focusing on changes in temperature, identifying different colourless solutions, exploring how many hydrogen atoms are in a drop of water, exploring how many nitrogen molecules are in a balloon, and a plate tectonics experiment with hot chocolate
- used new practicals in transition days and open evenings for prospective parents which has proved very successful in terms of engaging students and raising their interest in science
- delivered a whole day on particle physics following a trip to CERN which has benefited students
- used science in the news activities from the summer school
- introduced a new Science Club for Year 7 students which allows students to carry out practical work and other extra-curricular activities which has enriched their understanding.

Case study 10

The school has:

- created a literacy and questioning resource for the science department
- used questioning resources as a starter, particularly with year 7s
- used Assessment for Learning techniques acquired on a course e.g. getting feedback from students as to where they are and what support they need
- developed the Science Club for years 7s and 8s which is an environmental group which played a significant part in Science Week through running assemblies
- become further involved in Science Week which is now a whole day event with all year groups and which also involves a competition amongst the year groups

with students working in groups to solve problems
- arranged a visit to a Science Museum with ENTHUSE monies to which local primary school pupils are invited
- undertaken more effective, well managed and structured group work in class and built resources for group work sessions
- used worksheets and examples to deliver sessions in a way that students find easier to grasp e.g. sessions on motors
- embedded examples from a microbiology course in the classroom with all year groups, particularly years 10 and 11. The staff member who attended the course leads on the experiments in some teachers' classrooms but she has also run an INSET for teachers so that learning and resources and health and safety considerations can be more widely shared and they can deliver the experiments themselves
- set up local science technicians and D&T technicians support groups to share learning and good practice.

Case study 11

Telephone interviews by phone, rather than face-to-face, were undertaken with teachers during both rounds of case-study visits and, therefore, less data was collected for this school than for the other case studies. This school has:

- embedded new resources, ideas, practicals (such as a heat transfer practical) and strategies (such as word play exercises) in lessons
- created cross-curricular partnerships between the mathematics, English and science departments to address and improve weaknesses in students' scientific literacy, which has involved shared learning between subject teachers.

5.4 Benefits and impacts for heads of science undertaking National Centre CPD

Reflecting the comments from teachers, the heads of science departments who had undertaken leadership CPD commented that, as a result of their attendance at National Centre CPD, they had gained **increased confidence in leading their department and had further developed their leadership and management skills. These impacts have become embedded in their practice and were still evident during follow-up visits**:

> *It's been very good in terms of my own personal development, but also taking me away from school so that I had time to think about it… the course gave me enormous confidence in leading a science department…I think my management skills have changed massively…I now feel more confident as a subject leader, leading departmental meetings – they're quite hard you know – so that side of it was absolutely fantastic* (Subject leader for science, case study 4)

> *I understand* [subject knowledge] *so much better. Getting the enthusiasm, new techniques, better understanding means that you can be much more confident in your teaching and you can be enthusiastic about it because you know it's something really exciting that the kids are going to enjoy doing* (Head of physics, case study 5)

The head of science in one school reported that the development of his confidence and skills in leadership had resulted in a **'knock-on' effect on teachers within the science department** in terms of improved support to help them work more effectively and efficiently. This was ultimately impacting on students' experiences of science as teachers were more

effectively gathering information from students and uncovering any issues that could then be tackled:

> *The leadership skills I've got cascade down* [and], *if I effectively lead the department, get people doing effective things more efficiently, it filters all the way through to the kids…*[and] *I'm now more effectively getting information from the students...and* [discovering] *issues that I didn't even know about…*(Head of science department, case study 4)

5.5 Benefits and impacts for technicians undertaking National Centre CPD

Through undertaking CPD at the National Centre and, very importantly, having the opportunity to network with other technicians, **technicians have acquired increased confidence in their role and reassurance that they are using the right approaches** to help their students:

> [The last course was] *really good, really helpful and gave me reassurance that what I'm actually doing is helping the students…It does make you more motivated knowing you are doing it right…I've got more confidence in dealing with the kids when demonstrating…* (Technician, case study 9)

Technicians also reported feeling more confident in, and knowledgeable about, setting up equipment. For example, one technician reported difficulties in setting up the oscilloscope and commented 'once it was explained simply it made my life here so much easier' (Technician, case study 10).

As well as learning about ways of improving the experiments they already supported, technicians **have also gained ideas for new experiments, which has allowed them to suggest practicals to their teacher colleagues and to be more experimental**:

> *A lot of things I took from the courses was learning about improvements to experiments as well as new experiments and talking to other technicians about how they approached a particular experiment* (Technician, case study 8)

> *I know the technicians have benefited massively from the course they went on. It helped them to think outside the box, before that we were quite limited in what we were doing. They've now trawled the internet and looked for more interesting experiments, so it's had a knock-on effect* (Deputy lead teacher of science, case study 9)

> *It was absolutely fantastic, really, really good…we came back with lots of resources, paperwork and samples and different things…You find out things from other technicians at these conferences…and they* [technicians] *can share best practice with other technicians such as discounts on equipment* (Technician, case study 10)

During the follow-up interviews, one technician explained that the course he had attended had continued to have an impact because it had led to changes in the content of lessons. He has been able to put his learning into practice by providing new practical demonstrations to teachers, as well as providing ongoing support. Commenting on the importance of implementing demonstrations, the technician explained: 'if you just tell them [teachers] an

idea, nothing might happen, but if we put it together and show them, they know it's going to work and they're more likely to give it a try'.

Technicians have also acquired new subject knowledge as a result of attending courses, as this technician reports, as well as renewed enthusiasm and knowledge of where to go for further information:

> *My subject knowledge before going was minimal and I came back with loads of information and we have been doing so much more microbiology in school now…I just want to do more now. I have signed up for different organisations and things and have received lots of literature from them and during the summer holidays is an ideal time for me to sit down without the pupils and try out a lot more things* (Technician, case study 10)

One technician found the sharing of best practice that takes place on CPD courses so useful that he had since set up a local science technicians support group and a D&T technicians support group which allow technicians to meet up once a term to share learning, how they work, the different procedures they use and so on: 'There is a lot of sharing good practice going on' (Technician, case study 10).

One teacher went so far as to say that there was now a blurring of the roles of teacher and technician in their school as a result of technicians gaining more confidence and skills in demonstration and helping out with experiments through National Centre CPD:

> *I think the biggest impact it has made has been on our technicians. The line between teacher and technician gets more and more blurred, like the line between doctor and nurse and more often we get technicians coming in with a bit more confidence and demonstrating experiments and helping out with the more complicated experiments* (Teacher, case study 2)

A head of science commented that many technicians that were employed did not come to the role with particular experience or expertise and, as a result, the National Centre CPD was effective in giving them the skills and competence to fulfil their role effectively:

> *Technicians will use it* [National Centre CPD] *to gain confidence in basic competency skills that they should have as technicians*. *We find in schools a lot of technicians don't come with experience behind them…It's then a case of training them up to be competent enough to work with chemicals, understand cultures…* (Head of science department, case study 4)

Technicians also commented that the courses were helpful in that they gained an awareness of different equipment and resources their school might want to consider purchasing. One school had purchased a National Grid simulator following a course. However, another technician commented that schools did not always have the funding to buy the equipment recommended.

5.6 Wider impacts on schools

Many teachers had shared their learning with colleagues in their school thus ensuring a wider impact, which had been sustained through to the follow-up visits. This has mainly

included sharing ideas for practicals, resources and lesson plans, as well as revision packs that some teachers have developed as a result of attending CPD. Teachers tended to be more confident sharing ideas for experiments when they had gained experience of setting them up and doing them themselves at the National Centre.

Sharing has taken place more formally through departmental meetings and twilight sessions as well as more informally, for example through sharing resources on shared areas and one-to-one conversations. INSET days and workshops were also used to disseminate information to colleagues.

The good thing is we've now shared that [ideas for new practicals and resources] *with the rest of the department, and that just spreads out. It has a cascade effect* (Teacher, case study 4)

It's had a good impact. [Teacher's name] *came up with different ideas and resources that she's been taught at the centre and then ran an INSET in how to train the session, showing what the practicals she learnt were and showing how they can help. That was beneficial and not only to the individual, but to the whole department* (Head of science department, case study 5)

...every time we do something like this you get a little snippet and then it gets shared in our five minute meeting where we share good practice (Head of science department, case study 6)

When she [a relatively inexperienced biology teacher] *came back from the A-level course, the amount of resources she created in her first year as head of biology was absolutely phenomenal. She demonstrated some of the science ideas, she demonstrated some of the practicals and she put a breath of fresh air into teaching* (Head of science department, case study 6)

We then try to feed back to everyone when we get back to school (Teacher, case study 7)

If I have experience of doing an experiment I am more willing to come back and encourage a teacher to do a demonstration and the teacher might not be a specialist in that area but I can explain to them how it works and then they are able to implement that lesson rather than maybe shying away from it (Teacher, case study 8)

Like teachers, technicians have also shared their learning with other staff in school, with both technicians and teaching staff. In particular, they have shared ideas for new experiments:

> *The technicians, it was an amazing thing they went on. A course about all different science experiments and they came back and did a whole lunch time and afternoon session showing us all their experiments and the things they had found out. There were twelve teachers in the room just going 'wow!'* (Head of science department, case study 5)

5.7 Maximising the impact of National Centre CPD

Consultees were asked what factors maximised the impact of National Centre CPD on teaching staff and technicians, as well as more widely on their schools. The range of factors that they reported included:

- **senior leader commitment to staff undertaking National Centre CPD** and their understanding of the benefits (e.g. CPD coordinator and head of science department):

  If we are not getting CPD and we are not getting new ideas and staying ahead of the game then we are not going to get improvements in learning (Head of science department, case study 2)

- **funding** - the ENTHUSE Award not only allowed staff to go on CPD with no cost to the school, it could also be used to pay for books, materials and resources and teacher supply cover to support changes in practice and the undertaking of practical work (The ENTHUSE award and the action plan are the reasons that these courses are much more suitable than others' (Head of science department, case study 10))
- **time to implement changes back at school** – key to change occurring following CPD and new ideas and practicals being embedded within the curriculum was time for teachers to act on their learning
- the focus on **action planning and follow up work** – this made it more likely that teaching staff and technicians undertook work in school between CPD sessions, and after the CPD was completed, and that new learning and materials were, as a result, embedded in the curriculum and actions and achievements were monitored
- **the practical slant of courses** - impact was increased when staff gained ideas that could immediately be implemented back in the classroom and they felt confident in using the equipment after time spent familiarising themselves with it alongside experts:

  The CPD that stands out in my mind were the ones where people made really practical suggestions about how to implement things in the classroom (Teacher, case study 6)

- **coming back to school with materials and resources** – teachers highly valued the ideas, lesson plans and worksheets that they were provided with as part of the CPD which could be picked up and used straight away with little time required for adaptation. Resources for use with students were seen to be particularly useful:

  The resources. Just having a new spin on things. Things that teachers can take away (Teacher, case study 5)

  If you want instant impact, then you provide resources. If you have resources that you can use literally the next time that subject comes up, then inevitably you'll end up sharing it [with colleagues] (Head of science department, case study 6)

- **sharing learning and good practice at departmental meetings** – where schools dedicated a slot at meetings for those who had undertaken CPD to share learning, provide feedback on the effectiveness of different approaches and demonstrate practicals and new equipment and resources with other staff, this ensured a much wider impact in schools. Staff also shared learning informally during break and lunch-times
- **sharing resources on the science department's shared area** – this was also another very simple way of getting messages across and sharing learning with colleagues
- **accreditation** – particularly for longer courses, points gained towards Masters was seen to be attractive to staff (e.g. New and Aspiring Heads of Science CPD).

One teacher commented that CPD would have even more impact if attendees were given a step-by-step guide to delivering particular practicals and a list of the resources required that could be passed onto a technician. However, he realised that this might be asking too much of the National Centre:

> *...so you just walk back and slap it on your technician's desk and say 'I'd like that in three weeks' time' and they can order exactly what you need. It's all there and it doesn't take them long…I know I'm asking a lot, but they've got so many good ideas and they do some of this…* (Teacher, case study 4)

School staff were also asked to identify the issues that teaching staff and technicians faced in engaging with CPD at the National Centre. Their responses included:

- **lack of support from senior leaders for external CPD** – in some cases, senior leaders had a preference for in-house CPD and twilight sessions
- the **length of some courses** – teachers found it difficult to gain agreement to being out of school for more than 2 days due to the impact on their students' learning, and sometimes behaviour, so this made undertaking 3 day courses unlikely. This was particularly an issue for exam classes. Teachers also found it stressful returning to their classes when they had been taken by someone else. Childcare issues also meant that some teachers found attending residentials difficult
- **cost** – schools were able to undertake National Centre CPD because of the ENTHUSE Award. However, many senior leaders and teachers commented that, without this funding, they would not be able to attend the courses ('It's a massive factor, we wouldn't have the training otherwise' (Teacher, case study 9) and 'With cuts it will be even harder and the ENTHUSE Award courses will be the ones we are allowed to go to' (Technician, case study 10))
- **accessibility and travel time** – some teachers commented that courses had to be accessible and it was unlikely that they would go on courses that were too far away due to the travel time required
- **timing** – timing of courses was important and could be a barrier. Courses needed to be scheduled at times when teachers found it easier to take time out of the classroom. For example, they would not be able to attend courses that were held just before exam periods ('no-one wants to leave their year 11s') and after exams was usually a better time. Some teachers teaching exam classes reported that they could not miss lessons during the exam year due to the negative impact on students. Some teachers were open to attending courses in their holidays if they were felt to be beneficial. Other teachers commented that they preferred twilight courses to schedule in time to allow teachers the time to travel to the course after they had finished their day's teaching
- **the process of applying for and receiving the ENTHUSE Award** – a small number of teachers commented that the time required to fill out the application could be off-putting as was the time delay in receiving funds – one teacher funded himself for the CERN course and had to wait 9 months to receive the award
- **relevance** – teachers felt that they needed to see how what they would learn on courses could be applied in the classroom and they were open to being stretched and challenged

on courses. Schools wanted to see that courses fitted with their priorities for science. National Centre courses were generally very relevant but this did not always apply to other external courses

- the **lack of time to follow-up on CPD** when staff returned to school – although ENTHUSE funding could be used to pay for cover for follow-up work in school, more often teachers used their own personal time to develop new schemes of work, lesson plans and materials. Some teachers felt that they required more non-contact time to properly develop their ideas and resources and that **the National Centre should put more pressure on schools to use any remaining ENTHUSE Award monies on supporting teachers to implement what they have learnt on courses:**

  More pressure needs to be put on school leaders to ensure ENTHUSE Award monies are spent on supporting teachers…After a course I think a letter should be sent to the headteacher saying such and such has done a course, they have put together an action plan, this money has been allocated to implement their action plan, it is actually a requirement of the money being given to the school that it is spent on this and a review of its spending will be carried out in six months' time. Some kind of follow-up (Head of science department).

6. Benefits and impacts for students

Key findings

The benefits and impacts that have been realised for students as a result of National Centre CPD, reported by teaching staff and technicians, and supported by comments from students themselves, are highlighted below.

- **Students' increased enjoyment of, and engagement in, science lessons and extra-curricular activities** – this has been achieved through: increases in teachers' confidence in, and enthusiasm for, teaching science; through teachers keeping up-to-date with new ideas and introducing new content in lessons; and through teachers using, or becoming more expert in using, different approaches to teaching, with practicals featuring most prominently.
- **Students' increased confidence and understanding in learning science and their security in their existing knowledge** – this is a 'knock-on' effect of their teachers' increased confidence in teaching science and delivering practicals and the increased competence of technicians to support teachers.
- The **development of transferable and practical skills** – this includes a range of skills such as discussion skills, working in pairs and groups, independent learning, study and revision skills, thinking skills, hypothesising and questioning skills, and skills in undertaking practicals. These skills have been developed as a result of teachers using a wider range of teaching approaches.
- **Students' increased awareness of the importance and relevance of science to society** – this has been achieved by more topics being taught within a real life context and field trips e.g. to CERN.
- **Students' increased knowledge of career opportunities in science** – this impact had been achieved in schools where careers in science/STEM have been an element of teacher CPD.
- **Students' improved progress and attainment** – although teaching staff were more cautious in reporting impacts on student attainment, many felt that students' increased enjoyment of, and engagement in, science was impacting, or would ultimately impact, on their progress and attainment. A smaller number of teachers (and some students) reported actual improvements in students' grades.
- **Students' increased interest in, and uptake of, science subjects and careers** – again, many teaching staff felt that students' increased enjoyment of, and engagement in, science would ultimately lead to increases in students studying GCSE/BTEC and A-level science subjects. Many schools had already experienced increases in uptake at these levels which National Centre CPD had contributed to alongside other factors.

6.1 Introduction

This chapter explores the benefits and impacts of National Centre CPD **on students. It explores both the impacts reported by teaching staff and technicians as well as those reported by students themselves. Teachers, heads of science departments and technicians generally found it difficult to identify and/or quantify the impacts being realised for students** as a result of their, and other staff in school, undertaking CPD at the National Centre. As one teacher commented:

> *Scientifically, I don't know if we can measure that* [the impacts of National Centre CPD on students] *very easily…* (Teacher, case study 4)

However, teaching staff and technicians felt that the impacts for students would be positive as they themselves had all gained significantly from the CPD in terms of increased confidence in teaching science and had made a range of changes to their teaching practice, as detailed above in chapter 5. As a technician commented:

> *The way the courses are structured you are always going to bring something back that will impact the students, even if it is something that you have picked up over lunch* (Technician, case study 2)

As mentioned in chapters 4 and 5, schools had collected very little documentary evidence to support their perceptions of the impacts of National Centre CPD on students.

Perhaps not surprisingly, many students were not aware that their teachers had undertaken CPD and often attributed improvements in their interest and engagement, understanding and progress in science over the years to the fact that they were now higher up the school and were taking their studies more seriously, and that the curriculum and scheduling of lessons was different. However, some students were aware of the CPD their teacher had undertaken and could point to the changes in teaching and the resulting impact on them. Even though not all students were aware of the CPD that their teacher had completed, **the findings from the student interviews were very positive which suggests that students are experiencing effective and engaging science lessons and that a range of impacts are being realised for students as a result of the National Centre CPD that teachers and technicians have undertaken**.

The benefits and impacts for students, reported by teaching staff and technicians, and supported by comments from students themselves, include:

- increased enjoyment and engagement
- increased confidence and understanding
- the development of transferable and practical skills
- increased awareness of the importance and relevance of science to society
- increased knowledge of career opportunities
- improved progress and attainment
- increased interest in, and uptake of, science subjects and careers.

6.2 Increased enjoyment and engagement

6.2.1 Views of staff

The most commonly mentioned impact of National Centre CPD on students, which was reported by teaching staff and technicians, was students' **increased enjoyment of, and engagement in, science lessons and extra-curricular activities/clubs**. It was felt that this had been achieved through: increases in teachers' confidence in, and enthusiasm for, teaching science; through teachers keeping up-to-date with new ideas and introducing new content in lessons; and through teachers using, or becoming more expert in using, different approaches to teaching, with practicals featuring most prominently. Most consultees had not gathered quantitative evidence from students in relation to this impact. However, two teachers had administered surveys with students which provided evidence that students' engagement in science had increased since staff had undertaken National Centre CPD. One head of science summed up the view of many consultees:

> *They get a more committed and enthusiastic teacher who enthuses them. It makes their whole experience more enjoyable. They feel the passion you have* (Head of science department, case study 2)

In terms of pedagogical developments, teaching staff and technicians felt that students were becoming more engaged through their (teachers and technicians) expanded and improved repertoire of teaching approaches. This included, for example: more use of discussion in class; encouraging students to ask more questions; the (more effective) delivery of a greater number and range of practicals and demonstrations; topics being taught within a real life context; field trips, visits and other extra-curricular activities; and messages being delivered to the whole school, for example through assembly sessions. The use of **more engaging practicals** was identified by a number of staff interviewed as part of follow-up visits as having a lasting impact on students. For example, one head of science, commenting on his push to include more practical work in chemistry in the previous academic year remarked: 'The pupils still remember the practical work we did last year and [because of it] they have a love for chemistry'.

As previously mentioned, there was evidence that **more school science clubs** had been set-up by teachers attending National Centre CPD, allowing students to do experiments and undertake extra-curricular work. It was hoped that the activities stemming from such clubs would help improve students' learning in science. The formation of more science clubs was attributed to staff becoming more confident in science and developing new ideas as a result of attending National Centre CPD.

> [Students are] *getting new ideas and getting flash bang experiments to explain the things they are learning and make it more exciting…It probably doesn't impact results a huge amount but it gets them to engage with science…if we can get them to engage* [in the lower school] *then this will help further up the school and they will be interested in what they are doing* (Technician, case study 2)
>
> *…from that* [teacher CPD] *you got a field trip in physics, you got the kids engaged, you're actually then putting something like particle physics into context, so the kids have benefited from that enormously…we've actually got the students engaged*

saying 'Look at something happening here!' but the ideas have come from [the National Centre] (Head of science department), case study 4)

Students are becoming more engaged as a result of being able to see things happen (Teacher, case study 6)

…in terms of enjoyment, students working together, handling the equipment, finding the answer for themselves is very enjoyable. We all like being entertained, so when teachers do really good demonstrations people want to watch it (Head of science department, case study 8)

They find physics more interesting, they understand things better because I know more, so it helps them. Now I feel confident in promoting and teaching, they like physics (Teacher, case study 11)

New practical sessions that were engaging students range from very simple experiments using cheap resources to the more complex 'whiz bang' experiments. Sessions that delivered science within a real life context such as crime scene investigation (CSI)/forensics and particle physics were seen to get students 'hooked' and to engender more positive attitudes to science:

> *It* [using demonstrations and practicals] *makes it much more visual and helps* their [students'] *understanding and also keeps them engaged because it has the 'wow' factor* (Teacher, case study 7)

The introduction in one school of CREST Awards[5] had led to an increased enthusiasm and fascination in relation to science, as had a field trip to CERN in another school.

A consultee from one school reported that a lot of the ideas and practicals gained from National Centre courses were incorporated into transition days, as well as lessons, and that the feedback from students was very positive in relation to their increased engagement in science and interest in studying it further:

> *We do transition days and a lot of the things we learn from the courses, we incorporate in transition days and into students' lessons. They all come back and the feedback you get is 'wow!' They've really taken something from it, it's exciting, it's new, it's not just sitting writing out of books. It's nice to have a positive effect on them and for them to actually remember that* (Technician, case study 9)

Teachers commented that more engaging lessons overall were getting students 'hooked' on science and reducing disaffection and bad behaviour amongst students of all ability levels:

> *I would say the majority of them love it* [physics]*! I've had kids that are misbehaving in other subjects and I get really surprised hearing that because they walk into science loving it. They find it engaging, stimulating* (Teacher, case study 11)

Some of the ideas for delivering practicals, such as displaying notes in different ways, had allowed teachers to engage the more disengaged students. In addition, one teacher reported

[5] CREST is a project-based awards scheme for the STEM subjects (Science, Technology, Engineering and Maths). It links the personal passions of students to curriculum-based learning: http://www.britishscienceassociation.org/web/ccaf/CREST/

that the school had changed the timing of sessions to introduce topics when students were in a position to better grasp them, which had increased students' self-esteem.

Another teacher commented on the difficulties of engaging students who had come from primary schools in which teachers who were afraid of teaching science had instilled in students a perception that science was difficult. It was perceived to be even more important for these students to be motivated to learn through their involvement in exciting lessons and practicals and strategies which teachers had heard about on National Centre CPD:

> *A handful of girls have said 'I didn't like science and now I like it'. A couple had previously said it wasn't their favourite subject and now it was. You'd hope from that that they would start trying a bit harder* (Teacher, case study 5)

6.2.2 Views of students

All of the students involved in the interviews were engaged with science and found their science lessons enjoyable. While at least some of the students interviewed should be considered atypical, in that they were selected by teachers for the research team to speak to because of their interest in science, this is a positive finding in itself which suggests that the science lessons being delivered in case-study schools are effective. No strong negative attitudes to science were expressed and, **in many cases, mirroring the perceptions of their teachers, students commented that they were now more engaged with science than they used to be and looked forward to lessons**.

Students commented that their increased engagement was related to science lessons being more interactive and fun, and many students had noticed the (increased) confidence of their teacher in teaching science. In addition, they reported increased and effective use being made of paired and group discussions, videos, practicals, demonstrations and animations and games using the whiteboard. Older students commented that, as they progressed up the school, more use tended to be made of equipment and technology.

[Lessons are] *a bit more interactive… everybody gets involved* (Year 12 student, case study 1)

Personally for me it [the use of different teaching approaches] *made me get more excited, looking forward to it* (Year 12 student, case study 1)

The practicals have got a lot better…they've got more challenging (Year 11 student, case study 2)

The topics grab your attention and you can use what you learn in everyday life (Year 10 student, case study 3)

They're very up-to-date with it…and [Head of science department] *is very passionate about what he does…he creates an interest in the subject a lot* (Year 12 student, case study 4)

Science is more fun and interesting, we do practicals (Year 8 student, case study 5)

It's more involved [in year 10], *more enjoyable because you get to see stuff go*

'whoosh'! (Year 10 student, case study 6)

I think that there are a bigger range of tools and techniques [that are used in lessons] *so you can enjoy it a lot more* (Year 10 student, case study 8)

They are really good [science lessons], *the webcam has made it much easier* [to see what's happening in demonstrations] *because you can't see really well. The post-its allow you to see everyone's ideas which is really powerful* (Year 12 student, case study 8)

6.3 Increased confidence and understanding

6.3.1 Views of staff

Teaching staff felt that the increased confidence of teachers in teaching science and in delivering practicals was having a 'knock-on' effect on students. This was enhanced by the increases in competence of technicians to support teachers with practicals. The effect was to increase the **confidence of students in learning science and their security in their existing knowledge.** Through improved practical work, students were also gaining increased understanding of theory which was explained alongside practical work. As four consultees commented:

> *I think the more confident the teacher is in their own ability to deliver certain practicals or experiment in certain areas of their teaching practice, the more confident the student feels in what they're actually being taught…I would say that more people are not looking at the practical going 'Oh no'. More people are saying 'Yes, I can do the practical'* (Head of science department, case study 6)

> *Learning about real life applications of science increases pupils' interest in topics and helps their understanding too* (Teacher, case study 3)

> *Some of the demonstrations that we were shown were really astounding and the kids like that sort of thing as they want to watch and see things as it helps them understand more…Because every demonstration that you do, you have to explain the theory behind it. So that is helpful to get a greater understanding of different areas and different topics…definitely our kids learn well by watching something and seeing something…if you show them it they go 'yeah, now I understand'* (Teacher, case study 10)

> *I just think it's wonderful to see young people get so enthusiastic about things…They are getting quite confident whereas before we would never have dreamed about them pouring their agate plates themselves, they are now doing all of it. It makes science more interesting for them, rather than sitting telling them about something they can actively look at it and do it for themselves* (Technician, case study 10)

6.3.2 Views of students

Echoing the perceptions of teaching staff, **students also felt that they had a more secure understanding of topics and concepts as a result of more effective teaching** and increased one-to-one support. Students described more individual and targeted support

being offered in class, as well as informally during break and lunchtimes and in well structured after school science catch-up classes. As four students commented:

> *All the knowledge you get builds on top of the rest* (Year 10 student, case study 6)

> *I think it's described better, better examples. It's easier to understand than it used to be* (Year 10 student, case study 6)

> *Lessons are more involving now with teachers doing more one-to-one work with students* (Year 11 student, case study 2)

> *She draws us diagrams and if we can't do the practicals then we watch video clips and then she asks questions about what we saw and I think that makes us understand more as she asks us questions and sometimes we give the wrong answer but then she explains the right answer then you really understand about it* (Year 7 student, case study 10)

Students in one school also reported that their understanding had improved as a result of the learning outcomes of lessons being clearly stated at the beginning, the teacher frequently recapping on what they had learnt and the teacher making sure that everyone understood, 'not just those with their hands up'.

6.4 Development of transferable and practical skills

6.4.1 Views of staff

Teachers and heads of science reported that, through their use of an increased range of teaching approaches, **students were developing a number of useful transferable skills**. This included: discussion skills; working in pairs and groups; study and revision skills; planning (e.g. planning and delivering a practical experiment); thinking/critical thinking skills; questioning – particularly asking and exploring open questions; and skills in undertaking practicals. In one school, students were marking the work of others which tested out their understanding of the topic and, in the same school, students were also encouraged to become more responsible for their own learning. A further school commented that the practicals they were now delivering were helping students to think for themselves a lot more. In physics lessons students used and developed critical thinking skills, especially when studying topics like particle physics as the things they were studying did not occur naturally and responses did not rely on common sense. Teachers felt that the development of these skills would lead to students making better progress and achieving higher grades in the long-term. In addition, the young people would be more attractive to future employers. As three consultees commented:

> *...and also students' thinking skills are developed*, [which is] *what their future employers are wanting – they want thinking students* (Subject leader for science, case study 4)

> *I think discussion lessons are very difficult to run, but he* [the science teacher] *managed to organise the lesson in such a way that it allowed the students to then develop those skills* (Head of science department, case study 1)

Rather than saying 'we've doing this practical, here's what you will find out', it's more 'you're doing this, what is it telling you, what questions have you got from it? (Head of science department, case study 9)

6.4.2 Views of students

Students also reported that they had developed a range of useful skills through being exposed to different teaching approaches. The skills they mentioned mirrored those reported by teachers. Those of particular note included:

- hypothesising and asking questions
- independent learning: 'You have to learn how to think for yourself' (Year 10 student, case study 8)
- working in groups: '…you have to put your heads together, it is not like you are told something and then you have to move on' (Year 13 student, case study 8)
- undertaking practical work and using the equipment: 'I've got good skills at science' (Year 8 student, case study 5)
- presentation skills (STEM Club students in case study 10 had run an assembly in science week which had developed their presentation skills)

In addition, students in one school who had worked towards the achievement of CREST Awards felt that, through this involvement, they had developed some important skills such as working in groups, giving presentations and undertaking research.

6.5 Increased awareness of the importance and relevance of science to society

An impact frequently reported by students but less commonly identified by teaching staff and technicians was students' **increased awareness of the importance and relevance of science to society**. Students reported that this had been achieved through more topics being taught within a real life context. In addition, students in one school had been on an exciting field trip to CERN which had provided them with a much greater understanding of the importance and relevance of science:

A lot comes from the fact that they are enjoying science so they are engaged. That is a really important point…they see the relevance of it and that was what came out quite strongly…they recognise how science links into the real world and I think that since we made that connection that is one of the reasons we chose the 21st century course (Head of science department, case study 8)

They [students studying microbiology] *also link things together in everyday life with their learning, for example their GP giving them antibiotics. They may not have really thought about these things before* (Technician, case study 10)

Science is really useful. The things that you do in English etc. are interesting but the things that you do in science are actually happening today. You can look around and see it in real life (Year 12 student, case study 8)

We've learnt how science can be used in everyday life. It's good to have a basic understanding and to be able to apply that to the real world (Year 11 student, case study 7)

It showed [trip to CERN] *how much what we learn is at the forefront of science* (Year 12 student, case study 4)

I came away thinking it's a bit more relevant, 'cause you're learning it in a classroom, it's like what is this going to do for me in later life? But actually going there and seeing it working…we are actually learning about what they are doing today… (Year 12 student, case study 4)

6.6 Increased knowledge of career opportunities

6.6.1 Views of staff

A number of teachers reported that their increased awareness of STEM careers through undertaking National Centre CPD had enabled them to increase their focus on careers in lessons and had given them more confidence in providing careers advice to students. This had, in turn, they commented, led to **increases in students' awareness of the career opportunities in science open to them**:

...certainly, the responses that we are getting from the GCSE groups that we're doing this project [on careers in physics] *with are that they didn't realise where physics would fit in, and we're getting some saying 'We might well take it' and others, it's fine to have some of them say 'Well actually, no, we realise this isn't the right thing to do now'… that will mean we have a better cohort coming through* (Teacher, case study 4)

If the interest is there, then they do it. My two children are both at this school and do science. They love the interactive way the science department is with them. One is doing A-level sciences and the other has just finished year 11 and will be going on to do sciences as well (Technician, case study 9)

For one group of students, a field trip to CERN had significantly increased their awareness of careers in physics:

...going out there [to CERN], *it's shown them career paths as well, because they think 'Well this sort of thing happens at CERN'* (Head of science department, case study 4)

6.6.2 Views of students

In schools where teachers had gained an increased awareness of careers in STEM during their CPD, **students reported an increased awareness of the opportunities available to them in science**. In addition, students who had been to CERN mirrored the comments of their teachers in respect of their increased understanding of the career opportunities available within physics:

…seeing where it can lead to, in terms of jobs…it showed me that if you wanted, just literally, to do particle physics, there are job opportunities and it can happen. It's make it more relevant and makes you feel it could actually happen (Year 12 student, case study 4)

It inspires you because it shows you where it [studying physics] *can lead* (Year 12 student, case study 4)

6.7 Improved progress and attainment

6.7.1 Views of staff

Teaching staff generally felt less confident in reporting impacts on students' attainment and, in some cases, they did not feel that this was an intended impact of the National Centre CPD that they had attended:

I'm sure it will have some impact [on attainment] *but it's more about making science interesting, making it fun, making it a subject that students love and that's what we have all come into teaching to do* (Head of science department, case study 5)

The impact on the actual student results, you couldn't see them per se, but the engagement side of things you probably could (Head of science department, case study 6)

In addition, **teaching staff commented that many factors impacted on the attainment of students and that it was difficult to separate the impact of National Centre CPD from other factors:**

It's difficult to say for sure that the National Centre has had an impact [on grades] *but I would say it does contribute* (Head of science department, case study 6)

I think it is hard to attribute going on a specific course to impacts on pupils' attainment, particularly given all the other things going on (Head of science department, case study 7)

A lot of it is through my understanding in being able to motivate students better, get them interested in the subject and, as a consequence, they will perform better in their tests. I think it does happen, if you have a group of students that are motivated, generally they've got more of an interest and will achieve. That's all I can say on that because the attainment system, there are so many different factors that can affect it (Teacher, case study 9)

It is hard to show you impact of that but I think there has been impact obviously. I can give you trends of attainment in science. They are really good here with going up to 100% predicted this year. However, although we really enjoyed the National Science Learning Centre [CPD] *I am hesitant to give them credit for all of our hard work we have done to raise our students' achievement* (Head of science department, case study 10)

However, having said the above, teaching staff felt that students' improved enjoyment of, and engagement in, science were likely to, ultimately, have a positive impact on their progress and attainment:

…once students start enjoying science they start learning it, which leads to better results. If they are not engaged and not enthused then the results won't go up (Teacher, case study 8)

I think it's also about engagement as well, we're getting them hooked on a subject so they're working hard and trying hard and there's a knock on effect with grades increasing. We're getting less disaffection, especially in the top sets (Deputy lead teacher of science, case study 9)

Everything contributes to pupils getting a better grade but particularly having dynamic staff so it supports that. More engaging inside and outside of lessons you are going to get more interest [from students] (Head of science department, case study 10)

A smaller number of consultees reported actual improvements in students' grades which they felt National Centre CPD had contributed to alongside other factors.

In one school (case study 1), consultees reported that grades had improved in the practical paper of A-level biology using a new approach to photosynthesis picked up at the National Centre.

Consultees in another school (case study 2) reported improved grades in psychology, which is run as an after school activity. Students were previously getting Cs and were now achieving As and it was felt that the increase in grades was partly attributable to National Centre CPD:

In psychology it's easier to see because it is an after-school activity and it's a small group and they were getting Cs but now some of the students are getting As and it is definitely part due to going on the course, being aware of the resources out there and brushing up on my skills… (Head of science department, case study 2)

In another school (case study 3), grades had increased since the introduction of a BTEC course for which National Centre CPD had provided some direction. However, consultees were not able to say to what extent the improvement in grades was as a result of staff undertaking CPD at the National Centre.

A teacher in case study 8 commented that the school had changed their strategy for controlled assessments and, as a result, GCSE grades had improved:

For controlled assessment, after the course I changed the strategy and the results have doubled. Most of the children's target grades were C but they increased. I think using the different techniques definitely helped. Most of them are able to draw a graph when they couldn't have done before… (Teacher, case study 8)

The head of science in the same school also reported improvements in attainment, this time at Key Stage 3:

Most of the training that occurs [within the science department] *happens in the National Science Learning Centre, new ideas have come in, things have been done differently, with developing the courses, new practicals, new demonstrations, new teaching strategies and the result of that - and the data shows this – more students are doing better at Key Stage 3 in terms of level 6s and 7s that is basically what they need to get to do separate sciences…* (Head of science department, case study 8)

He commented that that an increased focus on regularly checking students' work and understanding, and using data to better identify performance issues amongst different

groups of students so that strategies could be put in place to boost performance (such as target setting) had also positively impacted on students' attainment across the board.

A teacher in case study 11 commented that, provided that students wanted to learn, the increased knowledge and improved teaching in physics which had come about as a result of National Centre CPD would help them achieve better grades.

6.7.2 Views of students

As reported above, many students were enjoying science more and felt that science was being taught more effectively. **A small number of students then linked their increased enjoyment of science to an improvement in their progress and grades.** As three students commented:

> [The teacher is] *very enthusiastic, and he draws us into the lesson and makes us involved and makes it stick in our heads easier* (Year 12 student, case study 1)

> *I do enjoy science now in the last year. Since* [name of teacher] *has been teaching me my grade has been going up and she has boosted my grades* (Year 11 student, case study 2)

> *In primary, science was almost a weak point for me because I wasn't very keen on science, but I did my best. But in secondary I was shocked to see I had level 6s for my sciences* (Year 7 student, case study 10)

In a school that was setting regularly setting targets and checking and assessing progress and putting in place strategies to support those who were under-achieving, this had been noticed by students:

> *Targets are regularly assessed and checked, so if there are people who are lagging behind, measures are taken to get them back to where they should be. They are also recalculated so that we are always trying to achieve something. People aren't left to stew and get complacent about things* (Year 12 student, case study 8)

6.8 Increased interest in, and uptake of, science subjects and careers

6.8.1 Views of staff

Teaching staff felt that students' increased enjoyment of, and engagement in, science would ultimately lead to **an increase in the number of students studying science subjects at GCSE/BTEC and post-16**. In a number of cases, uptake of science subjects had already increased in schools but, again, teaching staff could not entirely attribute this to National Centre CPD, due to a range of factors that had affected uptake. However, interviewees felt that the National Centre CPD had contributed to students choosing to study science at GCSE/BTEC and post-16. Examples of where uptake has already increased are provided below.

In one school (case study 1), there was a good uptake at A-level across the science subjects and numbers had increased in recent years. There was also a good uptake of A2 biology

and, as a result of that, the school was now in the process of developing an additional human biology course. However, it was unclear to what extent National Centre CPD had contributed to these increases.

In another school (case study 3), increases in uptake had been seen in a recently developed BTEC course and there was also much more interest in sciences at GCSE. The numbers of students taking A-levels in science subjects had also increased and a lower number were dropping out. In addition, the school had experienced a good uptake of CREST Awards. Again, it was unclear to what extent National Centre CPD had led to these increases although National Centre CPD had provided the school with some direction in the development of the BTEC course and had raised the school's awareness of CREST Awards.

In case study 4, it was felt that listening to students and teaching science more effectively, partly as a result of strategies picked up at National Centre CPD, had doubled A-level physics numbers in the last three years.

In case study 5, uptake in all three sciences at A-level had increased but this was due to a range of factors and the school could not say to what extent National Centre CPD had contributed.

In case study 6, a number of students in the class of the teacher who had undertaken National Centre CPD were considering taking A-level chemistry and the teacher hoped that this might relate to her changes in practice and increased confidence.

In another school (case study 7), there had been increases in the uptake at Triple Science though this was due to a range of factors, of which one was staff attendance at National Centre CPD.

In case study 8, staff reported that increasing numbers of students were choosing to study Triple Science at GCSE, Applied Science at GCSE and more students were also choosing science A-levels and going onto STEM careers. New approaches to teaching and ideas coming from the National Centre were definitely seen to be contributing to this increased uptake:

> *The numbers doing A-level sets have increased over the last number of years and the numbers of students going onto STEM subjects at universities have increased. It is by far the most popular subject in the school in terms of the number of students doing it at A-level and in terms of related degrees that they go on…there is a very collaborative approach in lesson planning and those new ideas are coming from the National Centre and regional centres because that is the only CPD that we do* (Head of science department, case study 8)

In case study 9, the head of science reported that the school had experienced an increase in the uptake of Triple Science over recent years but he added that this couldn't necessarily be attributed to National Centre CPD: 'I think we've quite discretely embedded it in all honesty. It's not necessarily been stand-alone, it's been integrated into our scheme. We've used it to enhance the scheme…measuring that [the impact of National Centre CPD] might be difficult'.

In case study 10, the head of science commented that encouraging students to study science at GCSE and A-level was a big focus for the school. This was being supported by staff at the University of East London, who were laying on activities to raise aspirations, and this focus had been developed in conjunction with learning from National Centre CPD. A teacher commented that some of the ideas that had been brought back from courses made students curious and interested in learning more at higher levels of study:

> *Some of the ideas that we brought back from the course are really interesting and it gets them thinking, it gets them quite curious about what is beyond the topic we are talking about and a lot of the time when they ask questions you can say 'at A-level you would learn more about this' so that gets them more interested definitely. A lot of the ideas go further and they are interested to go the extra mile* (Teacher, case study 10)

However, staff in this school were unable to say to what extent participation in science GCSEs and A-levels had been impacted by National Centre courses.

In case study 11, as a result of National Centre CPD, physics was being more actively promoted and students were gaining a better understanding and finding it more interesting. This was resulting in larger numbers of students wanting to study physics at A-level: 'We now [in the last two years] have a larger proportion of students who want to study physics at Key Stage 5. Some of these don't actually take it up because they want to do other subjects. But overall they are less 'scared' of studying physics (Teacher, case study 11).

6.8.2 Views of students

In some case-study schools, the students who were interviewed showed a strong interest in continuing their study of science subjects in the future, either at GCSE or A-level.

In case study 2, all of the year 11 students who were interviewed were considering going on to study a science subject further at A-level and, in case study 3, all of the year 10 students interviewed were also considering going on to study sciences at A-level. In case study 4, the 2 year 12 students who had been to CERN were now more aware of, and interested in, physics as a career and studying physics further. In addition, all year 8 students interviewed in case study 5 expected to take Triple Science at GCSE and were planning on undertaking higher study in science and STEM-related careers. All of the students interviewed in case study 8 were keen on studying science further and pursuing a career related to STEM. In case study 10, participating in the STEM Club had increased the interest in science of year 8s who were now more likely to pursue science subjects at GCSE and beyond.

6.9 Case-study examples of student impacts

The box below provides a summary of the impacts reported by students in each of the case-study schools.

Case study 1
11 students were interviewed from years 9, 10 and 13. There was a mix of boys and girls. All students enjoyed their science lessons and could point to improvements over previous years.

- A-level biology students were very enthusiastic scientists and described their year 12 experience as ‘a bit more interactive….everybody gets involved’. They identified videos as a valuable way of bringing learning to life. They felt they had a good awareness of science careers.
- Year 10 students commented that their science teacher was ‘very enthusiastic, and he draws us into the lesson and makes us involved and makes it stick in our heads easier’; ‘I think he’s put a lot more fun into it this year’. They reported their teacher using Assessment for Learning techniques such as ‘We are Learning to’ and ‘What I’m looking for’ and actively walking round the class involving all students.
- Year 9 students felt that science was more serious and harder and that lessons were stricter than in year 7/8 and that teachers made sure everyone was involved and concentrating. There was more opportunity to discuss ideas and undertake a variety of activities such as demonstrations and practicals, paired discussions and animations/games on the whiteboard (which helped recall). There was also more focus on STEM careers that students might want to consider. As one student commented: ‘Personally for me it’s made me get more excited, looking forward to it’.
- A student survey indicated that levels of engagement with science had increased for Key Stage 3 and 4 students between 2010/11 and 2011/12.

Case study 2

6 year 11 students were interviewed and there was a mix of boys and girls. The students all generally liked science and felt that the standard of teaching had improved in recent years and that lessons were becoming more engaging and enjoyable. Teachers were undertaking more challenging practicals with students and working more on a one-to-one basis with students when this was needed both in and outside of class. All students were considering going onto study a science subject further.

- Year 11 student: ‘I do enjoy science now in the last year. Since [name of teacher] has been teaching me my grade has been going up and she has boosted my grades’.
- Year 11 student: ‘Lessons are more involving now with teachers doing more one-to-one work with students’.
- Year 11 student: ‘The practicals have got a lot better…they’ve got more challenging’.
- Year 11 student: ‘I go to the after-school [science] sessions where we work in small groups and these are much better run than they used to be’.
- Year 11 student: ‘The best teachers know their kids individually and will recommend [individual] learning strategies. They recognise that there are different ways to help different students and that we have different learning styles’.

Case study 3

4 year 10 students were interviewed all of whom were girls. All of the students interviewed were positive about science. They found science interesting and enjoyable and particularly enjoyed practical lessons. They were all thinking about studying science subjects at A-level. Students were spending a lot of their own personal time on the CREST Award and felt that they were learning about new topics such as hair dyes and making paper and developing new skills such as giving presentations. They reported that their teacher had good slides and made the learning outcomes clear, re-capped regularly and asked questions and made sure that everyone understood. They felt that their grades were improving and that they were doing better than was predicted.

- Year 10 student: ‘The topics grab your attention and you can use what you learn

in everyday life'.

- Year 10 student: 'He recaps and asks questions to make sure everyone understands'.
- Year 10 student: 'The teacher wants us to get the best grades possible and creates a happy learning environment'.

Case study 4

2 year 12 students were interviewed, one boy and one girl. Both students had been on a trip to CERN. They saw some real life experiments and saw staff collecting data. They felt that it increased their understanding of why it was important to learn physics and their understanding of potential careers using physics. One of the students felt that the experience had made her realise that she might have a good chance in a job in physics as there were not many women at CERN. Both students were more aware of the careers in physics open to them and were considering studying physics further with a view to a possible career in physics. Students also felt that going on a field trip with their teacher made them develop a better relationship with the teacher, trust them and respect them more and feel more comfortable talking to them.

- Year 12 student: 'It showed how much what we learn is at the forefront of science'.
- Year 12 student: 'I came away thinking it's a bit more relevant, 'cause you're learning it in a classroom, it's like what is this going to do for me in later life? But actually going there and seeing it working…we are actually learning about what they are doing today'.
- Year 12 student: '…seeing where it can lead to, in terms of jobs…it showed me that if you wanted, just literally, to do particle physics, there are job opportunities and it can happen. It makes it more relevant and makes you feel it could actually happen'.
- Year 12 student: 'It inspires you because it shows you where it [studying physics] can lead'.
- Year 12 student: 'It helps you develop a relationship with your teacher, so you can trust them and talk to them…and you learn they're actually people not just teachers!'
- Year 13 student: 'It makes you not want to mess around as much because you have more respect, more understanding, that sort of thing'.

Case study 5

6 students in year 8 were interviewed with an equal number of girls and boys. Students remembered their teacher undertaking a course at the National Centre. Their teacher was a biology specialist who had started to teach chemistry. Students felt that undertaking the course had made a 'big difference' to their teacher. They all agreed that science was easier to learn and to understand and that they enjoyed and looked forward to it. They felt they were more knowledgeable and better at using the equipment due to their teacher doing more practicals. They also felt that students were encouraged more to ask questions and hypothesise and to speak and that they all knew more about science as a result and were more interested in it. All of the students agreed that the teacher now tried to 'make science fun' and that the practicals were a key element to making chemistry more enjoyable and helped them to understand better. All students felt that they were doing better than in year 7 than previously and felt lessons were more interesting. All expected to carry on to take Triple Science at GCSE. All students felt that it was a good idea for their teacher to go on the course. A student survey carried out with year 7 students prior to and after their teacher had undertaken CPD indicated that students' levels of engagement with science had increased.

- Year 8 student: 'Science is more fun and interesting, we do practicals'.

- Year 8 student: ‘I’ve got good skills at science’.

Case study 6

9 students were interviewed, 6 were in years 12 and 13 and 3 were in year 10. All of the sixth formers were boys and the year 10 students included 1 boy and 2 girls. All students felt that science was now ‘more interesting’ than it had been a few years ago and that their knowledge had improved and that they were doing better in science. This was partly because they had to write about things a lot more and put their understanding into words. All year 10 students felt that science had improved since year 9, that it was better taught and more practically orientated and so easier to grasp.

A year 12 student also felt science was easier to understand but was not sure if that was down to being older or the teaching. Year 12 students enjoyed doing more experiments and seeing for themselves how and why things happened. Some had chosen particular science subjects like physics because they wanted to do practical work.

Students felt that a good science teacher was one who did more practicals and someone who tried to teach students by interacting with them ‘not just stands there going this is this’.

Year 10 student: ‘We’ve started doing proper stuff’.
Year 10 student: ‘It’s more enjoyable because you get to see stuff go ‘whoosh!’
Year 10 student: ‘I think it’s described better, better examples. It’s easier to understand than it used to be’.
Year 10 student: ‘All the knowledge you get builds on top of the rest’.
Year 12 student: ‘I prefer to know why things happen than they just do’.
Year 12 student picked physics: ‘…because it was more about understanding what it could be used for, why it happened…the practical stuff, you actually see it in front of you’.

Case study 7

3 year 11 students were interviewed who were studying Applied Science, 2 were boys and 1 was a girl. The students had not previously been engaged with science and although they now generally enjoyed their science lessons more, for many it still was not their favourite subject. However, they did find the CSI focus interesting and enjoyed the practicals and applied nature of the course they were following. Both of the boys felt that they would get a higher grade at GCSE on the Applied Science course than they would have on a different course. None of the students, though, were intending to go onto further science study but this was not a key aim of the course – the main aim was to keep students engaged in science and in school.

Year 11 student: ‘It’s interesting finding out how CSI investigate crimes. You see it on TV but you don’t understand it as much. The forensic science lessons are now more interesting than our other science lessons because of the practicals’.
Year 11 student: ‘Science lessons are more enjoyable this year. Compared to last year we’ve done a lot more practicals and it’s been a lot more interesting’.
Year 11 student: ‘Forensics is my favourite lesson. The topic is interesting and the practicals are good’.
Year 11 student: ‘We’ve learnt how science can be used in everyday life. It’s good to have a basic understanding and to be able to apply that to the real world’.

Case study 8

15 students were interviewed, 5 in years 13, 2 in year 12 and 8 in year 10. There

was a mix of boys and girls. There was a perception amongst all students that science provision had changed over the last few years and that teachers were utilising a wider range of approaches and strategies in their lessons (e.g. webcams so that students could see a demonstration, post-it notes for student feedback, working in pairs and groups, videos and white boards). Students felt that they were learning to be independent learners and that targets were being set and reviewed and students were being stretched and challenged. Students had a good awareness of the importance of science in society and daily life. In addition, year 12/13 students felt that lessons were well structured which meant that they were able to finish practicals in the time allocated. All of the students interviewed were keen on science and wanted to study it further and to pursue a STEM career.

Year 10 student: 'I think that there are a bigger range of tools and techniques [that are used in lessons] so you can enjoy it a lot more'.
Year 12 student: They [science lessons] are really good, the webcam has made it much easier [to see what's happening in demonstrations] because you can't see really well. The post-its allow you to see everyone's ideas which is really powerful'.
Year 10 student: 'You have to learn how to think for yourself'.
Year 12 student: 'Targets are regularly assessed and checked, so if there are people who are lagging behind, measures are taken to get them back to where they should be. They are also recalculated so that we are always trying to achieve something. People aren't left to stew and get complacent about things'.
Year 12 student: 'Science is really useful. The things that you do in English etc. are interesting but the things that you do in science are actually happening today. You can look around and see it in real life'.
Year 13 student: '…you have to put your heads together, it is not like you are told something and then you have to move on'.
Year 12 student: 'It is also reinforced by watching a video or demonstration'.
Year 12 student: 'Better interacting as well, things like white boards and stuff'.
Year 12 student: 'I find it more structured in the lessons, if you do like practicals in chemistry. I found that lower down the school you would do the practical and then you wouldn't necessarily get it finished and the next session you would forget it but now you tend to find you get everything done and it is better'.

Case study 9

No students were available on the day of the case-study visit as they were preparing for exams.

Case study 10

6 students were interviewed, of which 5 were girls. 3 students were year 7 and 3 in year 8.

All of the year 8 students were members of the STEM Club and had been attending all year since its inception. All of these students liked being a member of the STEM Club and had enjoyed the various activities that they had undertaken such as rocket cars experiments and building eco houses. They particularly valued the interactive nature of the club, the more individual attention, the time to learn at their own pace and the opportunity to ask lots of questions. All felt that they had acquired more confidence, knowledge and skills from being a member of the STEM Club and, as a result, they had been doing better in science and were more interested in studying it further at GSCE and beyond.

Year 8 perceptions of the STEM Club and its impacts
Year 8 student: 'I like all the different activities we get to do and that it is more interactive than normal lessons'.

Year 8 student: ‘In science we do more with chemicals…but in Science Club we do bigger things. We do more fun and different projects and experiments’.
Year 8 student: ‘I think it is different because it is based all around practicals and you can pick things up and you can have fun doing it which is different from lessons when they are directing all of what you are doing into learning whereas with this they are directing all you are doing into something cool and fun to get us interested in science’.
Year 8 student: ‘ I think it [STEM Club] has definitely got me more interested as it has shown me another side to the science we do in class and you can be more open with your questions and you can work at your own pace rather than keeping up with the rest of the class’.
Year 8 student: ‘It’s a good thing because you get more attention and you can do more things’.
Year 8 student: ‘We have more practicals and with practicals we learn more’.
Year 8 student: ‘The practicals make us more confident with the teacher [in lessons]’.

The year 7 students enjoyed the emphasis on practicals in their lessons and felt that they were introduced clearly and that the practical focus increased their understanding. The practicals were their favourite part of science lessons and increased their interest and motivation. All year 7 students felt that they were doing better in science this year though none saw science as one of their favourite subjects.

Year 7 student: ‘With Miss x [teacher] I liked the practicals that we did and we had to plan it out well. When Miss x [teacher] is introducing something new she doesn’t quickly go straight into it, she firstly explains and goes slowly step by step so if we are doing something totally different she changes one theme or something and then goes on to the next one’.
Year 7 student: ‘In primary, science was almost a weak point for me because I wasn’t very keen on science, but I did my best. But in secondary I was shocked to see I had level 6s for my sciences’.
Year 7 student: ‘Demonstrations show how something works a lot better than explaining it in words. If we see it then we can understand it better’.
Year 7 student: ‘She draws us diagrams and if we can’t do the practicals then we watch video clips and then she asks questions about what we saw and I think that makes us understand more as she asks us questions and sometimes we give the wrong answer but then she explains the right answer then you really understand about it’.

Case study 11
Due to other pressures, interviews with staff were undertaken by telephone so no students were consulted as part of the case study.

7. Strengths, sequence and sustainability of impacts on teachers

Key findings

Introduction

- Using a list of the range of impacts on teachers identified during the first round of visits to schools (see Chapter 5), teachers in follow-up visits were asked to rank these impacts based on their perceptions of the strengths, sequence and the sustainability of impacts over time.

Strengths and sequences of impacts on teachers

- Senior leaders ranked **increased enthusiasm in teaching science, new ideas and strategies for effective lesson delivery and increased confidence in teaching science** as both the strongest impacts and those most likely to occur first, following National Centre CPD. This suggests a relationship between the perceived strength of impacts and how soon they were implemented after teachers returned from training.

Sustainability of impacts on teachers

- The most sustainable impacts following CPD at the National Centre were reported to be **new ideas and strategies, increased subject knowledge and increased confidence in teaching science.** Interviewees reported that teachers were most likely to retain and implement new ideas and subject knowledge over time. Other impacts related to practical work - such as increases in skills and confidence - were said to be less sustainable as they were dependent on teachers finding the time to implement new practicals. Increased enthusiasm was typically said to diminish after the initial 'buzz' of training.

7.1 Introduction

A diamond ranking exercise[6] was used with senior leaders during follow-up visits to explore their perceptions on the impacts of National Centre CPD identified during the first round of case-study visits. Interviewees were asked to rank the impacts based on their perceptions of the strengths, sequence and the sustainability of impacts over time, within the context of CPD undertaken in their schools. This chapter explores the views of senior leaders on the following six impacts on teachers:

1. **Staff have increased enthusiasm in teaching science**
2. **Staff have increased confidence in teaching science**
3. **Staff have increased/more secure subject knowledge**
4. **Staff have increased confidence in practical work**
5. **Staff have increased skills in practical work**
6. **Staff have new ideas, strategies and materials for delivering lessons more effectively**

[6] This technique is useful for generating discussion with interviewees, particularly when interviewed as part of a group. It encourages consideration of selected options and in-depth thinking. See Appendix for examples of the diamond ranking exercises used with interviewees.

7.2 Strengths of impacts

In total, six senior leaders participated in ranking the strengths of impacts from the **strongest** to the **weakest.** All interviewees positioned increased staff enthusiasm in teaching science' between the first and third strongest impact. Interviewees made the following comments about the importance of enthusiasm and how it relates to other impacts.

> *It's the enthusiasm that hits first. I'm always struck by that* (Head of science, case study 2)
>
> *If you're enthusiastic about* [science] *then* [other impacts] *follow from it. If you're not enthusiastic, you're not bothered* [about CPD] (Head of science, case study 9)
>
> *'Staff have increased enthusiasm in teaching science' comes first as staff always come back with a smile on their face. They have more motivation which is being passed on to pupils and pupils are really enjoying the science* (Head of science, case study 4)

Interviewees reported that increased enthusiasm helped to invigorate and encourage teachers to try new ideas and introduce positive changes to teaching.

Five interviewees ranked the statement 'new ideas, strategies and materials for delivering lessons more effectively' between the first and third strongest impacts, although this was most frequently highlighted as the second strongest impact. Senior leaders were aware of the need to ensure that staff were not always delivering the same ideas and schemes of work and commented that **National Centre CPD had played a key role in introducing teachers to new ideas and resources**, illustrated by the comment below.

> *I think that one is very high ('new ideas') because that is a real strength of the Science Learning Centre courses, is that you come away directly with new ideas straight away that you can just go straight and use.*(Head of science, case study 7)

There was some slight variation amongst interviewees ranking of the statement 'staff have increased confidence in teaching science', although four interviewees positioned it between the first and third strongest impact. In schools where increased confidence was ranked as the strongest impact, interviewees said this impact was strongest '*especially if* [CPD] *is in a non-specialist subject'* (Head of science, case-study 5). Where this was ranked third, senior leaders explained this was because teachers were already confident in teaching science and had pursued CPD for other reasons.

Interviewees typically placed the two statements relating to increased confidence in practical work and increased skills in practical work together. Four interviewees ranked the statements between the fourth and sixth areas of the diamond, towards the weakest impacts. Senior leaders praised the high quality of the practical demonstrations and resources available while accessing courses at the National Centre. They explained, however, that carrying out practicals was not always the main reason that staff accessed CPD and therefore the resulting impacts were not as strong as others. Other interviewees reported that teachers were not always able to carry out the same practicals in a school

context compared to the environment at the National Centre, demonstrated by some of the comments below.

Yes, I think that it is more of the ideas and concepts [of CPD]*…I don't think our staff need concrete training on how to carry out certain experiments and anyway we do a lot of that amongst ourselves* (Head of science, case study 7)

The thing with practical work is that it depends on the students that you have got in front of you and it depends on the resources that you have as well. At the Science Learning Centre you have no students but you have amazing resources and that often doesn't truly reflect what it does in schools…if you have a class of 30 boisterous year eleven students and you have got half of the equipment missing, then you soon lose confidence in doing practical work (Head of science, case study 8)

Staff are usually pretty OK on practicals. I usually have to restrain them from blowing things up. But some staff, particularly new staff, don't always know what practicals are available in school, and sometimes the practicals get put to one side (Head of science, case study 2)

The final impact relating to greater subject knowledge was ranked as the weakest impact by four interviewees. Senior leaders said that teachers were usually already very experienced and secure in their subject knowledge prior to attending training. One interviewee said the strength of this impact would be strongest for NQTs or staff undertaking CPD in a non-specialist subject. However, this was countered by another interviewee who said that increased subject knowledge for non-specialists was difficult to gain through one-off courses and that ongoing support through internal CPD would be most effective at developing this impact.

Figure 7.1 Perceptions on the strength of impacts on teachers

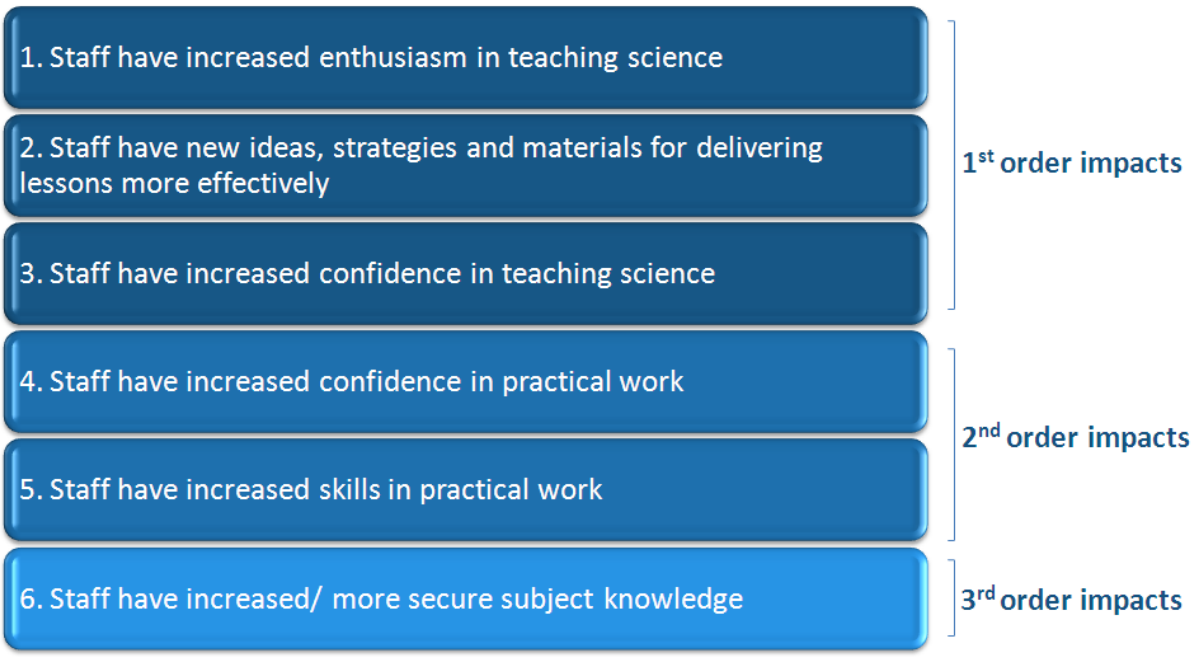


Figure 7.1 above outlines interviewees' perceptions on the strongest through to the weakest impacts of teacher CPD. The three weakest impacts, increased confidence in carrying out practical work, increased skills in practical work and more secure subject knowledge were ranked lower down by interviewees, either because these were typically not the main reasons for pursuing CPD or because teachers were reported to already have these.

7.3 Sequence of impacts

Six senior leaders participated in ranking the sequential order of impacts from the first through to the final occurrence. **Interviewees unanimously ranked increased enthusiasm in teaching science as the first impact to occur.** As with the strongest impact, enthusiasm was reported to be the first notable impact both during CPD and after teachers returned to school.

> *The people who deliver* [CPD at the National Centre] *are really passionate about what they are delivering. The great sense of what you get from them is why you became a teacher in the first place. It is because it is so focused on teaching and learning and because you have got these positive people who are still teachers who know what they are talking about* (Head of science, case study 8)
>
> *Teachers tend to come back with more enthusiasm which then leads to fresh ideas* (Head of science, case study 5)

Senior leaders ranked teachers' acquisition of new ideas and strategies as either the second or third impact to occur following training, although this impact was most frequently ranked as the second to occur. Interviewees said that teachers were keen to introduce new ideas and approaches to teaching science. Three interviewees reported that, while it was positive

that staff came back with new ideas, time and workload was sometimes a factor in preventing the implementation of new ideas:

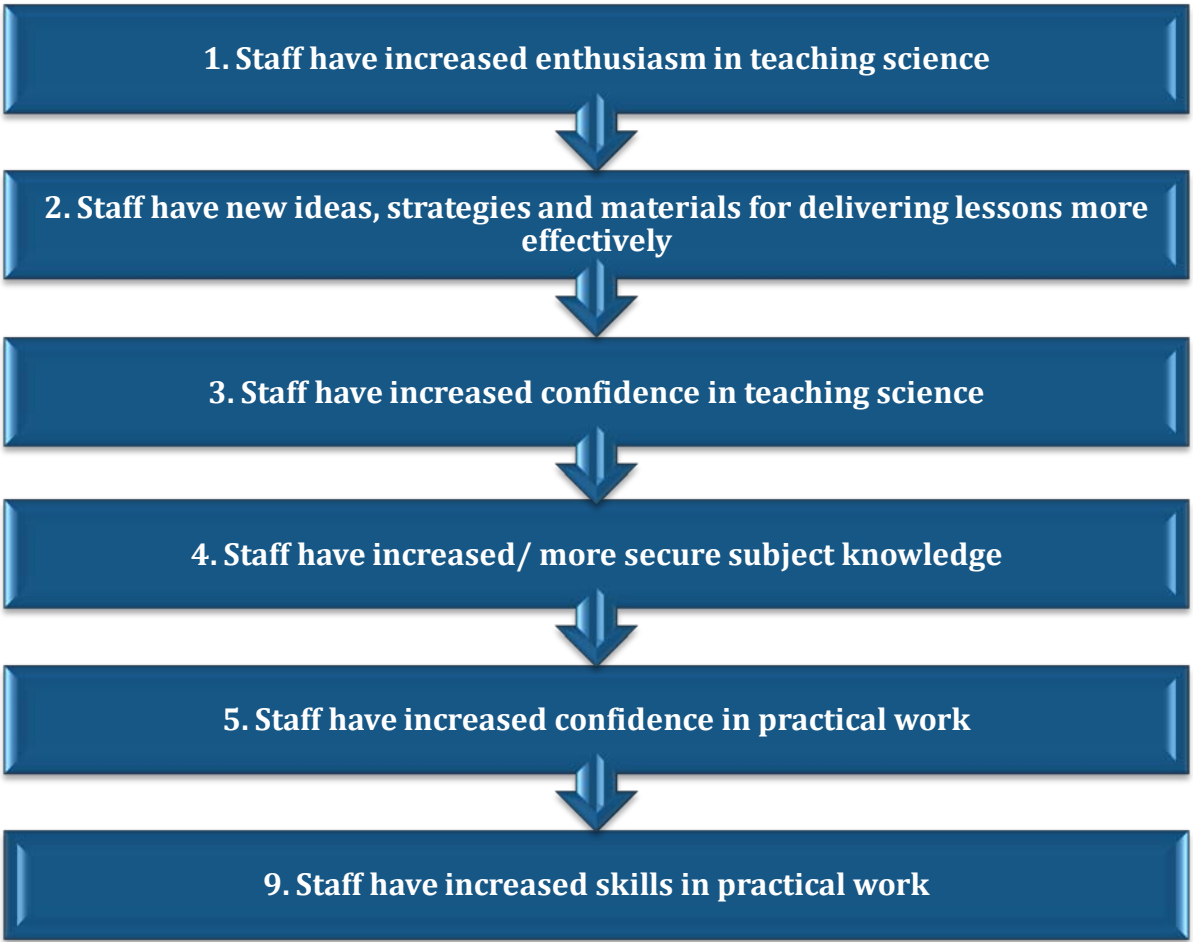
> *What is often happening, is that you come back and you have these new ideas and because you often don't have time to implement them or pass them on to the department…quite quickly those new ideas can be sapped from you* (Head of science, case study 8)

There was some variation in the ranking of increased teacher confidence in teaching science amongst interviewees. Three interviewees ranked it as either the second or third impact to occur and the remaining rated it between the fourth and sixth impact. Senior leaders who ranked this statement most highly reported that **the quality of courses at the National Centre had a positive effect on teachers' self-confidence which could be seen in changes in attitudes and a willingness to try new ideas** after returning to school. Where confidence was perceived as a lower sequential impact, interviewees related this to the reasons for staff attending training, for example some teachers were said to already be confident prior to attending training.

There was similar variation in the ranking of increased subject knowledge. Three interviewees ranked it as the third impact to occur and three ranked it as the fourth to final impact. This was again reflective of the different reasons that CPD was undertaken across the case-study schools. Some senior leaders expected staff to have acquired some new information through CPD, particularly where CPD was aimed at non-subject specialists. However, others felt that, within the contexts of their schools, staff were already experienced and had a good grasp of subject knowledge.

Increases in practical skills and confidence in conducting practicals were often ranked together and were consistently placed by the majority of interviewees between the fourth and final impacts to occur. Interviewees said that while practicals were an important aspect of training, it sometimes took time to introduce new practicals and implementation was dependent on when certain topics were being taught and the availability of resources to carry out practicals.

Figure 7.2 Perceptions on the sequence of impacts on teachers



Interestingly, Figures 7.1 and 7.2 above show clear patterns between interviewees' perceptions of the strongest impacts and the sequence in which these impacts occur over time. This suggests that interviewees may perceive the strongest impacts as those that can be more readily implemented in the classroom and across the department following attendance at training.

7.4 Sustainability of impacts

Four senior leaders participated in ranking the sustainability of impacts, from the highest to the least sustainable impact. **Interviewees were unanimous in positioning new ideas for effective delivery of lessons as the most highly sustained impact of National Centre CPD**:

> *The new ideas in delivering lessons effectively that I have put at the top, because one, if you are working in a department where you collaborate and things are implemented in schemes of work then it is there until someone changes it. The other point of that is that as a teacher if you do try an activity and it works, you usually carry on using that activity* (Head of science, case study 8)

> *I have put 'new ideas' at the top because we are good at putting the ideas into our schemes of work and they do last* (Head of science, case study 7)

Interviewees were also unanimous in ranking increased subject knowledge as the second most highly sustained impact. Senior leaders reported that where new subject knowledge was acquired during training, teachers were actively using new knowledge and concepts and did 'not lose this'.

> *It's the ideas and the subject knowledge and the confidence that tends to stay* (Head of science, case study 2)

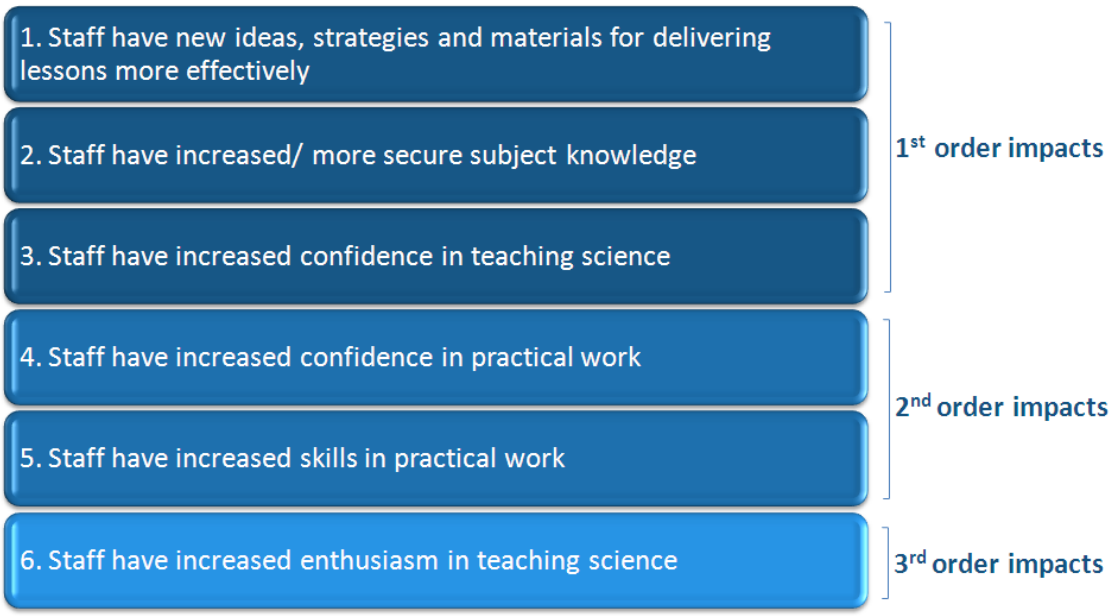
> *Second is 'secure knowledge' because I think the more you do it, the more confidence you are going to have and the better your knowledge is going to be. So as long as you keep trying these things I think it will be sustainable* (Head of science, case study 7)

Increased confidence in teaching science was ranked by two interviewees as the third highest sustainable impact, whilst the remaining two positioned it as the fifth and sixth least sustainable impact over time. Senior leaders who rated this highest reported that teachers retained their confidence over time, although in schools where it was ranked lowest, other impacts such as increased enthusiasm and new ideas were said to help increase teacher confidence over time. Similar to the patterns for strengths and sequence of impacts, interviewees commonly positioned increased skills in practicals and confidence in carrying out practical work together. There was some variation in the rankings, although interviewees tended to position these impacts lower down the scale of sustainability as they were dependent on the extent to which practicals were regularly incorporated in lessons.

Interviewees ranked increased enthusiasm between the fourth and least sustainable impact. They described teachers experiencing an initial 'buzz' after attending effective training but due to the 'everyday grind' in delivering lessons, enthusiasm was viewed as least sustainable.

Figure 7.3 below demonstrates clear differences in the ranking of the sustainability of impacts and their strengths and sequence.

Figure 7.3 Perceptions on the sustainability of impacts on teachers



8. Strengths, sequence and sustainability of impacts on students

Key findings

Introduction

- Using a list of the range of impacts on students identified during the first round of visits to schools (see Chapter 6), interviewees in follow-up visits were asked to rank these impacts based on their perceptions of the strengths, sequence and the sustainability of impacts over time.

Strengths and sequence of impacts on students

- Interviewees ranked **increased student engagement, enjoyment and confidence in science** as both the strongest impacts on students and those most likely to occur sequentially, following teacher CPD.
- When ranking **improved student attainment and progress**, teachers and students typically related this impact to changes in revision technique or exam approaches.

Sustainability of impacts on students

- Improved **transferable and practical skills** was perceived as the most highly sustained student impact, followed by **increased engagement, enjoyment and confidence in science.**

Across strengths, sequence and sustainability of impact, those ranked lowest were increased student participation at GCSE level, greater student awareness of the importance and relevance of science to society and better student knowledge of the career opportunities available in science.

8.1 Introduction

A diamond ranking exercise was used with senior leaders, teachers and students to explore their perceptions on the impacts of National Centre CPD on students. Interviewees were asked to rank the impacts based on their perceptions of the strengths, sequence and the sustainability of student impacts over time. This chapter explores the views of senior leaders, teachers and students on the following nine student impacts, following teacher CPD:

1. **Students make improved progress and attainment in science**
2. **More students choose to study science at GCSE level (or equivalent) and post-16**
3. **Students enjoy science more**
4. **Students develop transferable and practical skills**
5. **Students have increased awareness of the importance and relevance of science to society**
6. **Students develop an increased understanding of science topics**
7. **Students become more confident in science lessons**
8. **Students become more engaged in science lessons**
9. **Students develop better knowledge of the career opportunities available in science**

8.2 Strengths of impacts

In total, three senior leaders, two teachers and one student group participated in ranking the strengths of impacts from the strongest to the weakest. A summary of the findings is presented in Figure 8.1 below.

Five school staff ranked students' increased engagement in science as the first or second strongest student impact. Staff explained that a combination of new ideas, strategies and increased skills in carrying out practical work had been successful in engaging students. Student engagement was said to be instrumental in leading to the other eight identified student impacts. Students ranked this as the second strongest impact. Although students were typically unaware that their teachers had undergone training, they were sometimes aware of changes to classroom practice, such as new approaches to revision or practicals. One interviewee who reported high student engagement said that CPD at the National Centre had positively impacted on this:

> *I think that one ('pupil engagement') is very high. We have good attainment and we have very good progress levels, it has increased over the last few years but whether it is directly as a result of the CPD or whether it is the staff or the kids that you have got is difficult to say. I think CPD does impact on it, how you measure it and how you say yes because of my training course, then I don't know* (Head of science, case study 7)

Students' increased enjoyment of science was unanimously positioned between the first and fourth strongest impacts by school staff and students ranked this as the strongest impact. One year 10 student said: 'I definitely enjoy science more than I used to and given that science has got harder I think that comes down to the teachers (case study 2).

An increase in students' confidence was also ranked between the first and fourth position on the diamond and some interviewees commented that the top three strongest impacts on students (increased engagement, enjoyment and confidence) 'were linked' and were 'the more obvious things you can see straight away'. The perception that National Centre CPD has contributed to these three impacts reflects findings across the research that these have been the most notable, though difficult to measure, changes in student outcomes. One student reported:

> *If you feel confident in science, you do better at it and the teachers help to make you feel confident and interested* (Year 10 student, case study 2)

There was some variation in interviewees' perceptions on the strength of increased understanding amongst students. Three interviewees ranked this impact as the second to third strongest impacts, while the remaining interviewees ranked it between the fifth and sixth.

Three interviewees ranked increases in students' transferable and practical skills between the first and fourth impacts, with students ranking this as the fourth.

Students made the following the comments about their acquisition of transferable skills:

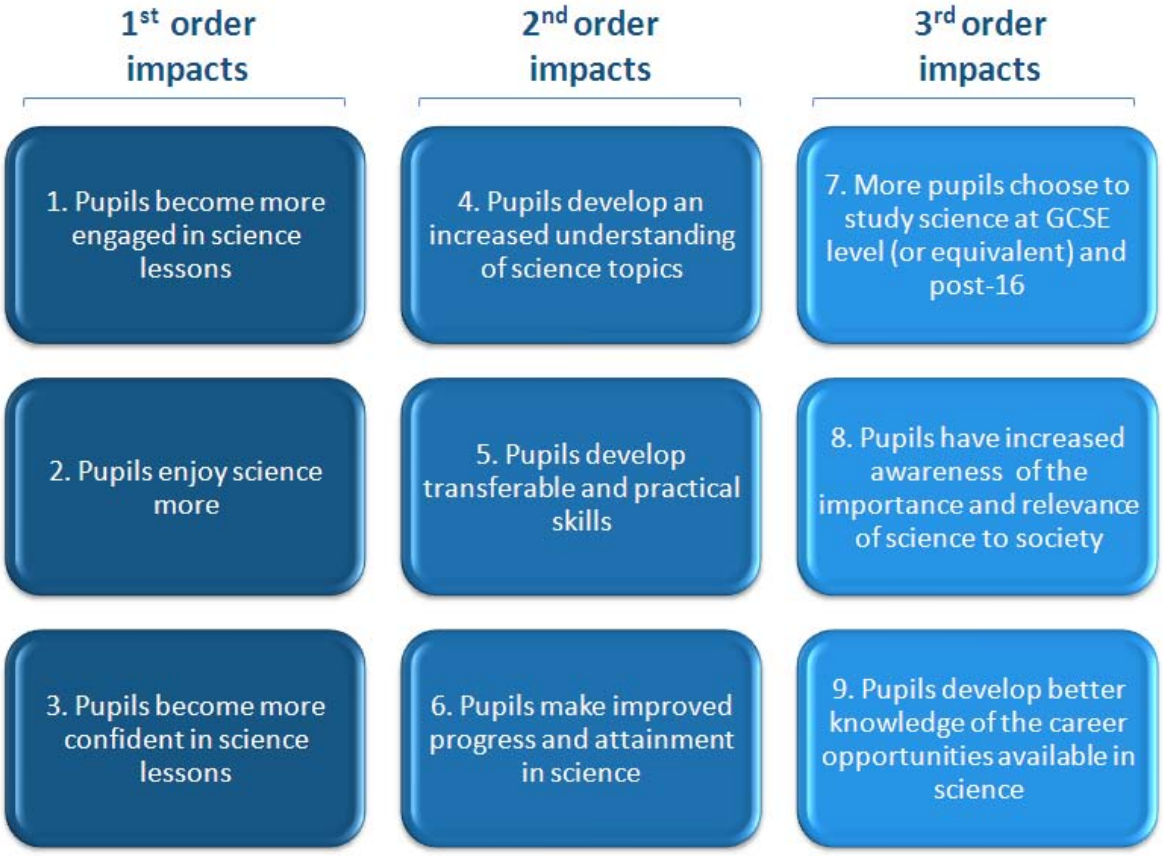
> [Science teachers] *have helped us with this, although I think I learnt how to do graphs in maths rather than science* (Year 10 student, case study 2)
>
> *I guess in biology they have taught us things about health that we use outside of school* (Year 10 student, case study 2)

Interviewees most frequently ranked improved student attainment and progress in science as the fifth strongest impact. Most reported that this was a difficult impact to judge but that indicators other than improved exam results were used to assess this:

> *I am going to put attainment in the middle because it's not just what we're doing but what they* [students] *are doing. If they are enjoying it more they work harder and achieve better results* (Head of science, case study 2)
>
> [Teachers] *have given us revision techniques and ran revision sessions after school, so that helped with our exams* (Year 10 student, case study 2)

Increases in the number of students choosing to study science at GCSE, students' awareness of the importance and relevance of science and better knowledge of career opportunities in science were respectively most frequently ranked as the weakest student impacts (see Figure 8.1 below). These were said to be dependent on a number of other factors within schools and therefore difficult to attribute to teacher CPD. Teachers reported not specifically addressing careers-related issues during teaching and said the majority of courses attended had not focused on this.

Figure 8.1 Perceptions on the strength of impacts on students



8.3 Sequence of impacts

A total of three senior leaders and two teachers participated in ranking the sequence of impacts from the first occurrence through to the final occurrence. A summary of the findings is presented in Figure 8.2 below. Similar to the most strongly ranked impacts, **increased student engagement, enjoyment and confidence in science, were perceived by most interviewees as the first three sequential impacts to occur following teacher CPD.** A head of science said:

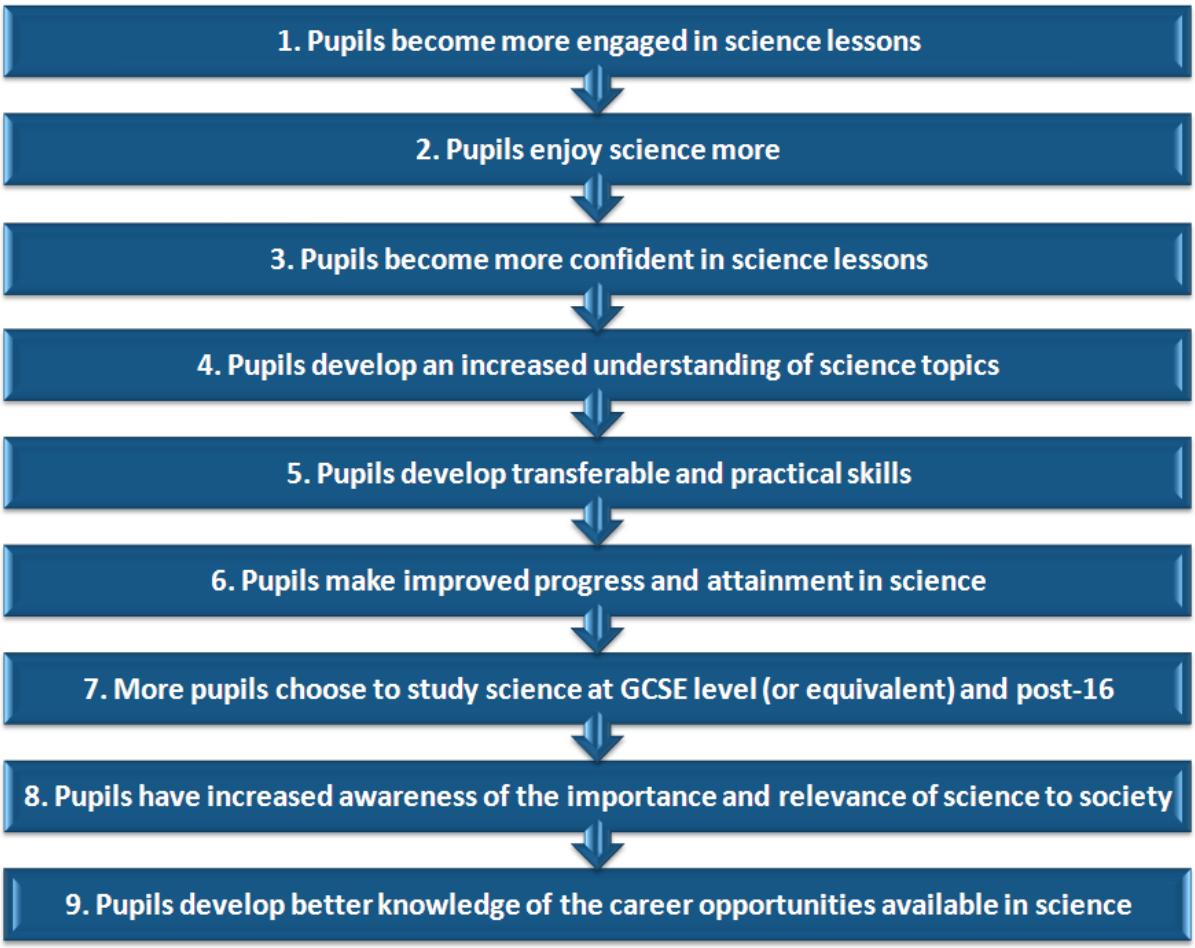
> [Students] *are more engaged because the teacher has become passionate and that means that they enjoy it more. Now if they enjoy it more, they become more confident and they are more likely to make progress because they are trying harder* (Head of science, case-study 2)

Interviewees most frequently ranked students' improved understanding in science as the fourth impact to occur, followed by improved attainment and progress. It is interesting to note that improved attainment was positioned in the middle of the diamond, despite interviewees' difficulty in evidencing the impact of attainment and progress. However, as with the strengths of impact, a head of science explained that that were many attainment and progress related impacts, such as improved exam technique and literacy skills.

Students' development of transferable and practical skills, increased awareness of the importance and relevance of science, better knowledge of science career opportunities and

an increase in the numbers of students studying science at GCSE were subsequently ranked as the next sequential impacts to occur.

Figure 8.2 Perceptions on the sequence of impacts on students



8.4 Sustainability of impacts

Three senior leaders and two teachers participated in ranking the sustainability of impacts, from the highest to the least sustainable impact. Interviewees positioned transferable and practical skills as the most highly sustained student impact. Other impacts were reported to be less sustainable because they could 'go in a couple of lessons if you have got a teacher who hasn't got the same enthusiasm as the teacher who went on the course' (case study 5).

The second most sustainable impact was reported to be increased pupil engagement, followed by increased students enjoyment and more confidence in science lessons. With the exception of transferable and practical skills, interviewees' patterns of ranking the sustainable impacts are largely reflective of those for the strengths and sequence of impacts.

There was a lot of variation in terms of where interviewees positioned the remaining impacts, which is somewhat unsurprising as the diamond exercise is specific to each school context and the courses undertaken. Hence, it is difficult to draw useful conclusions of interviewees' perceptions in relation to the sustainability of improved student attainment and progress and

increased understanding of science. However, the following three impacts, in no particular order, were almost consistently ranked as the least sustainable:

- more students choose to study science at GCSE level (or equivalent) and post-16
- students have increased awareness of the importance and relevance of science to society
- students develop better knowledge of the career opportunities available in science.

Variations in ranking were dependent on the year groups teachers taught and the year groups that CPD had focused on. For example, a teacher who had undertaken A-level specific CPD ranked increases in students' knowledge as the seventh most sustainable impact, explaining that 'by the time they've chosen [A-level] they're already engaged and a lot of them are already thinking of a career path' (case study 5).

9. Conclusions and recommendations

This final chapter draws together the key messages from the evaluation and provides a final assessment of the impacts on students resulting from the subject-specific CPD undertaken by their teachers. We also offer some recommendations for the National Centre to further maximise the development of their programme of professional development and for schools, to enable them to ensure that subject-specific CPD is both sustainable and continues to have a positive impact on teaching and learning.

9.1 Conclusions

The National Centre has made a valuable contribution to enhancing students' enjoyment of, and enthusiasm for, science by providing course participants with relevant, practical and high quality CPD. The evidence collected from this evaluation indicates that National Centre CPD has enhanced teachers' knowledge and skills, and provided significant stimulus and resources which have, in turn, strengthened teaching quality and improved classroom practice. Both heads of science and classroom teachers associated attendance on National Centre courses with positive impacts on students' engagement with science, their intentions regarding further study at GCSE and beyond, and to a lesser extent their progress and attainment. While very limited quantifiable evidence was available to support these judgements, it seems likely that teachers' new knowledge, skills and attitudes, will, when put into practice, ultimately affect and benefit students' learning and achievements.

The challenges of attributing outcomes, particularly student learning outcomes, to a particular CPD activity, even those as intensive and of as high a quality as those provided by the National Centre, are generally well understood, and were encountered during this evaluation. It was not surprising, for example, that many students were not aware that their teachers had undertaken CPD. For these students, improvements in their interest and engagement, understanding and progress in science over the years was often attributed to the fact that they were now higher up the school and were taking their studies more seriously, and that the curriculum and scheduling of lessons was different. However, some students talked positively about aspects of their lessons that, unbeknown to them, had changed or been introduced as a result of a teacher's attendance on a National Centre training course. Such aspects included: the enthusiasm and subject knowledge of their teacher; the use of exciting and engaging practicals; changes in relation to group work or assessment; and the use of specialist equipment or learning resources. A small number of students had some awareness of the CPD their teacher had undertaken and pointed to the changes in teaching and the resulting impact on them. Even though not all students were aware of the CPD that their teacher had completed, the findings from the student interviews were very positive and suggested that students were experiencing effective and engaging science lessons and extra-curricular activities and that a range of impacts were being realised for students as a result of the National Centre CPD.

The impacts on students stemmed from the key impacts identified for teachers, which included: increased enthusiasm for, and confidence in, teaching science; more secure and up-dated subject knowledge; and new ideas, resources and strategies for delivering lessons

in a more engaging and effective way. Of particular note was teachers' and technicians' increased confidence and skills in undertaking practical work, which was having a direct impact on learners in terms of placing lessons within a real life context and making them engaging, memorable and fun. These impacts continued to be sustained and were still evident during follow-up visits to schools, further demonstrating the success and legacy of National Centre CPD.

The importance and power of making lessons enjoyable for learners should not be underestimated. For example, NFER research has shown that young people's preferences when making subject choices are shaped by a range of factors, which can be different for each young person, but are often centred on individual attributes (such as personal enjoyment and perceived usefulness of the subject) and structural factors (such as the school's provision and ethos, and teaching styles) (McCrone et *al*., 2005). Indeed, the evidence we have collected suggests that, in line with our analysis of different models for evaluating CPD practice, case-study schools were providing the conditions necessary for young people to enjoy and succeed at science, aided and supported in no small part, by the CPD provided by the National Centre. This is of particular importance given that case-study schools were not systematic in evaluating the impact of CPD on teaching and learning. While some individual teachers had evaluated their practice following CPD, there was no evidence to suggest that schools had adopted a departmental or school-wide approach to evaluation. Most of the evaluation work being undertaken in schools has focused on individual teacher outcomes and specifically on improvements in teachers' confidence and enthusiasm. Work to disseminate and share practice within science departments also appears to be widespread. However, there was some confusion amongst interviewees about the difference between dissemination and evaluation, where dissemination of CPD learning or resources was often reported as evaluation. While CPD at the National Centre was reported to have had a range of positive impacts on students, respondents reported that schools were rarely evaluating its impacts on students. Most teachers and heads of science reported they did not know how to evaluate the impact of CPD on student outcomes, particularly in relation to improvements in student attainment and progress.

Further evidence was collected from schools during follow-up visits to ascertain their perceptions on the strengths, sequence and sustainability of impacts for teachers and students, following CPD undertaken at the National Centre. Most schools identified the following as both the strongest three impacts for teachers, and those which occurred first?: increased enthusiasm, the use of new ideas and materials to support effective delivery of lessons and increased confidence in teaching science. The most highly sustainable impacts were said to be the introduction of new ideas, increased subject knowledge and greater teacher confidence. Both the strongest impacts and the sequence of impacts of teacher CPD on students were identified as increased student engagement, enjoyment and confidence in science, and the most highly sustainable impacts were reported as transferable and practical skills, followed by greater student engagement, enjoyment and confidence in science.

9.2 Recommendations

The evidence presented in our report demonstrates that:

1. Science-specific CPD undertaken at the National Centre has impacted positively on science teachers and technicians. Impacts attributed to course attendance include: increases in confidence; more secure subject knowledge; and a greater repertoire of ideas and teaching skills.
2. The resulting improvements to teacher practice have led to positive impacts for students, including on their enjoyment of, and engagement in, science lessons and extra-curricular activities, and in their confidence and understanding of science.
3. Teachers' perceptions that attending science-specific CPD at the National Centre has contributed to improvements in students' progress and attainment are difficult to verify using the data available. The findings suggest there is more schools could be doing to explore and analyse the impacts resulting from CPD on teaching and learning.
4. A school's performance management structures and practices and its culture and attitude towards the value of subject-specific CPD can influence both teachers' opportunities for undertaking CPD at the National Science Learning Centre and the resulting impacts.
5. There is a need for further research to explore the evidence for and mechanisms by which subject-specific CPD can positively impact on learners.

Our recommendations therefore relate to the need for better monitoring and evaluation in schools of the impacts resulting from subject-specific CPD, and the need to target the staff responsible for CPD and senior school leaders to encourage them to support and lead this activity. Recommendations are presented separately for Myscience and for schools.

Recommendations for Myscience/National Science Learning Centre

Amongst the teachers we spoke to there is universal agreement that the courses provided by the National Centre are relevant, appropriate and of the highest quality. Yet the experiences of staff returning to their schools from such experiences, and the resulting impacts, varied, reflecting the need for schools' performance management structures and practices to reflect the value placed on subject-specific CPD and to monitor its impacts.

Hence we recommend:

- The need to emphasise to school CPD leaders and senior managers the importance of using the ENTHUSE Award bursary to help fund teachers' ideas for improving the teaching of science, the purchase of science equipment or materials, and/or allowing time for staff to share and develop their practice with peers.
- Continuing to support schools (and science teachers and technicians in particular) in analysing the impact of CPD on teaching and learning. Such support could include the development of a toolkit for schools (see Section 9.2.1 below), modelling assessment techniques and approaches as part of course content and developing training in how to effectively evaluate CPD. Such provision would be in line with the new Ofsted framework which calls for evidence of a school's internal monitoring and evaluation of teaching and how the findings are used. Specifically, an enhanced role for informal

assessment would make a strong contribution to this. Many schools are familiar with Assessment for Learning (AfL) approaches, which include specifying the learning objectives for each lesson, sharing these with students and reviewing progress against the learning objectives at the conclusion of the lesson. These ongoing informal assessments have great potential for linking CPD directly to pupil learning.

- Commissioning further research to explore the links between subject-specific CPD and its impact on learners. This should develop and build on the research already undertaken but avoid some of the limitations of this study by following the development of teachers on a specific course. The study would seek to capture the impacts of the course on individual teachers and their class, and track these impacts over time using surveys and assessments of teachers' and students' knowledge, confidence and skills. A randomised controlled trial (RCT) may also offer the opportunity to better measure and evaluate the contribution of National Centre CPD. For example, the practice of NQT teachers who have undertaken CPD at the National Centre could be compared with NQTs in schools that have not had prior engagement with the National Centre to explore differences in teacher and student outcomes.

Recommendations for schools

- Schools could improve internal systems and develop guidance to enable the effective monitoring and evaluation of the impact of CPD. More effective links should be made with performance management processes in schools and evaluation should be built into the application and planning process, covering both short- and long-term evaluation outcomes.
- School and departmental wide approaches to the evaluation of CPD should be adopted. This could be further supported by ensuring that senior school leaders and those responsible for CPD have appropriately defined roles and receive training to enable them to support staff in maximising the impacts and benefits of undertaking CPD.
- Senior school leaders should communicate clearly the purpose and value of CPD to staff, outline their priorities for its use, and introduce school-wide processes by which staff can share their learning from such experiences with their peers.

9.2.1 Outline of a toolkit for evaluating CPD

One of the key findings to emerge from this study is that schools tend to lack confidence and skills in evaluating the impact of the CPD that they undertake. A strong recommendation to emerge from the study, therefore, is that schools require further support in building evaluation skills, for a number of reasons. Evaluation will allow schools to build their understanding, leading to effective selection of CPD in the future. This understanding can also be fed back to the National Centre and will contribute to the continued development of the CPD programme on offer. Evidence that CPD has been effectively evaluated to enable schools to show evidence of impact will also be valuable in discussions with Ofsted and will support schools in making a well-informed case at whole-school level to justify the investment of time and resources on future CPD.

We therefore recommend that Myscience develops an evaluation toolkit, with the following overall features:

- the toolkit would be introduced as part of the CPD and plans for evaluation would be developed as part of the planned follow-up to the course. This would link existing good practice to systematic steps that would lead through evaluation activities to conclusions and action points.
- it would reflect the current state of CPD policy, capturing the changing landscape in which evaluation of CPD has taken on greater importance, many schools have well developed ongoing assessment practices, and the overall policy climate favours an increase in peer-to-peer and school-to-school collaborative development.
- it would provide practical resources which teachers could use 'off the shelf', making it easy and straightforward to build in effective evaluation following all CPD. These resources could be provided in a paper-based or web-based form.
- it could include a mechanism for collating schools' evaluations, thus building a knowledge base for the future.

Whilst the toolkit will require a systematic development process, the following outline serves to illustrate some of the possibilities.

CPD evaluation toolkit: a possible outline

Section	Content	Resources	Possible data sources
Introduction	Purpose of evaluation Structure of evaluation	A simple logic model with which participants would map the intended outcomes, benefits and impacts of the CPD undertaken for the individual, learners, colleagues and wider school	Performance management system; school development plan; CPD outline
Planning	Planning for implementation of CPD learning on return to school; effective evaluation of CPD	Proforma which identifies existing good practice, how CPD will build on good practice; appropriateness of CPD evaluation	Performance management system, school development plan, department-wide consultation
Outcomes	Putting plans into action: establishing a timeline for intended impacts and regular progress reviews; barriers and strategies for overcoming them	Proforma to capture timeline for impacts and review stages	Department plan; school development plan
Short-term impacts: teachers	Increases in understanding, confidence and enthusiasm	Checklist for completion by teachers to capture these short-term impacts	Lesson observations, teacher proforma, performance management
Medium-term impacts: teachers	Changes in approaches to teaching and learning	Format for lesson planning Checklist for reflecting on implementation	Lesson observations, performance management, student focus groups/surveys, pre and post lesson planning and schemes of work
Medium-term impacts: teachers	Peer-to-peer dissemination of learning	Exemplars of internal systems for recording in-school development activities	INSET training/meetings, lesson observations,

		with colleagues	focus groups with teachers, pre and post lesson planning and schemes of work
Long-term impacts: teachers	Reviewing evaluation findings and formulating action points	Simple tool for recording conclusions and next steps	Performance management, school development plan, Ofsted
Short-term impacts: students	Student views and attitudes in response to changes in teaching approaches and teacher enthusiasm	Simple questionnaire for students	Focus groups, survey data
Medium-term impacts: students	Monitoring improvements in student learning using ongoing assessment	Suggestions for ongoing assessment activities Format for record-keeping	Lesson observations, attainment data, survey data
Long-term impacts: students	Improvements in formal attainment measures and take-up of sciences	Case studies of effective tracking Simple tracking tool	Attainment data, focus groups, survey data

Appendix: Diamond ranking exercise

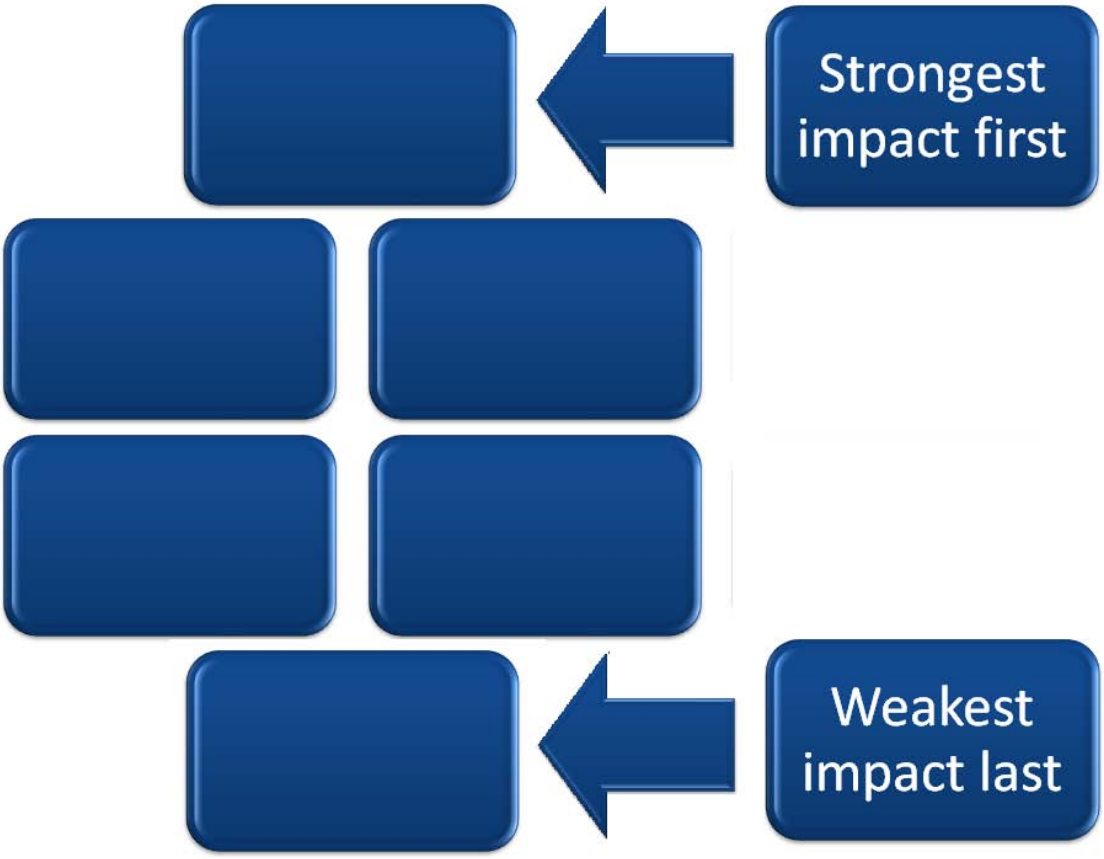
National Science Learning Centre CPD: Senior Leaders Diamond Ranking Exercise on teacher impacts

Our research has identified six ways in which teacher CPD has benefited school staff. We are interested in exploring your views on:

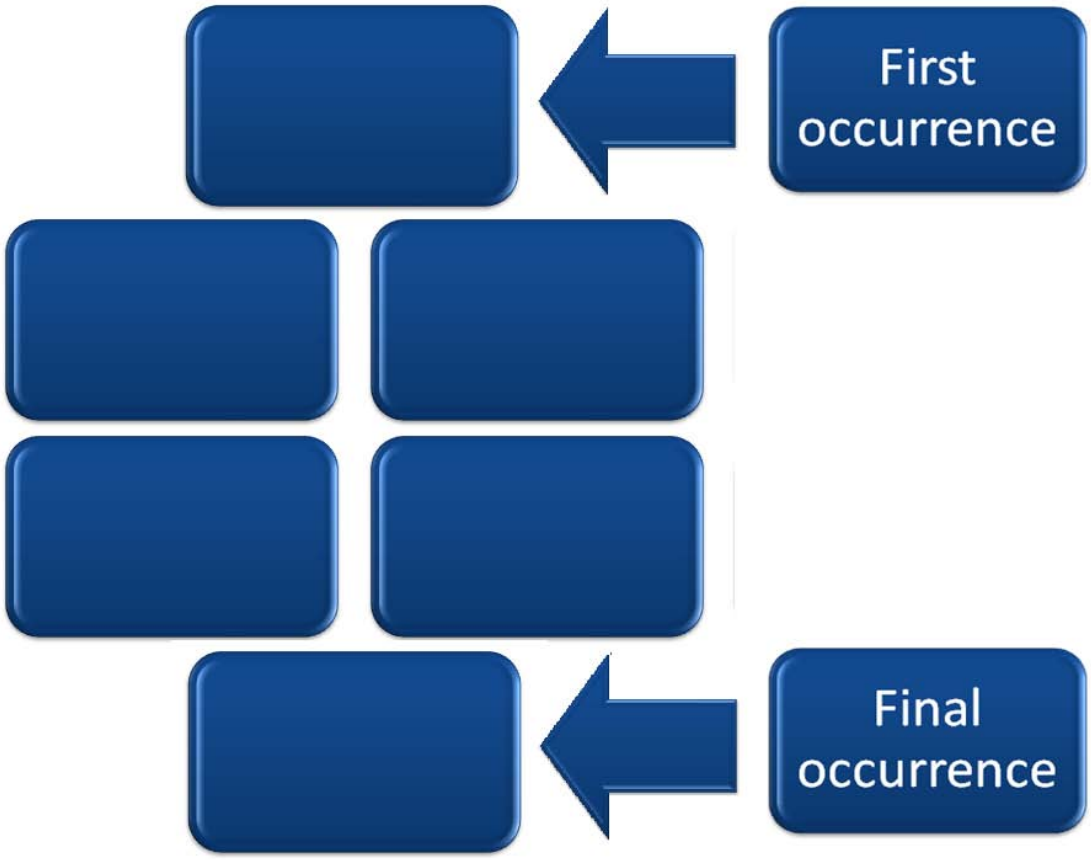
a) the strength of the impacts resulting from teacher CPD, and

b) the sequence in which these impacts occur over time.

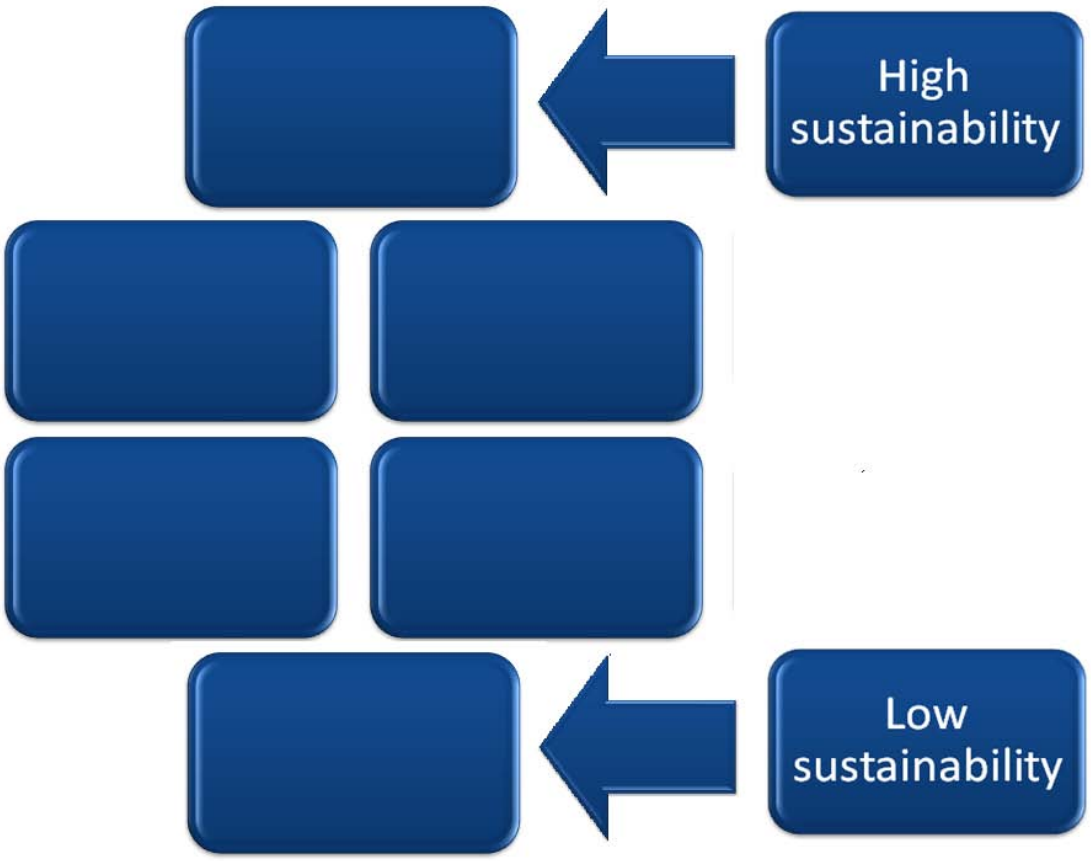
a) Please rank the statements below in the order in which you think the impacts are strongest.

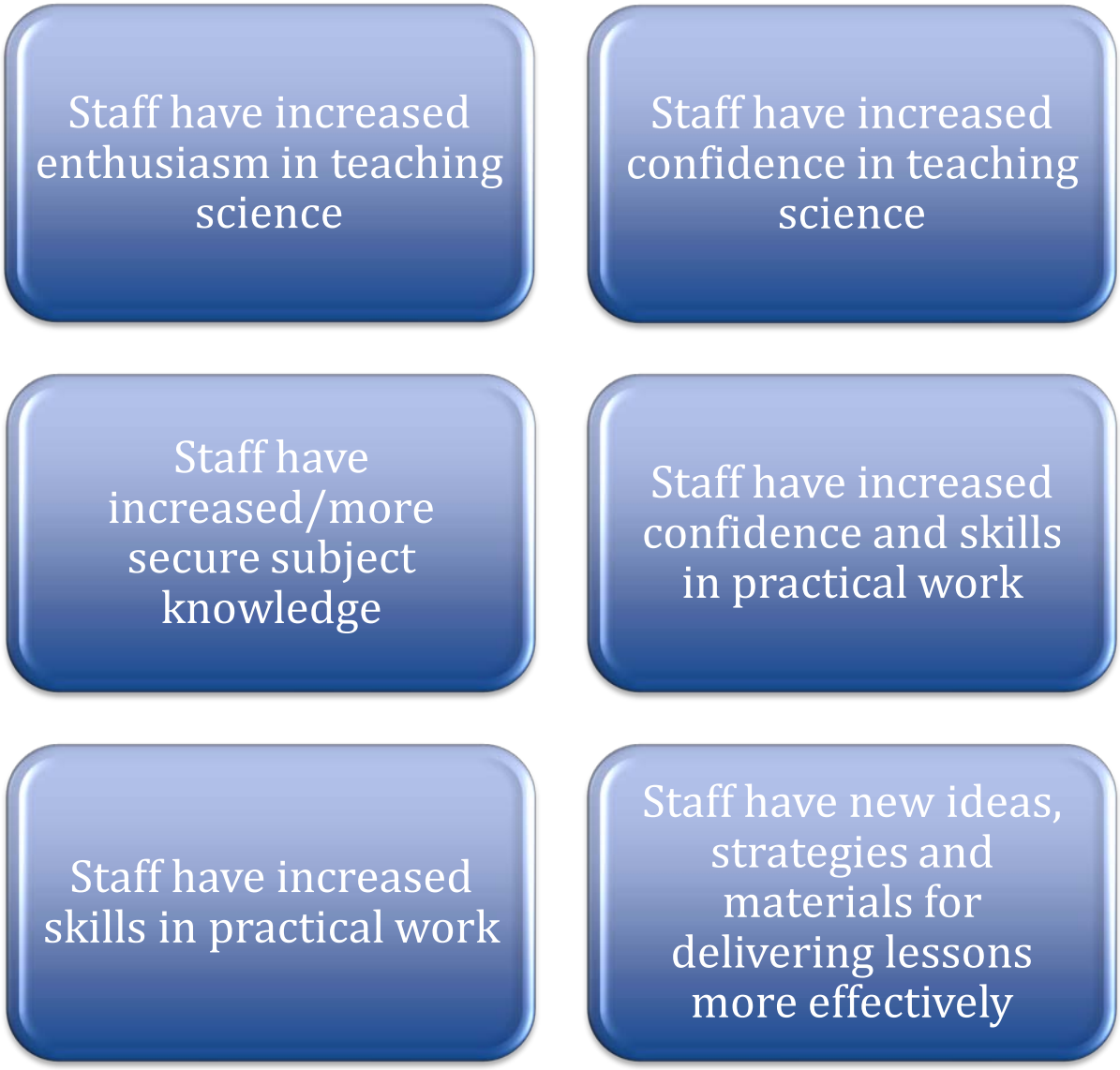


b) Please rank the statements below in the sequence in which you think they occur.



c) Please rank the statements below to demonstrate the sustainability of these impacts over time.



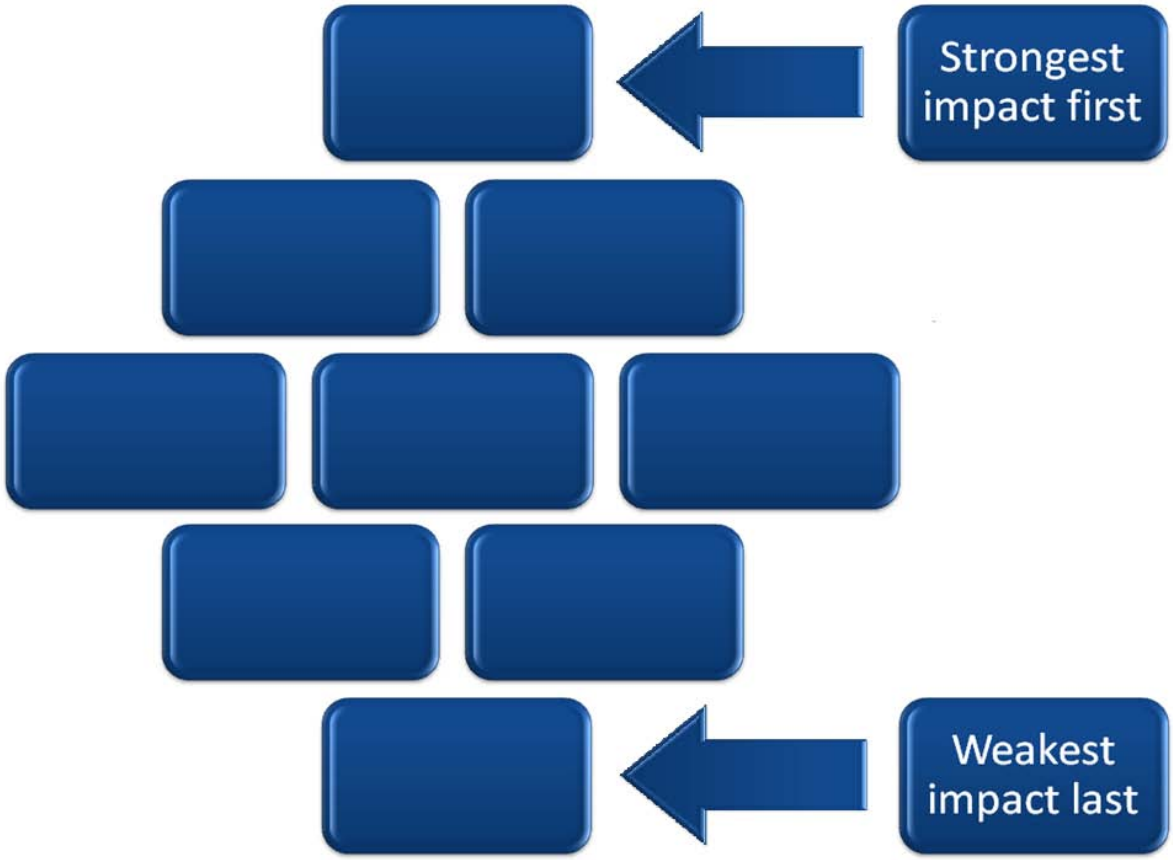

Staff have increased enthusiasm in teaching science
Staff have increased confidence in teaching science
Staff have increased/more secure subject knowledge
Staff have increased confidence and skills in practical work
Staff have increased skills in practical work
Staff have new ideas, strategies and materials for delivering lessons more effectively

National Science Learning Centre CPD: Teachers Diamond Ranking Exercise on student impacts

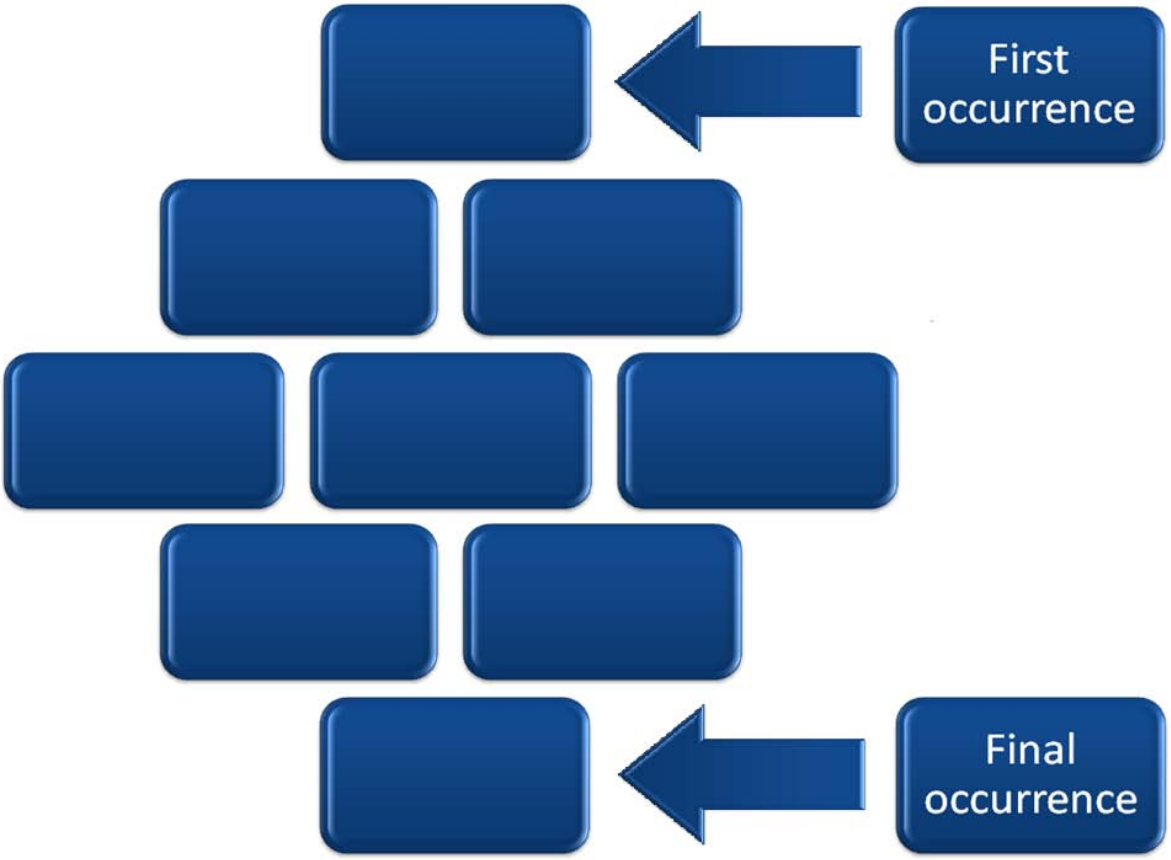
Our research has identified nine ways in which teacher CPD has benefited learners. We are interested in exploring your views on:

a) the strength of the impacts resulting from teacher CPD
b) the sequence in which these impacts occur over time and
c) the sustainability of impacts over time.

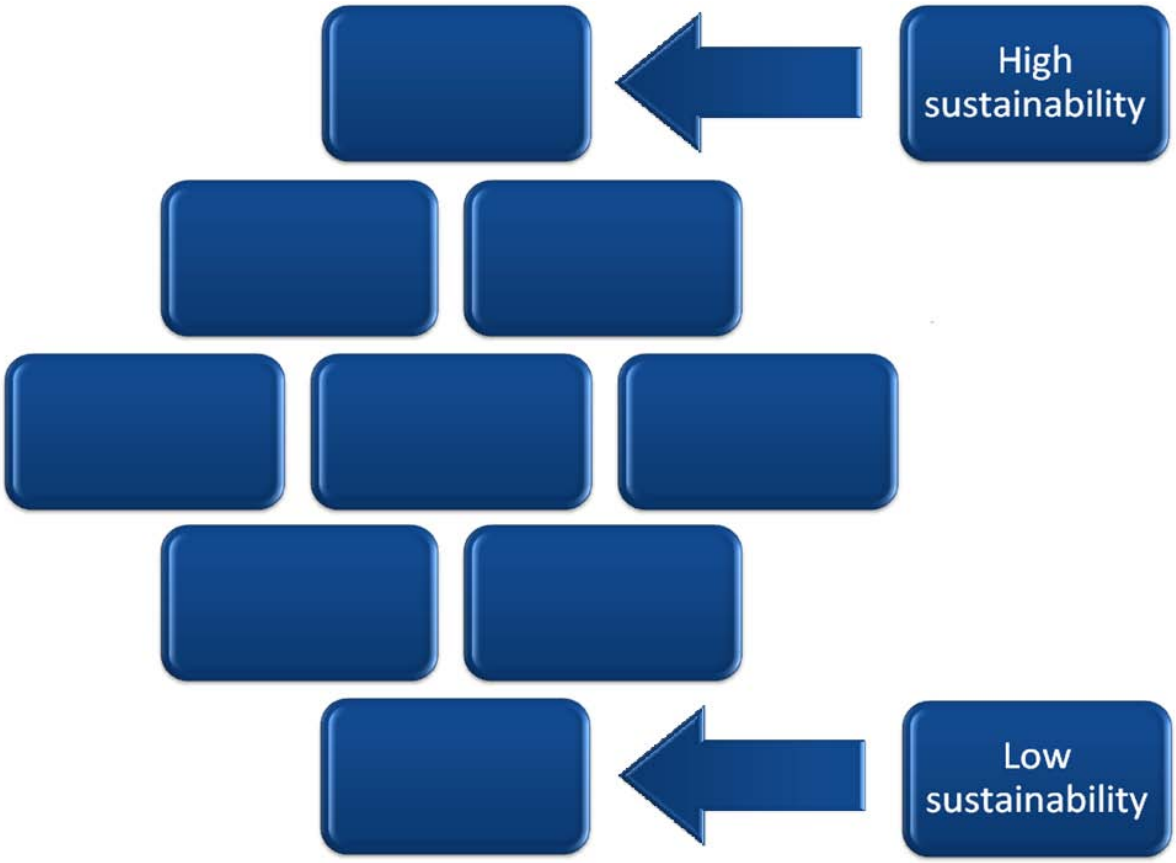
a) Please rank the statements below in the order in which you think the impacts are strongest.

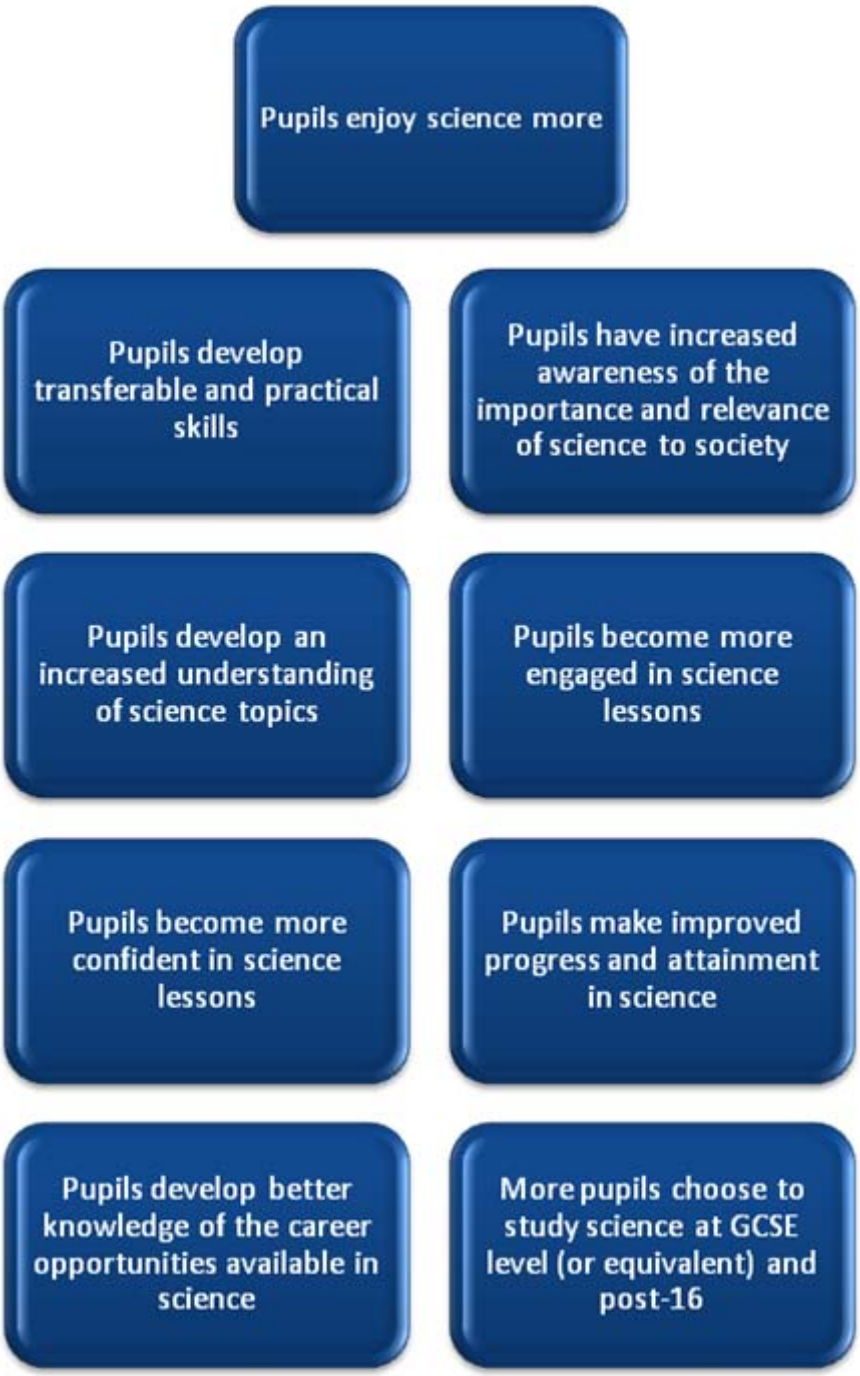


b) Please rank the statements below in the sequence in which you think they occur.



c) Please rank the statements below to demonstrate the sustainability of these impacts over time.

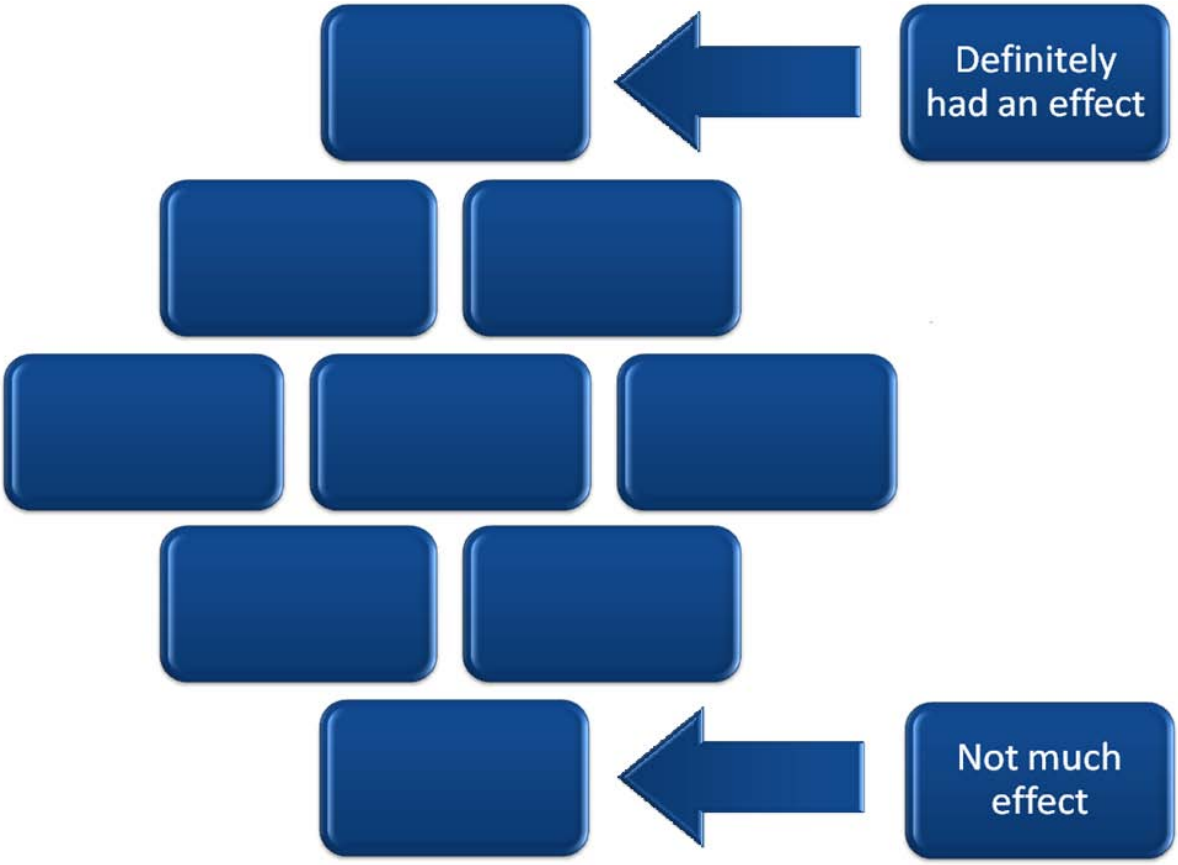



Pupils enjoy science more
Pupils develop transferable and practical skills
Pupils have increased awareness of the importance and relevance of science to society
Pupils develop an increased understanding of science topics
Pupils become more engaged in science lessons
Pupils become more confident in science lessons
Pupils make improved progress and attainment in science
Pupils develop better knowledge of the career opportunities available in science
More pupils choose to study science at GCSE level (or equivalent) and post-16

National Science Learning Centre CPD: Student Diamond Ranking Exercise on student impacts

Your teachers have been on courses to learn about new ways of teaching science and new activities and approaches for science lessons. We have identified nine ways in which you may have benefited from this. We are interested in finding out what you think about whether this has had an effect on you.

Please rank the statements below according to whether you think they have had an effect.




Enjoy science more
Develop practical skills that will be useful in other lessons of outside school
Understand more about science in society
Better knowledge and understanding about science topics
Do better in science exams
Really feel involved in science lessons
Choose sciences for future study
Feel confident to speak up and ask questions in science lessons
Understand more about science careers

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