A description and analysis of the United Kingdom's system of professional development for science teachers

John Holman, August 2013

This paper describes the overall context for professional development of science teachers in the UK, and then focuses on the largest and most significant initiative of the past 10 years: the introduction of the national network of Science Learning Centres for science teachers' professional development, its organisation, impact and lessons learned.

Contents

Acknowledgement

I am grateful to Professor Mary Ratcliffe MBE, for expert guidance in the preparation of this paper. Mary Ratcliffe was Associate Director of the National Science Learning Centre between 2008 and 2011, and Director of Science Learning Centre South East between 2004 and 2008.

1. Context

1.1. The devolved character of education in the UK

The nations of the UK - Scotland, Wales, Northern Ireland and England – each have jurisdiction over their own education systems. The systems in Wales, Northern Ireland and England are similar, but Scotland's is very different. This paper will be mainly about England, which has 84% of the population of the UK.

1.2. The situation prior to 2004

Not long after Tony Blair was elected Prime Minister in 1997, the Department for Education (DfE)[1] in his government introduced the Primary and Secondary National Strategies (DfE, 2011). Their goal was to impose a more uniform approach to teaching the core subjects of English, mathematics and science in England, with the objective of raising performance as measured by national tests. The Secondary National Strategy for Science (ages 11 – 16) was introduced in 2001, and under it science teachers were expected to attend professional development (PD) linked to the Strategy. PD was provided by a range of public and private organisations, co-ordinated by the local education authority (the equivalent of a school board). To receive funding from central government, PD had to conform to the framework set out by the Secondary National Strategy and as a result this came to dominate the provision of science PD.

This centrally-driven initiative made some impressive early gains, but as early as 2003, it was becoming clear that a nationally-imposed strategy linked solely to improving test results had limitations. In particular, there was concern at declining interest in science, technology, engineering and mathematics (STEM) among students in secondary schools and universities (HM Treasury, 2002). This provided the impetus for the Science Learning Centres initiative.

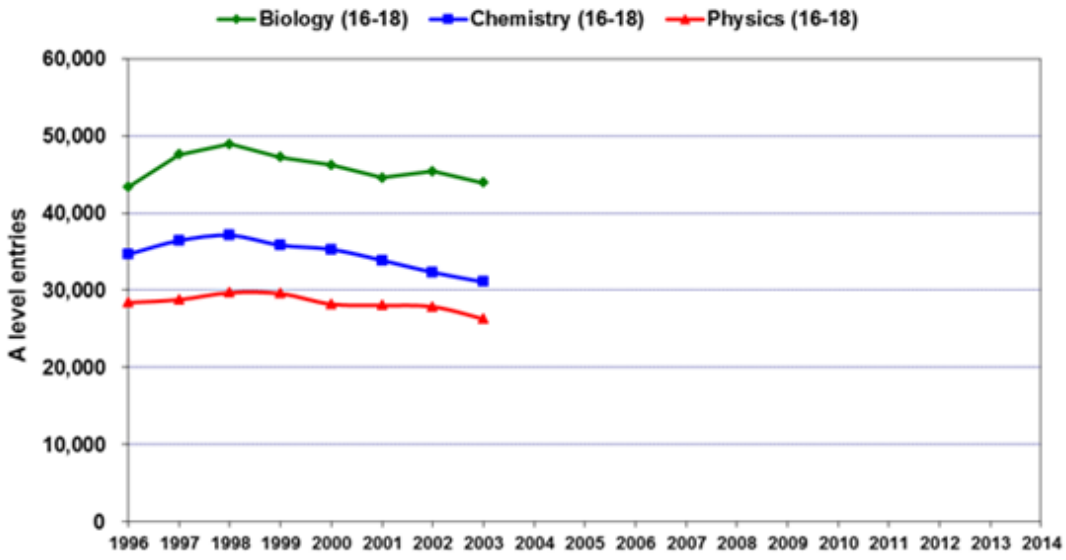
2. The Science Learning Centres initiative

[1] Prior to 2007, the Department for Education was called the Department for Education and Skills. Between 2007 and 2011 it was called the Department for Children, Schools and Families.

2.1. Motivations

By 2003, the decline in uptake of STEM subjects was clear to see (Figure 1).

Figure 1 Science A level entries 1996 to 2003 A (Advanced) level is England's pre-university qualification. Students have a free choice to take whatever subjects they prefer.



This concern coincided with a growing realisation that the quality of teachers is the single most important influence on students' motivation and achievement in science. The House of Lords Report *Science in Schools* (2001) highlighted the importance of PD, saying: 'Those who teach science, and particularly those who teach beyond the scope of their degree, should be given priority in the development of CPD policy'.

It was against this background that the DfE and the Wellcome Trust joined forces in the Science Learning Centres initiative. The Wellcome Trust is the UK's largest charitable foundation; although its primary mission is in biomedical research, it has strong interest in improving the quality of science education at all ages. The Wellcome Trust agreed to provide £25 million ($40 million) to establish the National

Science Learning Centre for the UK, while the DfE agreed £25 million for a network of nine Regional Science Learning Centres in England.

2.2 Establishing the network of Science Learning Centres

Table 1 gives some of the critical dates in establishing the Science Learning Centres.

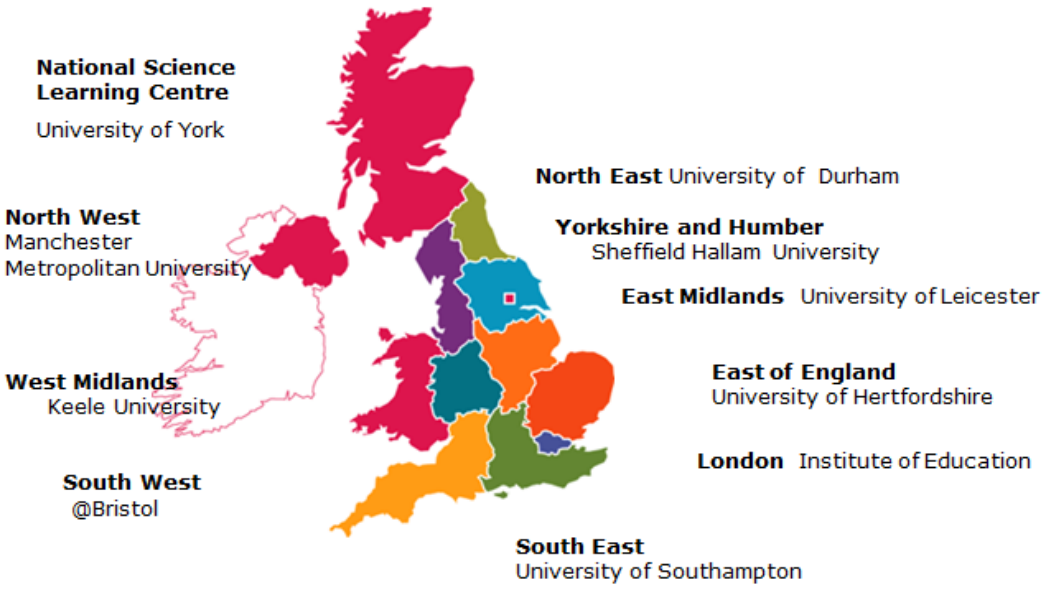
Table 1 Timetable for establishing the Science Learning Centres network

2003	Science Learning Centres project launched by English government and the Wellcome Trust
2004	First Regional Science Learning Centres started to open, funded to 2008 by government
2006	National Science Learning Centre opened, funded to 2013 by Wellcome Trust
2008	'Project ENTHUSE' created £27 million fund to enable schools to attend National Science Learning Centre at no cost
2011	Government continued Regional Science Learning Centres funding until 2013
2013	Wellcome and government agreed funding of National Science Learning Centre to 2018 Government agreed funding for Regional Science Learning Centres until 2015 National Science Learning Centre reorganises Regional network, making it more school based.

From 2003, Wellcome and the DfE began the process of procuring the National and Regional Science Learning Centres. This was done by open competition, and bids were received from a variety of consortia, mostly led by universities but also involving businesses, schools, interactive science centres and museums.

From October 2004, the first Regional Science Learning Centres began to open, usually in refurbished university accommodation. By early 2006 the network of Regional Science Learning Centres was complete, covering the nine regions of England (Figure 2). In March 2006, Prime Minister Tony Blair opened the purpose-built, £11 million ($18 million) National Science Learning Centre in the University of York, completing the network of Science Learning Centres. The author of this paper was the founding director of the National Science Learning Centre and leader of the network.

Figure 2 The network of Science Learning Centres in 2006



2.3 Organisation of the network of Science Learning Centres

The Science Learning Centres provide a comprehensive and systematic programme of PD for teachers in primary and secondary schools and further education colleges[2], covering the full range of sciences: physics, chemistry, biology, earth science, psychology etc. The content of the programmes is described in section 3.2.

[2] Further education (FE) colleges in England are similar to comprehensive community colleges in the US.

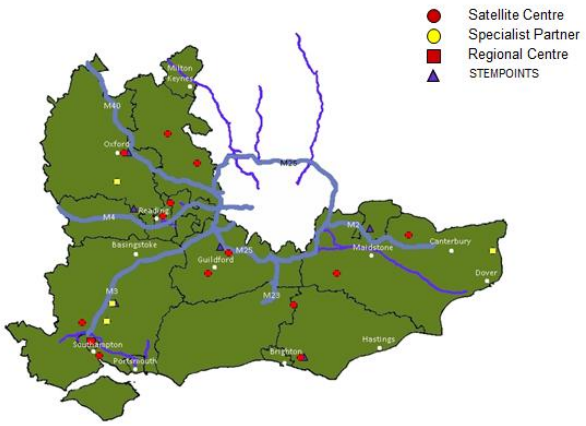
The National Science Learning Centre (figure 3) is both the network's headquarters and a residential Science Learning Centre in its own right. It provides PD programmes for science teachers across the whole of the UK, most of the courses being residential and lasting three or more days. The centre has its own hotel and restaurant, and is purpose built to be a high quality professional development centre to match the quality expected in business and the professions. It has two lecture theatres, several laboratories (configured as for schools), seminar rooms and the largest STEM resource collection and archive in the country. The emphasis on high quality facilities extends across the whole network, the intention being to make a statement about the high value placed on science teachers.

Figure 3 The National Science Learning Centre in the University of York

The National Science Learning Centre manages the web portal www.slcs.ac.uk which is used across the whole network for marketing purposes as well as a virtual learning environment which supports the growing online PD element.

The regional centres provide national coverage in England, delivering day or part-day courses either in the centre itself or in satellite venues around the region (figure 4). Increasingly, the regional centres work directly with schools to provide quality-assured PD for teachers in a local school cluster.

Figure 4 Science Learning Centre South East: Satellite Venues and Partners



2.4 Business model for the Science Learning Centres

Each Science Learning Centre is effectively a separate non-profit organisation. The following is a description of the business model for the National Science Learning Centre, which has been established as an independent non-profit company.

The building costs for the Centre were provided by a grant from the Wellcome Trust, and this grant also covered the Centre's operating costs for its first three years, making it possible to provide PD programmes effectively free of charge to teachers from government schools. In 2008, a successful fund-raising initiative named *Project ENTHUSE* raised a further £27 million from business, government and the Wellcome Trust to sustain free provision until the present date.

The major challenge for the Science Learning Centres was, and remains, to persuade school principals to release teachers to attend PD events, especially the extended residential courses at the National Science Learning Centre. (In England, there is no tradition or expectation of teachers undertaking PD in the summer vacation.) Once the reputation of the Centres was established, this became easier, but even so it remains difficult to enable teachers to have time for externally organised PD, especially those schools in deprived circumstances that have most to gain from it. For this reason, a model that has no cost to schools was essential if system-wide penetration was to be achieved.

However, there was concern that teachers would not value PD which was free of charge, however high its quality. Therefore, the model adopted was to make a full charge to teachers' schools for attendance, the cost to be reimbursed in full, together with travel costs and the cost of providing a replacement to cover the teacher's attendance, once the teacher has completed all the course requirements. This approach has proved successful in securing the commitment of teachers to the entirety of the course.

A similar approach to costs and charging is taken by the Regional Science Learning Centres, though they have a more diverse mix of funding sources, including local industries and enterprises as well as the main funding from central government, which they receive under a sub-contract with the National Science Learning Centre.

3 Content and character of PD at the Science Learning Centres

3.1 Principles

When the Wellcome Trust and DfE set out the principles for the Science Learning Centres, they emphasised that they should be about more than just raising results in national tests. To improve motivation and engagement with STEM, students need to be inspired and enthused by their teachers, and this meant helping teachers to be

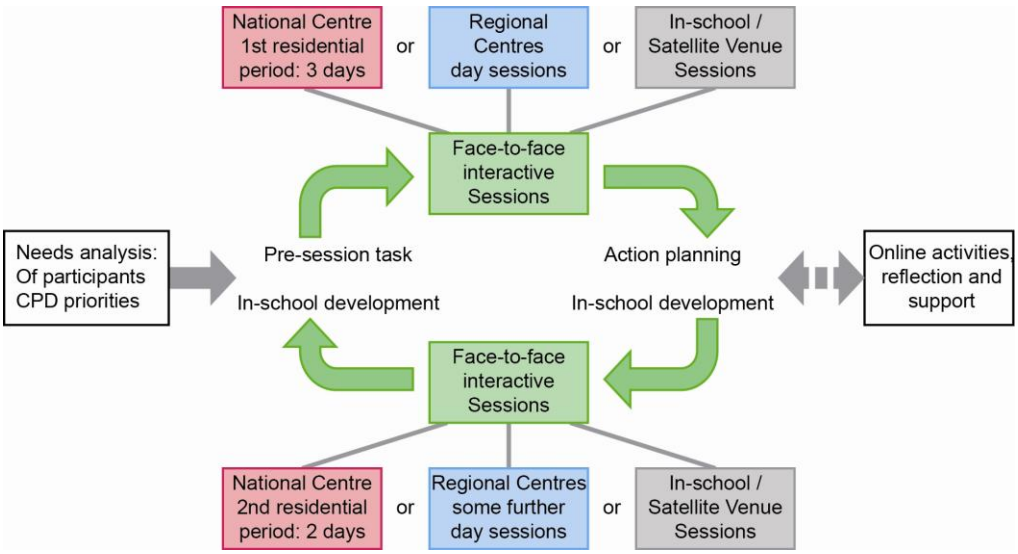
creative and to find hands-on approaches to learning science. It also meant accepting that many teachers need to improve their subject knowledge as well as their teaching skills, so that they have secure and up-to-date knowledge of the subject they teach.

From its early stages the network took a co-operative approach to implementing agreed principles of professional development, based on research evidence about the kind of PD that is effective in embedding lasting change in teachers' knowledge and skills. There is a substantial body of evidence about the most effective professional development for teachers of science (e.g. Loucks-Horsley et al., 1998; Darling-Hammond, L. & Youngs, P., 2002; Adey, 2004.) and teachers more generally (e.g. Desimone et al., 2002; Garet et al., 2001). As a summary, effective PD is:

- relevant to the teacher's needs – teaching science to their students in their school;
- collaborative, with teachers working together and with experts on shared concerns;
- sustained and continuing throughout the teacher's career;
- embedded in the culture of the school.

The network aimed to follow these principles as far as possible when designing the PD programme – whether the PD episode is undertaken residentially at the National Science Learning Centre, at a regional Science Learning Centre or in a school. The design of the PD has the cyclical features shown in figure 5.

Figure 5 Framework for PD at the Science Learning Centres



Before attending PD sessions, teachers are expected to work with their school managers and the network's PD leaders to identify their individual needs and, in many cases, undertake preparatory tasks in school. The PD sessions involve collaborative experiences with the intention of embedding new practices within the teachers' own school. Residential courses at the National Science Learning Centre are normally in two blocks, typically of 3 days and 2 days, separated by several months back in school where teachers carry out a project related to the course and may also undertake online learning.

The Impact Toolkit is an important component of the network's professional development approach (www.slcs.ac.uk/research-and-impact), supporting participants' active engagement throughout and beyond their PD experience. Using the toolkit, participants are expected to record their progress through a three stage process:

- identification of their specific development needs and their expectations of the PD;
- recording their action plan: what they will do to modify practice as a result of the PD;

- completing a reflective record of the outcomes of their action plan on their teaching, their students and their colleagues. This record is validated by their school manager.

3.2 Programme content

The core programme is planned jointly across the National and Regional Science Learning Centres, giving coherence, avoiding duplication and providing progression routes. The programme of PD is planned with reference to the following.

- Market research: what do teachers and schools want?
- Educational research: what does the literature tell us about what works?
- Government requirements: what are the policy priorities? (For example the introduction of a new version of the national curriculum.)

The programme across the network is planned to provide support for science teachers at every stage of their career, from newly-qualified teacher, through experienced classroom teacher to science leader. Well-organised schools that appreciate the importance of PD take advantage of the progression provided by the Science Learning Centres programme, and the results can be seen in their achievements (see section 4 on Impact, below).

The core programme is consolidated around four themes.

Science knowledge and understanding. Teaching strategies that enable students to access and understand science concepts and processes, and to appreciate the importance of science in modern life and society.

Progression, achievement and success. Teaching strategies for assessment and management of learning in order to raise attainment and achieve the potential of all young people.

Skills for learning science. Teaching young people the skills they need to achieve their potential in science, including an understanding of the methods and technologies that scientists use in discovering and communicating new knowledge.

Enrichment, behaviour and motivation. Strategies to differentiate and tailor the science curriculum to widen participation, enhance interest and increase continuation of study.

The PD content which individual schools experience can be quite varied. For example, some schools and colleges may focus on residential PD with an emphasis on leadership; others may have individual teachers experiencing school-based PD to improve subject knowledge and pedagogy; others may use a combination of content and methods of access.

Table 2 shows a few examples of PD events at the Science Learning Centres. Full details can be found on the website www.slcs.ac.uk.

Table 2 Examples of PD events at the Science Learning Centres

Title	Audience	Centre and duration
New and Aspiring Heads of Science	Heads and aspiring heads of science in secondary schools	National, 12 day residential in 4 blocks, with in-school tasks and online learning
Microbiology for Schools	Science laboratory technicians	National, 3 day residential, with in-school tasks
Inspiring Post-16 Physics	Teachers of pre-university physics	National, 5 day residential in 2 blocks, with in-school tasks
Leading Subject Knowledge in the New Primary Curriculum: Genetics and Adaptation	Science leaders in primary schools	National, 3 day residential, with in-school tasks
Summer School for newly-qualified teachers	Teachers from primary and secondary schools who have just completed their first year of teaching	National, 5 day residential, with pre- and post-tasks
Enhancing Literacy Skills in	Secondary science teachers	London, 1 day, with in-school

Science		tasks
Practical Work in Biology	Secondary biology teachers	London, 1 day, with in-school tasks
Physics at Theme Parks!	Secondary physics teachers	East Midlands, 1 day, with in-school tasks
Science demonstrations: effective and safe	Secondary science teachers	South-west, 1 day, with in-school tasks
Leading Professional Development in Science Education	Leaders of science in secondary schools	East of England, 1 day, with in-school tasks

Much of the PD at the Regional Science Learning Centres is shared across the network so that teachers across England can have local access to a core programme. But Regional Centres also run additional PD in response to regional priorities and interests – for example the Regional Centres support school-based PD requested by individual schools or clusters of schools.

3.3 Delivery of the programme

All the Science Learning Centres have a number of permanent **Professional Development Leaders (PDLs)** on their staff, who are often science teachers who have undergone a programme of induction and training on joining the Science Learning Centre. Each PD event is the responsibility of a PDL, who may also do some of the teaching, but is likely to engage expert teaching assistance, for example from Advanced Skills Teachers[3], university faculty staff (both scientists and educationalists) and professional trainers, according to the subject involved.

[3] Advanced Skills Teachers are highly accomplished classroom teachers who receive additional pay in return for supporting and training other teachers, in their own and other schools.

Occasional staff of this kind are recruited through a light-touch selection and training process.

The hallmark of PD at the Science Learning Centres is the high quality of its design and delivery. At the outset of the initiative, the Science Learning Centres agreed and implemented a process to assure a quality standard that would be consistent across all the Science Learning Centres, and in other delivery centres such as schools. Having established the agreed protocols, quality is monitored by peer review and by analysis of customer feedback.

Where PD events are shared across the network of Centres, they are planned by a small team of PDLs on behalf of the network. Planning is a meticulous and time-consuming process: typically, it takes 3-4 days of preparation for every day of delivery.

4 Impact of the network of Science Learning Centres

4.1 Headlines

In 2011-12

74% of all secondary schools and colleges in England used the national network of Science Learning Centres

21% of secondary schools and **26%** of further education colleges in England used the National Science Learning Centre

14,000 teachers from across England used the national network of Science Learning Centres

16,864 professional development days were delivered by the regional Science Learning Centres

10,321 professional development days were delivered by the National Science Learning Centre for teachers across the UK, an **8%** increase on 2010 - 11

98% of all secondary schools and colleges in England have used the network of Science Learning Centres since they were launched in 2004

4.2 Studies of impact

Like any provider of PD, the Science Learning Centres routinely carry out formative evaluation, usually by asking participants to complete post-course questionnaires. This is used to continuously improve the PD offering.

However, to provide robust evidence of long-term impact, more than this is needed. Evaluating the impact of PD on the eventual target – students – is hard because it means measuring the outcome at the end of a chain that begins at the Science Learning Centre and ends with students in a teacher's classroom.

In PD interventions that are time-limited, tightly focused and experienced in the same way by all participants, it is possible to undertake experimental studies, comparing outcomes of 'treatment' with a control group. There are few such studies of PD to be found in the literature (see, for example, the review by Yoon et al, 2007). For the network of Science Learning Centres there have been limited quasi-experimental studies to date (e.g. Scott et al, 2010; Rietdijk et al, 2011). This is because there is so much variation in what individual teachers and schools undertake through the rolling network PD programme that it is very difficult to define the 'intervention', establish baseline and outcome data, and provide appropriate control groups. The best example of a controlled study, currently under way at the Science Learning Centres, is the Primary Science Specialist Programme. This study involving 84 primary school teachers in three groups ('treatment', 'partial treatment' and 'no treatment') will measure the effect on primary science teaching of training a teacher in the school to a defined level of science specialism. The results of this study will be available in Autumn 2014.

There have been over 20 published studies of the impact of PD at the Science Learning Centres. Most of these have taken a well-trodden path of mixed-methods approaches to examining outcomes for teachers, and where possible, their students. Studies of the impact of professional development in the Science Learning Centres network fall into four categories.

a) **Quasi-experimental studies (QE)** with some focus on student outcomes (e.g. Scott et al, 2010; Rietdijk et al, 2011; Abrahams et al, 2011);

b) **Large-scale quantitative evaluation (LQ)** of main outcomes for teachers and /or students, mainly using nationally available datasets (e.g. GHK, 2008; National Audit Office, 2010; Kudenko et al, 2011; Lowden et al, 2011; SQW, to be published);

c) **Mixed-methods examination (MM)** of particular aspects of network PD (e.g. Ratcliffe & Hanley, 2005; Jarvis et al, 2008; Jones et al, 2008; Bennett et al, 2011; Walker et al, 2012; Wolstenholme et al, 2012);

d) **In-depth qualitative case studies or small scale studies (CS)** of particular aspects of network PD (e.g. Stylianidou et al, 2005; Bennett et al, 2010; Bevins et al, 2011; De Winter 2011, Richardson, 2011).

Appendix 1 has a summary of 19 studies by category. The reported studies are all either publications in peer-reviewed journals or conferences, or detailed research reports in the public domain, some of which will form the basis of future peer-reviewed publications.

4.3 Impact: the overall picture

Taken together, these studies have collectively demonstrated, through an abundance of evidence, that the programme of Science Learning Centres' PD has resulted in:

- clear outcomes for <u>teachers</u> in improving their understanding, skills and classroom practice. These alone contribute to important improvements in science education;

- for students, improved attainment and engagement in science, shown by association between focused PD and student outcomes;

- for schools, reported impacts beyond those on the immediate participants and their classrooms.

The research has also shown that the extent of impact depends as much on systems within schools as on the quality of the PD itself.

Two studies by national monitors are worth special mention. First, the national school inspectorate, Ofsted[4], in a report on science education in England (Ofsted, 2011), said:

The quality of professional development received from external providers was variable, but that provided by the national network of Science Learning Centres was consistently reported to be good.

Second, the National Audit Office, which monitors government spending on behalf of Parliament, carried out a 'value for money' study of the various initiatives the government has funded to increase the uptake of STEM subjects in schools (NAO, 2010). The study, which was based on large national datasets, says:

There is evidence that participation by teachers in Science Learning Centre programmes is associated with improved teaching and learning, and higher take-up and achievement in science in their schools …. For example, attendance on a course of average duration (3.5 days) at the National Science Learning Centre was associated with an increase of 0.5 percentage points in the proportion of the schools' pupils gaining A–C grades in science GCSEs[5].*

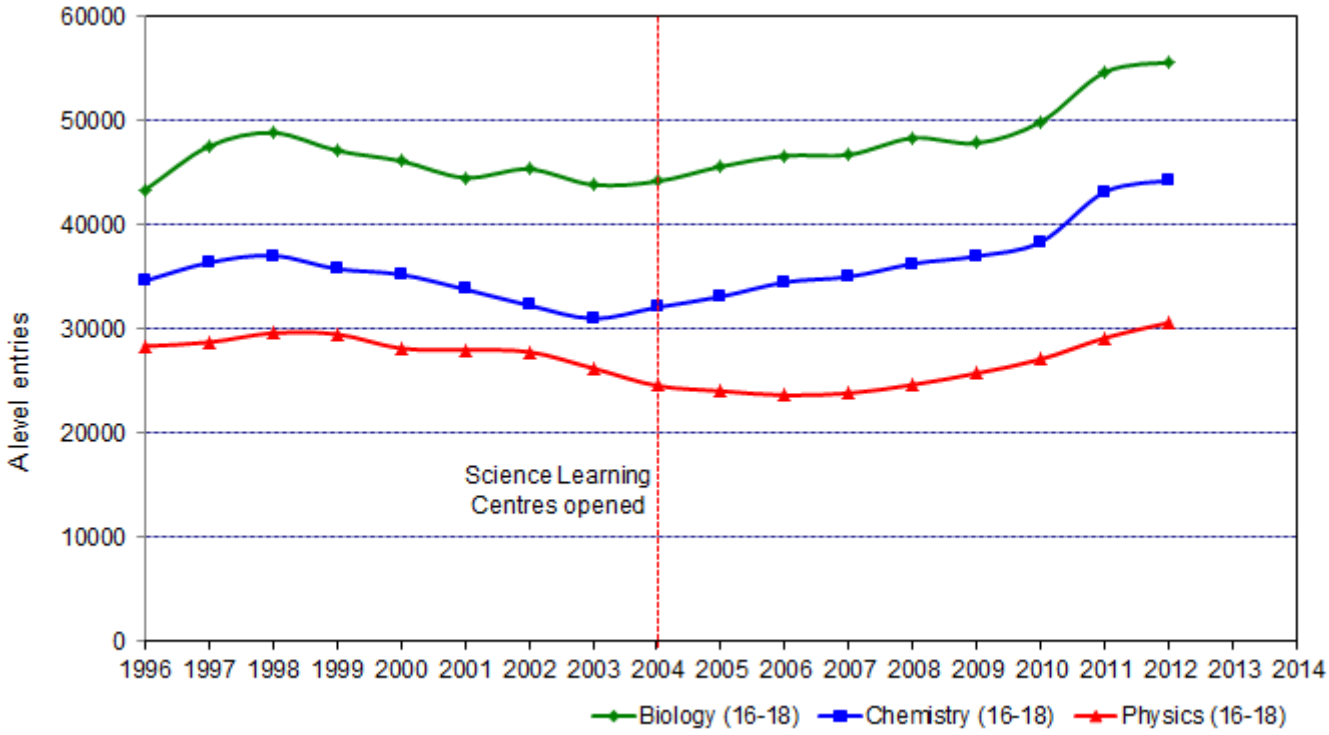
Finally, the establishment of the Science Learning Centres has coincided with a notable upturn in the popularity of the sciences (figure 6). Although this pleasing

[4] The Office for Standards in Education, Ofsted, inspects all government schools in England. Ofsted inspection reports have a major (and some would say excessive) influence on the behaviour of schools.

[5] GCSE is the General Certificate of Secondary Education, a national examination taken at age 16.

effect cannot be attributed solely to the Science Learning Centres initiative, it is a reason for satisfaction, given that the prime motivation for establishing the network was to bring about exactly this change.

Figure 6 **Science A level entries 1996 to 2012**



4.4 Impact beyond one teacher

System-wide improvement will be felt more quickly if teachers attending PD at the Science Learning Centres can create a 'ripple' effect across their own and other schools. The impact studies described above, and teachers' own evaluations, suggest that this indeed happens. Beside looking at impact on the individual PD participant, several studies present evidence of the wider influences within the school.

Analysis of teachers' reports on their PD experiences is illuminating. The reports of a sample of 2,596 teachers participating in Science Learning Centres PD in 2008 – 2011 were

analysed as part of the network's internal evaluation: 85% reported an impact of their own PD on colleagues, and 45% considered colleagues' teaching had improved as a result. These findings are based on subjective reports by teachers, but they are backed up by external studies based on quantitative surveys (table 3).

Table 3 Summary of reports of impacts on colleagues and school from quantitative analysis of external studies.

Sample size	Reporting sharing with colleagues	Reporting impact on whole school objectives related to science	Reporting impact on school development plans	Reporting others were trained or their teaching changed	Study
893	56%	57%	53%		GHK 2008
579	74%			47%	Kudenko et al 2011
125	45%	76%			Lowden et al 2011
493			28%	20%	SQW
177	57%				Jones et al 2008
150	49%			27%	Bennett et al 2011

These quantitative data confirm that there is impact on colleagues and whole school practices, although to a lesser extent than impact on participants' own practice.

4.5 How can wider impact be maximised?

Impact beyond the individual can be designed into the PD programme. The Impact Toolkit described in section 3.1 is designed to make teachers think, before, during and after the PD experience, how they will make sure the experience has an impact on their own practice,

and how this can be extended to others within and beyond their school. For example, they might report back to a department meeting; better still, their school manager might use the PD experience as an input to department development planning: if the Physics department wants to improve their use of practical work, for example, they might ask a teacher to participate in appropriate PD and report back. This kind of planned integration of individual and school needs has become more common with schools using the impact toolkit effectively. In two-block residential courses at the National Science Learning Centre, teachers are asked to report back in the second block on how they have influenced their colleagues.

Beyond this, much of the PD at the Science Learning Centres is designed with subject leaders in mind. For example, the *New and Aspiring Heads of Science* course at the National Science Learning Centre includes several modules designed to train teachers to lead their team and to disseminate new ideas across their department. The *Primary Science Specialist Programme* (section 4.2) is designed to improve subject knowledge and teaching skills in primary science, and also to show teachers how to disseminate most effectively their knowledge to colleagues back in school.

One of the external studies (Walker et al, 2012) has identified particular features of PD collaboration between the National Science Learning Centre and schools that enables wider impact beyond the individual participant. These features include: a focus on action planning and follow up work; use of new materials and resources; senior school managers' commitment to PD and their understanding of the benefits; time for teachers to implement changes; sharing learning and good practice at school departmental meetings; sharing resources on the school science department's web-space.

5 The Science Learning Centres: lessons learned and unanswered questions

5.1 The importance of clear objectives

What do we want to achieve from science education, and therefore from teachers' professional development? This may sound an obvious question, but in practice it has turned out to be controversial. For example, in the early days of the Science Learning Centres, there were subtle tensions between the Wellcome Trust's wish for more inspired, creative science teaching and the then government's emphasis on improving results in national tests. Later, in 2010 the incoming Coalition government wanted a more knowledge-based curriculum (influenced by the writings of E D Hirsch Jr) than the previous government. Such tensions are not impossible to resolve, but it helps to have a shared view from the start about what science education is for, and therefore what the PD programme should include.

5.2 The importance of collecting the right data from the start

In a nationally-funded initiative like the Science Learning Centres, it is important to be able to monitor the effect you are having, both for formative reasons – to modify the approach if necessary – and summatively, to demonstrate effect to funders. This means being clear what you are trying to achieve (see 5.1), deciding how to measure it, and collecting the right baseline data from the start.

5.3 Getting the right professional development model: the right balance between Centre-based, in-school and online

The Science Learning Centres were intentionally conceived as striking physical centres intended to make a statement about the importance of science teaching. Inevitably, therefore, the dominant model of PD adopted initially was face-to-face delivery within the Centre. But this has its limitations: researchers have pointed to the importance of embedding PD within the school setting, and often school-based PD is easier for teachers to attend. The power and reach of online learning is undeniable.

But the value of getting teachers off site, away from school distractions, in front of experts and above all with other teachers to share their experiences, should not be underestimated. Over the nine years of their existence, the Science Learning Centres have evolved the model, maintaining the importance of teachers working together on changing practice but with increasing emphasis on school-based PD. The National Science Learning Centre, though, remains a premier destination for extended residential PD designed to make a deep impact.

5.4 How to stimulate demand as well as supply of science teachers' PD

The Science Learning Centres initiative was supply-driven, and has brought a step-change in both the quality and the quantity of available science teacher PD. Yet the major challenge remains enabling teachers to have the time for PD experiences.

The problem is that in most schools there is no embedded culture of systematic, career-long PD. Many school principals give greater priority to the short term challenge of replacing absent teachers than to long-term investment in their staff. This is in marked contrast to professions such as medicine, law and accountancy, where PD is an embedded expectation.

There has been much discussion of the possibility of a national accreditation system for teachers' PD, perhaps linked to credit accumulation towards higher degrees at Masters level. Such a system, if linked to pay and promotion, would be a powerful driver of demand. But there is a long way to go: teachers do not see credit accumulation as a priority, and the accompanying assessment systems for Masters awards places an additional burden on PD that few are prepared to carry. School principals and the teaching unions would resist such a system unless it was accompanied by substantial additional funding, and government is not ready for that.

So for the foreseeable future it seems likely that enabling teachers to have the time for PD will be the Science Learning Centres' biggest challenge, despite the growing

and persuasive evidence that this kind of sustained PD has impact on teachers, students and whole schools. What seems certain is that a self-sustaining model, in which teachers or schools pay the full cost of PD at the Science Learning Centres, is some way off, and external funding of one kind or another will be needed for the foreseeable future. Whether the government and Wellcome Trust will be prepared to shoulder this burden indefinitely remains to be seen.

6 Future developments

6.1 The current context

Despite the upturn in the popularity of sciences at school and university, the supply of people with STEM skills remains a high priority for the UK. With an estimated shortfall of 40,000 STEM graduates each year in the UK (SMF, 2013), STEM is critically important to growth and economic recovery.

The incoming Coalition government in 2010 had a different education policy to its Labour predecessor, and it also had a huge budget deficit to deal with. Many of the previous government's educational initiatives were abandoned, but the Science Learning Centres survived and received continuation funding under the new administration, though this funding is being tapered down from its original level.

Other policies of the Coalition government include strong emphasis on school autonomy and a programme of Academies and Free Schools[6] designed to free schools from local and national bureaucracy. Government is also moving to shift initial teacher training away from universities and into schools, and aims by 2014 to have 500 Teaching Schools in operation, giving these outstanding schools a lead role in the training and PD of teachers and other school staff.

[6] Academies are state-funded schools that are independent of control by the local education authority. Free schools are similar to Charter schools in the US.

Against this background, the Science Learning Centres network is evolving towards a model of delivery that is more strongly school-based and offers a greater prospect of sustainability.

6.2 A new regional model for the Science Learning Centres

In 2013, the National Science Learning Centre began a process of reorganising the regional Science Learning Centre network, with the aim of making it more sustainable and more directly accessible by school and teachers. The strategy has the following features.

1 Reducing the number of English regions from nine to five.
2 Within each of the five Regions, there will be a Regional Consortium which will combine the physical facilities of one or more Science Learning Centres with around 10 local Science Learning Partnerships.
3 Each local Science Learning Partnership will bring together Teaching Schools, universities, employers and others interested in PD for science teachers.
4 PD programmes delivered through the Science Learning Partnerships will be mainly based in schools and will be quality assured by the National Science Learning Centre through the Regional Consortium.
5 There will be a gradual move towards charging schools the full economic costs of the PD programmes.
6 Residential PD will continue to be offered at the National Science Learning Centre.

The new infrastructure will be established by September 2013. The aim is for 60% of PD to be delivered locally through the Science Learning Partnership by March 2014, rising to 70% by March 2015.

This new model offers embedding in local schools and a route to sustainability as government funding is reduced. It has yet to be seen whether it will be able to

sustain the measured impact of the initial phases of the Science Learning Centres initiative. As ever, much will depend on the value that school principals place on investing on the long term professional development of their staff.

6.3 Finally, in France

The Science Learning Centres model has attracted interest in other countries. Notably, the French Academy of Sciences is establishing a network of 'Maisons pour la science au service des professeurs', modelled on the Science Learning Centres network. Four Centres have opened, and more are planned.

The last word comes from the Right Honourable Charles Clarke, who was Secretary of State for Education for England between 2002 and 2004 . *'High quality scientific education requires high quality and inspiring teaching allied to high quality resources. The Science Learning Centres were set up to achieve that high quality through focusing upon, and sharing, the best experiences. I believe they have already had a substantial impact and hope that they will do still more'.* (Clarke, 2013)

Appendix 1 Summary of reported studies of PD at the Science Learning Centres

Category	Study	Focus	Methods	Sample type & size	Framework / notes
QE1	Scott. P., Ametller, J., Edwards, A. (2010)	Chemistry / physics for non specialist teachers – outcomes for teachers and pupils	Quasi experimental Pre- / post-test teachers Comparison test students	All cases 85 teachers	
QE2	Rietdijk, W., Grace, M., & Garrett, C. (2011)	Action research projects in physics Outcomes for teachers and pupils	Quasi experimental Qunaires, focus group teachers Qunaires, pre- post-control pupils	All cases 67 teachers c. 5000	
QE3	Abrahams, I., Reiss, M. J., & Sharpe, R. (2011)	*Getting Practical* – outcomes For teachers	Quasi experimental pre- post- lesson observation, interviews	30 cases (10 primary 20 secondary)	Analytical framework focused on nature of practical work
LQ1	GHK. (2008)	Operations and outcomes of the network	Survey of users (non-users) Questionnaires Follow-up interviews Case studies – CPD observation, Interviews with stakeholders	18% of all 893 63 30	
LQ2	National Audit Office (2010)	Outcomes of the network for pupils	Statistical analysis GCSE science achievement vs schools involvement in NSLC/rSLC CPD	All secondary schools England	Effect size, value for money
LQ3	Kudenko, I., Ratcliffe, M., Redmore, A., & Aldridge, C. (2011)	Changes in practice; strengths and limitations of self-reported impact	Survey Impact forms, follow up interviews RSLCs Action plans, impact forms NSLC	Stratified random 579, 38 171 users	Guskey's 5 level framework
LQ4	Lowden, K., Hall, S., Lally, V. & Mancy, R. (2011)	Outcomes and operations of SSERC's CPD including for NSLC	Survey of users Follow-up interviews / focus groups Interviews with stakeholders	25% of all 436	Guskey's (2000) framework
LQ5	SQW (2012) (not in public domain)	Operations and outcomes of the network	Survey of users E-questionnaires (2 waves) Follow up interviews	14%, 17% of all 493 users	Some repeat study of GHK (2008) sample

Category	Study	Focus	Methods	Sample size	Framework / notes
MM1	Ratcliffe, M. & Hanley, P. (2005)	Format of CPD delivery – Outcomes for teachers	Survey Evaluation questionnaires, some interviews	All cases 223 teachers	
MM2	Jones, M., Harland, J., Mitchell, H., Springate, I., & Straw, S. (2008)	Chemistry for non-specialists (CFNS) – outcomes for teachers and pupils	Mixed-methods Survey Questionnaire Case study – interviews & pupil questionnaires	38% of all 184 teachers 28 CFNS teachers	
MM3	Jarvis, T., Hingley, P., & Pell, A. (2008)	Technicians	Pre- / post-course survey with observation of the course & some interviews.	40 technicians	Harland & Kinder's framework
MM4	Bennett, J., Braund, M., Lubben, F., & Mason, Y. (2011)	Different modes of CPD delivery	Mixed methods Online survey participants Case studies – interviews participants, line managers	150 teachers 14	Guskey's 5 level framework
MM5	Walker, M., Straw, S. and George, N. (2012)	Outcomes of National Centre's CPD on Pupils	Case studies Interviews with senior leaders, heads of science, teachers, technicians, pupils	Stratified 11 schools	
MM6	Wolstenholme, C., Coldwell, M. and Stevens, A. (2012)	Retention, career progression and Recruitment of teachers	Survey Questionnaire, Interview	Random stratified 519 teachers 23	
CS1	Stylianidou, F., Reiss, M. & Hall, A. (2005)	Method of CPD delivery - outcomes for teachers	Case study Interview	12 teachers	
CS2	Bennett, J., Braund, M., & Lubben, F. (2010)	Case studies of professional journey and Impact	Case study Observation, interviews – pre-post- delayed participants, line managers.	Stratified 8 schools	Guskey's 5 level framework
CS3	Bevins, S., Jordan, J., & Perry, E. (2011)	Action research projects in science	Case study Interview, observation, reflections	9 teachers	
CS4	De Winter, J. (2011)	Science as Additional Specialism (Physics)	Survey Assignments, evaluation forms	22 teachers	
CS5	Richardson, I (2011)	Clusters of schools working on focused CPD projects	Questionnaires Interview visits	Stratified 9 clusters	

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