London Schools Excellence Fund

Self-Evaluation Toolkit

Final report

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1. Executive Summary

The Physics Factory is a grassroots network of teachers aiming to boost uptake and performance in physics, by deepening immersion in subject knowledge.

It seeks to redress a catastrophic decline in student engagement in the physics with greater levels of support for students and their teachers, and more inspirational approaches to the subject.

The project aimed to operate a hub-model delivery strategy, to be rolled out in two stages. Firstly, in Year 1, consistent participation would be achieved among a sustainable core of teachers, comprised of a mix of non- and subject specialists, with buy-in for the project then extending across the department in each of their schools. Evaluation of the effect on teaching would be begun in this year. Then in Year 2, the effect on student outcomes could begin to be evaluated, while the number of participating schools expanded and the project programme honed and targeted.

In total, 154 teachers in 44 schools from 11 London boroughs have registered as part of the Physics Factory to date, reaching at least 4620 students.

The evaluation in this report is based on data from 136 separate attendances.

The main evaluation methods used were:
1. Initial questionnaire data supplied by teachers on joining the programme
2. Pre- and post- event evaluation forms completed by participants
3. Interview data from teachers in schools that had made the greatest use of the project
4. An End of Year Survey completed by around 25% of participants

All interview schedules and survey pro-formas were designed to address the key outcomes identified in the Theory of Change document.

The evaluation report identifies that good progress has been made with regard to all Teacher Outcomes and Wider System Outcomes (Table 1, Section 3) listed in the Theory of Change.

The main successes in the first year of the project have been:
1. an increase in the interest and enthusiasm of participating teachers to teach physics;
2. the subject knowledge of non-specialist physics teachers has been improved;
3. teachers are increasingly aware of new approaches to the teaching of physics and are more confident in those areas addressed by the project's CPD;
4. a good teacher support network exists across at least four boroughs;
5. pupils in participating schools have access to a wider range of physics activities;
6. teachers, technicians and physics departments are better able to make productive use of practical equipment and resources already in their possession;
7. anecdotal evidence suggests pupils are enjoying their physics lessons more;

Evaluation responses have also helped Project organisers to identify priorities for action or improvement during Year 2 of the project. The main issues identified are:
1. Gathering evidence of pupil progress and the use of Project resources at school level;

2. Expanding the network and increasing coverage to Key Stage 2;
3. Developing hubs and increasing their responsibility for delivery;
4. Offering a more strategically planned, targeted and well-publicised programme;
5. Improving routes for sharing of resources, planning and teaching ideas, such as the website and a conference for all participants

A major limitation of the project was considerable procedural delay in start-up which lead to only Year 1 of the project being completed at time of writing of this report.

2. Project Description

A series of organisations including the Department for Business, Innovation and Skills, the Confederation of British Industry, the Royal Society, Teach First and Engineering UK have all reported in recent years on the low number of physics and engineering graduates and underlined the serious consequences of this trend for the UK's STEM base and, in particular, the number of qualified physicists in teaching.

The Institute of Physics (IOP) reports (2015) that over 500 state secondary schools lack a physics specialist and that 50% of newly qualified physics teachers leave the profession within 4 years. The IOP also reports that less than 20% of current science teachers have a specialist physics background. This suggests that non-specialists teach around 80% of the physics component in science courses. No data is available on whether London schools reflect this national trend, though we do know (Institute of Education) that around 25% of London teachers are under 30 and that teacher turnover in London is around 21% per annum.

Of all teachers who have registered with the Physics Factory, 54% are not physics or engineering specialists.

This dearth of physics specialists in London schools has led to low confidence, knowledge and morale among those teaching physics, and so depressed attainment and take-up beyond Key Stage 3 among pupils.

A recent report into subject progression in the three sciences by the Department for Education found that the brightest GCSE physics students were less likely than their counterparts in biology and chemistry to progress the subject to Key Stage 5; they were less likely to get the highest grades at A level, with C grades or below accounting for more than half of all physics results; and they suffered the highest drop-out rate of all subjects.

Also a bigger proportion of those who took Core and Additional Science at GCSE achieved the highest grades at A level physics than those who had pursued a physics GCSE.

38% of A* pupils at GCSE physics progressed to A level compared to 54% in chemistry and 47% in biology.

Only 67% of physics students continued from their AS level into A level physics – the lowest rate among all subjects. Although the report was produced before the scrapping of AS levels, one could reasonably extrapolate that the removal of AS physics from the curriculum could discourage up to a third of formerly typical students from taking the subject at A level at all.

The average number of first year Key Stage 5 physics students in Physics Factory schools is 20, with a drop out rate of around 50%.

These are the general circumstances of physics education, often summarised as a ‘crisis of physics’, that the Physics Factory seeks to address. The project is focused on, though not restricted to, East London.

While the general GCSE pass rates for the four East London boroughs of Newham, Tower Hamlets, Hackney and Barking and Dagenham are broadly in line with the national average, there is currently no consistent data for performance specifically in physics. Most students in the region do not follow a Physics GCSE course, but general Core and Additional Science GCSEs instead. Grades for these are not routinely segmented into the various sciences. Adoption of GCSE Physics is patchy and often restricted to a small number of the highest-achieving students in a school. In other words, the true state of performance in physics at GCSE is not yet known.

However, the indices for free school meals and poverty, as well as English as an Alternative Language, are significantly higher in the boroughs (see Table: Socio-economic and Performance Data in section 7.2.1) and these add a further complication to the challenges of teaching physics outlined above.

The Physics Factory views the solution to these challenges as rooted in enthusiasm for physics coupled with strong subject knowledge. We believe that the biggest impact on student outcomes will come from a knowledgeable teacher in love with their subject.

Therefore our activity is geared towards giving physics teachers across the breadth of London schools a chance to rejuvenate through a conversation with each other, and reengage with the subject aside of the demands of their own workplace.

The obvious effect of this is to give pupils the chance to believe, and the confidence to achieve, in big physics especially where there are few or no subject specialists. We aim to make physics important once more and reverse its catastrophic decline in London schools.

Our tactics are bespoke, ranging from continuing professional development training (CPD) for teachers, to providing support, advice and resources, academic and industrial networking opportunities, visits, lectures and workshops. Everything is free at the point of delivery. What we deliver depends entirely on the specific needs of an individual school. For this reason, the Physics Factory is unique. Other initiatives exist to help physics teachers, such as Capital Physics and the Stimulating Physics Network, but these are institutional projects with a fixed programme to which participants sign up. The Physics Factory is the only project that develops a tailor-made programme specific to the precise physics needs at individual student, teacher and school level.

In total, 154 teachers in 44 schools from 11 London boroughs have registered as part of the Physics Factory. Of these, 96 teachers from 25 secondary schools across 8 London boroughs have participated in our activities. These reached at least 2880 students. A total of 17 CPD training sessions were held at 11 host schools, at which 78 physics teachers attended, generating 136 attendances. 37 teachers attended multiple sessions, accounting for 70% of post-session evaluations. A further 42 staff from 23 schools joined in with some of the wider Physics Factory teacher-activities including visits to sites of interest (such as the European Space Centre) and field trips. Excluding teacher-only events, the Physics Factory supported or ran an additional 14 events, including revision sessions, lectures and workshops for students. These events reached at least 900 students.

The project began its work when Gareth Sturdy and Dominik Golinski were appointed as joint leads and co-ordinators of the Physics Factory in April 2014. At the time of writing (September 2015) the project is still operational with plans to continue indefinitely.

During this time, the Physics Factory has been jointly overseen by the headteachers of the East London Science School (ELSS) in Newham and Sydney Russell School in Barking and Dagenham. The work has been managed and delivered by Gareth Sturdy at ELSS and Dominik Golinski at Sydney Russell, with some services delivered by Philip Jones of training contractor Hooked on Physics.

The project aims to continue into the future, and will embark on a second phase of analysing its impact on students. This will be done by aligning post-activity evaluation activities more closely with the explicit aims of the project; by conducting school-level book scrutinies and comparison of topic-specific test results with pre-involvement data other relevant evidence will be used to identify improvements in accuracy, comprehension and depth of coverage. Teachers will also be asked to report on examples of good progress using Physics Factory resources and ideas. Pupil attitudes will be assessed along the same kind of matrix as the teacher self-efficacy evaluations and this will include data from newly registered schools, to capture attitudes prior to any Physics Factory involvement. Any improvements in take-up of physics at Key Stage 5 will also be assessed.

2.1 Does your project support transition to the new national curriculum? **Yes**

We have held network discussions about the new syllabus requirements and we have delivered training sessions specifically on the changes. Most importantly, however, the new syllabi specifically require schools to carry out controlled assessments based on 'practical' activities. Students will need, in general, to carry out more practical assignments to familiarise themselves with techniques and methodologies prior to formal assessments. Traditionally, many non-specialist science teachers have been reluctant to oversee practical work in classes. Weak subject knowledge, low confidence and apprehension about poor pupil behaviour have all contributed to this position. Poorly planned, boring practicals and an over-emphasis on teacher demonstration, rather than pupil participation has often led to a vicious circle effect. Pupils behave badly because they are not occupied or enthused. Teachers, in turn, become less willing to attempt practical experiments.

A central theme of the project is to address this deficit model. Disseminating new, interesting, relevant and engaging practical activities lies at its heart. In interview (see later) teachers frequently asserted that, as a result of the project's input, they were now more confident that they (and their non-specialist colleagues) would be able to deliver these new requirements effectively.

Of the recent changes to the curriculum, the most important have taken place in Key Stage 2, where primary schools are taking on a very substantial part of the work that had hitherto been undertaken at Key Stage 3. Therefore there is now a much greater need for physics support at primary level than has ever been present before, and this will result very quickly in secondary schools having to re-invent their Key Stage 3 curricula. The project has so far only focused on secondary education, but a focus on Key Stage 2 will be a major dynamic for future development.

2.2 Please list any materials produced and/or web links and state where the materials can be found. Projects should promote and share resources and include them on the [LondonEd website.]()

Everything the Physics Factory delivers is free at the point of delivery. Of most value are the training materials developed in partnership with Hooked on Physics, and the complementary specialist lab equipment which enables the CPD ideas to work in a class setting.

These are high quality, high value resources and in order to obtain them schools need to sign-up to the Physics Factory and agree to take part in its activities. It would undermine our work to distribute these on a general basis.

However, the resources we delivered were as follows:

Physics Topic	
Forces and Motion	• Teaching strategies and ideas powerpoint • Activity worksheets • Deep sea diver kit • Ferrofluid • Neodymium magnets
Light and Sound	• Teaching strategies and ideas powerpoint • Activity worksheets • Kits for building an electromagnetic loudspeaker
Electric Circuits	• Teaching strategies and ideas powerpoint • Activity worksheets • Junction blocks
Energy	• Teaching strategies and ideas powerpoint • Activity worksheets • Wind turbine kits (SEP)
Generating and Transmitting Electricity	• Teaching strategies and ideas powerpoint • Activity worksheets • Kits for building an electromagnetic loudspeaker
Simple Electric Circuits	• Teaching strategies and ideas powerpoint • Activity worksheets • Earth/live/neutral wiring demo kit

Momentum and Car Safety	• Teaching strategies and ideas powerpoint • Activity worksheets • Specialist long slinky springs
Radioactivity	• Teaching strategies and ideas powerpoint • Activity worksheets • Half-life analogue modelling packs
Electromagnetic Spectrum	• Teaching strategies and ideas powerpoint • Activity worksheets • Gravity well pack
Lenses and the Application of Light	• Teaching strategies and ideas powerpoint • Activity worksheets • Class set of diffraction glasses

3. Theory of Change and Evaluation Methodology

A copy of the validated Theory of Change and Evaluation Framework is provided at **Appendix 1.**

3.1 Table 1- Outcomes

Description	Original Target Outcomes	Revised Target Outcomes	Reason for change
Teacher Outcome 1	Increased enthusiasm and motivation to teach Physics	No change	No change
Teacher Outcome 2	Increased Physics subject knowledge	No change	No change
Teacher Outcome 3	Awareness of new approaches/improved pedagogy in Physics	No change	No change
Teacher Outcome 4	Increased confidence in teaching Physics	No change	No change
Pupil outcome 1	Pupils have access to a wider range of stimulating Physics activities and opportunities	No change	No change
Pupil outcome 2	Increased pupil subject knowledge in Physics	No change	No change
Pupil outcome 3	Increased pupil interest and engagement in Physics	No change	No change
Wider system outcome 1	Teachers develop new relationships and widen their network of external contacts	No change	No change
Wider system outcome 2	Teachers have access to more effective resources	No change	No change
Wider system outcome 3	Schools and teachers are properly equipped and understand how to implement the curriculum	No change	No change

3.2 Did you make any changes to your project's activities after your Theory of Change was validated? **Yes**

Although we were able to establish good links with some leading companies, such as Rolls Royce, Intel and Crossrail, we found it very difficult to organise industry events. Therefore midway through the project we modified our approach to include industry/business involvement through careers work involving third party careers advice specialists.

Safeguarding considerations also made it very difficult to organise Physics Factory student trips. This is an area we are continuing to work, but our first trip is scheduled beyond the evaluation period of this report.

We found it was easier and more secure to deliver our resources personally on an individual basis, rather than through the Physics Factory website. To do the latter would involve a significant upgrade and redesign of the website which we did not consider to be cost effective.

3.3 Did you change your curriculum subject/s focus or key stage? **No**

3.4 Did you evaluate your project in the way you had originally planned to, as reflected in your validated evaluation plan?

Yes, but on reflection:

1. The initial course evaluations were too simplistic (see 4.1 below). Subsequent pre- and post-CPD evaluations were altered to cover more issues and enable numerical analysis. (Targets 1, 2, 3, 4, 5, 6, 9, 10)
2. Because of the fragmentary nature of schools' engagement with the project, book scrutinies, pupil interviews and other pupil level evaluations have been postponed until Year 2. (Targets 7 and 8)
3. To augment numerical evaluation and paper survey data, and to support judgements on wider system outcomes, a programme of practitioner interviews was set up. Interviewee selection focused on schools where staff had attended multiple Physics Factory events.

4. Evaluation Methodological Limitations

4.1 What are the main methodological limitations, if any, of your evaluation?

The project seeks to improve (i) the enthusiasm of physics teachers, (ii) their knowledge of available teaching techniques and, ultimately, (iii) their practice and its impact on pupils. Before item (iii) can be addressed, relationships need to be built with teachers and training delivered. Accordingly, for the first year of the project, data is available mainly for areas (i) and (ii) only. More pupil impact data will be gathered in Year 2. All school-level data derives from survey and interview responses. Although response rates from project participants are high - every participant at every training event completed a proforma - it must be recognised that:

- All responses are self-reported using a numerical scale (e.g. "how motivated are you to teach this topic?"). No independent verification or validation of responses is possible.
- Each individual interprets a numeric scale differently (i.e. one person's '4' may equate to another's '5').
- Different participants attended different sessions and in different numbers. Someone reporting a knowledge gain of 2 in the session on 'radioactivity' cannot be compared with someone else reporting a gain of 4 in the session on 'forces'. Average responses from a session with 12 participants differ in significance from the average in a session with only 4 participants.

- Broad conclusions must therefore relate to data trends and be based on average responses, rather than absolute values. For example the statement that "globally, 98% of all participants reported that their topic knowledge improved as a result of the training activities" is a valid, overall conclusion. We cannot draw significant conclusions, however, from comparisons between the various sessions.

Some minor limitations relate to the survey proformas used:
- The first 3 CPD sessions were evaluated by a single question - merely requiring participants to rate the overall quality of the session.
- Subsequent CPD evaluation proformas asked 7 questions, each awarded a numeric value
- Pre-session self-efficacy questionnaires also asked 7 questions but these were not matched, on a 1:1 basis with the post-session questions.
- For example: pre-course question 1 asked "how motivated are you about teaching this session?" Post-course evaluation question 7 asked "have your perceptions of physics and physics teaching improved?"

In consequence of the above, the first 3 CPD sessions, though positively evaluated, have been excluded from all subsequent analyses. In addition, some post-CPD responses have been used as proxy success indicators in relation to pre-course self-efficacy judgements (see above example).

Around 30% of attendances at project sessions were by people who attended only one event. Interview evidence has been restricted, therefore, to individuals who attended multiple events.

As no pupil level evidence has yet been collected, no pupil gender or ethnicity data is available at this stage (re section 7.2). Evidence of improved teacher practice and pupil performance (such as might be available from book scrutinies) is best gathered at the end of an academic year enabling a long term perspective of any improvements in the standard of work. For example, changes in presentation, depth, detail or accuracy in the target topics can be compared with the quality of work produced in the early part of the school year. This exercise will need to be carried out from September 2015. Current evidence of improved performance is available only from teacher interviews.

4.2 Are you planning to continue with the project, once this round of funding finishes? **Yes**

If **yes**, will you (and how will you) evaluate impact going forward?

- Pre-session self-efficacy questions will be more closely aligned with post-session course evaluations to enable 1 : 1 correlation
- School-level book scrutinies and comparison of topic-specific test results with pre-involvement data other relevant evidence will be used to identify improvements in accuracy, comprehension and depth of coverage
- Teachers will be asked to report on and exemplify good progress. Interview, and other evidence will be collated and evaluated.
- Pupil attitudes will be assessed along the same kind of matrix as the teacher self-efficacy evaluations. This will include data from newly registered schools, to capture attitudes prior to any Physics Factory involvement.
- Improvements in take-up of physics at Key Stage 5 will assessed

- Information from initial interviews with schools will be formalised into a matrix to allow the compilation and comparison of data.

5. Project Costs and Funding

Table 2 - Project Income

	Original[1] Budget	Additional Funding	Revised Budget [Original + any Additional Funding]	Actual Spend	Variance [Revised budget – Actual]
Total LSEF Funding	443 000	0	320 250		
Other Public Funding	0	0			
Other Private Funding	0	0			
In-kind support (e.g. by schools)	0	0			
Total Project Funding	443 000		320 250	177 428.42	142 821.58

Table 3 - Project Expenditure

	Original Budget	Additional Funding	Revised Budget [Original + any Additional Funding]	Actual Spend	Variance Revised budget – Actual]
Direct Staff Costs (salaries/on costs)	142000.00	0	142000.00	121236.01	20763.99
Direct delivery costs CPD consultant, materials, resources	47250.00	0	47250.00	11868.66	35381.34
Management and Administration Costs (financial administration + Jim Whittell consultancy)	35000.00	0	35000.00	26000.00	9000.00
Training Costs	0	0	0	8280.00	-8280.00
Participant Costs (e.g. Expenses for travelling to venues, etc.)	0	0	0	978.39	-978.39
Publicity and Marketing Costs	5000.00	0	5000.00	2765.36	2234.64
Teacher Supply / Cover Costs	66000.00	0	66000.00	0	66000.00
Other Participant Costs	0	0	0	0	0
Evaluation Costs	25000.00	0	25000.00	6300.00	18700.00
Total Costs	**320250.00**	**0**	**320250.00**	**177428.42**	**142821.58**

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5.2 Commentary on Project Expenditure

After essentially a little over a year's work (in what was conceived as a two-year project) we spent 56% of the allocated budget. Spending was significantly under budget in each category. Two new budget categories were created in the course of the year: Training, and Participant Costs, but total spending here amounted to just over 3% of total budget.

The innovative nature of the Physics Factory meant that the original budget was drawn up largely *in vacuo*, and consequently was revised many times during execution of the project as the actual spend profile took shape.

A prime example was costing for teacher cover. We originally envisaged that teachers would not be able to participate if we weren't able to fund release from their normal timetable. As the project developed, it became clear that teachers were extremely reluctant to leave school during the day even when funded to do so, but conversely were happy to stay until late into the evening despite not being funded at all.

Another substantial saving was in funding a full-time specialist to deliver CPD and bespoke support for schools. In the end, such a role proved too difficult to recruit in the time available, and so a strategic investment, which wasn't included in the original budget, was made in training the project managers to deliver CPD instead. We also used some of the allocation to fund a project administrator post, which also didn't appear in the original budget. It rapidly became clear that a key weak point in achieving good levels of participation was the overly long communication lead times encountered when dealing with schools. Having someone available to continually chase contacts and sign-up attendees made a big difference to the success of the project.

Through a combination of this investment, plus establishing good working relationships with the CPD and workshop contractors, achieving good take-up on getting schools to host events, and developing partnerships with other third party suppliers, we were able to make substantial savings on the cost of delivering our sessions to teachers and their students. We often found organisations and individuals were inspired by the Physics Factory vision enough to lower their prices or in some cases provide resources for free.

The other new budget line created was for Participant Costs, which covered some expenses for participants travelling to special events who otherwise would not have been able to attend. Total spending here amounted to 0.3% of total budget.

We were also able to make substantial savings in evaluation costs by carrying out a lot of data gathering and other tasks in-house, removing some of the budgeted requirement for the external evaluator's time.

6. Project Outputs

Table 4 – Outputs

Description	Original Target Outputs	Revised Target Outputs *[Original + any Additional Funding/GLA agreed reduction]*	Actual Outputs	Variance [Revised Target - Actual]
No. of schools	50 schools recruited	50	44 schools recruited	12%
No. of teachers	At least 50 teachers	50	154 teachers	308% (104)
No. of pupils	2000+. 10% of pupils to complete questionnaire	2000+	Deferred to Year 2, but on assumption that each teacher affects at least a typical class of 30 students: 4620	213% (2260)
Additional output 1:	More than half of CPD participants attend more than 1 event	50%+	46% attended more than one event	4% (3 teachers)
Additional output: 2	75% of participating teachers report increased motivation to teach physics	75%	Teachers report, post-CPD, average score of 7.3 on "improved perceptions of physics teaching". Pre-CPD average was 5.9. Interview data confirms increased willingness to use practical activities in lessons and make better use of practical equipment.	n/a: proxy indicators used

7. Key Beneficiary Data

7.1 Teacher Sub-Groups (teachers directly benefitting counted once during the project)

All participants submitted initial questionnaires as a precondition for participation. In Year 1 the project provided 14 training sessions between January and March 2015, attended by 78 physics teachers from 16 schools. In total there were 136 attendances. 37 teachers attended multiple sessions and account for 70% of post-session evaluations. Evaluations were collected immediately after each session. There is a 100% response rate with only a small number of individual questions not answered on some documents. A sample group of teachers was interviewed at the end of the year. Interviewees were chosen from teachers who had attended multiple sessions.

Definition of benefitting teachers:

1. All teachers who attended CPD sessions (re: session evaluations and perceptions of the subject)
2. Teachers who attended more than one event (re: interview programme)
3. All teachers who completed the End of Year Survey (re targets 1, 2, 3, 4, 5, 6, 9, 10)

Table 5 – Teachers benefitting from the programme

Key: ***CPD attendance*** ***Other Activities attendance***	**No. teachers (see note below)***	**% NQTs *(in their 1st year of teaching when they became involved)***	**% Teaching 2 – 3 yrs *(in their 2nd and 3rd years of teaching when they became involved)***	**% Teaching 4 yrs + *(teaching over 4 years when they became involved)***	**% Primary (KS1 & 2)**	**% Secondary (KS3 - 5)**
Project Total CPD attendance	**82**	**17%**	**33%**	**50%**	**0**	**100**
School 1	3				0	100
School 2	7				0	100
School 3	4				0	100
School 4	4				0	100
School 5	7				0	100
School 6	4				0	100
School 7	8				0	100
School 8	8				0	100
School 9	1				0	100
School 10	11				0	100
School 11	14				0	100
School 12	1				0	100
School 13	2				0	100
School 14	1				0	100
School 15	3				0	100
School 16	4				0	100
Project Total: Other activities	**17**				**0**	**100**
School 17	2				0	100
School 18	2				0	100
School 19	1				0	100
School 20	1				0	100
School 21	2				0	100
School 22	1				0	100
School 23	2				0	100
School 24	6				0	100

*Note: the total number of teachers given in Table 4 refers to all those teachers who have been recruited to the Project, agreed to take part in activities and with whom we have had a dialogue over how the Physics Factory can address their needs. The numbers given in Table 5 reflects the actual attendance figures for our activities/CPD sessions at time of writing report.

7.1.2 Commentary on teacher sub-groups

Our data indicates that 50% regular Project participants have been teaching for less than 4 years. We did not ask for the ages of participants but, on the (default) assumption that most entered the profession at age 22 or 23, then at least 50% are under the age of 30. Of the remaining 50%, only 11 individuals had been teaching for more than 5 years. It is reasonable to suggest, therefore, that Project participants represent a younger demographic than the London average.

In most cases schools, rather than individual teachers, joined the project. Some schools requested bespoke training activities for their own staff, on their own premises. In these cases, data was not collected about the age and experience of each participant. Other Project activities were hosted by participating schools but with wider attendance from staff from other schools. Around 45% of these participants attended multiple courses. Our age and experience data, therefore, is partial and mainly reflects individuals who have been regular participants. For this reason only the top row of Table 5 is populated with data.

7.2 Pupil Sub-Groups (these should be pupils who directly benefit from teachers trained)

Tables 6-8 – Pupil Sub-Groups benefitting from the programme

	No. pupils	% LAC	% FSM	% FSM last 6 yrs	% EAL	% SEN
Project Total	No pupil-level data is available from Year 1 of Project (see notes above)					
School 1						
School 2						
School 3						
School 4						

	No. Male pupils	No. Female pupils	% Lower attaining	% Middle attaining	% Higher attaining
Project Total	No pupil-level data is available from Year 1 of Project (see notes above)				
School 1					
School 2					
School 3					
School 4					

	% Asian Indian	% Asian Pakistani	% Asian Bangladeshi	% Asian Any Other background	% Black Caribbean	% Black African	% Black Any Other Background	% Mixed White & Black Caribbean	% Mixed White & Black African	% Mixed White & Asian	% Mixed Any Other Background	% Chinese	% Any other ethnic group
Project Total													

School 1	No pupil-level data is available from Year 1 of Project (see notes above)
School 2	
School 3	
School 4	

	% White British	% White Irish	% White Traveller of Irish heritage	% White Gypsy/Roma	% White Any Other Background
Project Total	No pupil-level data available from Year 1 of Project (see notes above)				
School 1					
School 2					
School 3					
School 4					

Commentary on pupil data

At this stage, no specific pupil groups have been targeted (see Table 4: Outputs). The nature of schools involved with the project varies considerably from borough to borough. Data for academies and free schools is not readily available and is not benchmarked against the performance of maintained schools. Socio-economic conditions vary widely and are changing over time. By way of illustration the chart below identifies some basic data about the 4 Local Authorities that have been most closely involved with the project:

Socio-economic and Performance Data: 4 London Boroughs 2014

LA	2014 GCSE: % 5A*-C	% FSM (secondary)	% E2L	% living in Poverty	% Educated Privately	% White British 2007	% White British 2015	% adults with no higher level qualifications
Barking & Dag	65.7	22.5	37	34.9	0	60.2	39.5	15.4
Hackney	71.8	36.5	43.8	44	21	31.4	34.1	9.3
Newham	66.1	41	68	33	2	18.4	17.7	10.9
Tower Hamlets	68.8	57	74	60.5	6	18.4	14.9	12.1
London Average	70.8							
National Average	65.6	14.6	14.4				71.6	9.0

All 4 boroughs exceed the national average for free school meals and have high deprivation indices. In all 4 boroughs the proportion of adults with no higher-level qualifications exceeds the national average. This should paint a picture of lower than expected academic performance.

Despite this, however, all 4 boroughs exceed the national average for 5A*-C GCSE including English and maths and all are close to the London average for GCSE. This data, however, conceals some polarisation and change is ongoing. Hackney, whose GCSE performance is above the London average, also has a high proportion of privately educated pupils. To a lesser extent this also applies in Tower Hamlets. This potentially inflates overall GCSE performance in these areas. The predominance of English as a second language is high across all 4 boroughs. In 3 boroughs the proportion of white British pupils has fallen over an 8 year period, most significantly in Barking and Dagenham. In Hackney, however, the proportion of white British is rising.

Within this difficult analytical context science qualifications have also been changing and will change further in the coming year. Core and Additional Science have replaced 'Double Science'. The relative position, within these qualifications, of physics, chemistry and biology is highly variable from year to year. Students taking GCSEs in the separate sciences are generally drawn from higher attaining groups only. Each school that participates in the project will have made different curricular choices in relation to its science teaching. In view of these difficulties the project organisers believe that it is better, in Year 2, to evaluate pupil progress on a school-by-school basis rather than set generalised targets.

8. Project Impact

8.1 Teacher Outcomes

Date of first CPD session (Year 1): 13.1.15
Date of final CPD session (Year 1): 25.3.15

Summary data, analysing the impact of each individual CPD session can be found at Appendices 4 and 5 (below). A 9 point scale was used to standardise estimates of pre-session efficacy and the impact of the training received - as follows:
1 = very low / no change
3 = low / very little change
5 = moderate / some change
7 = high / noticeable change
9 = very high / significant change

Table 9 – Teacher Outcomes: teachers benefitting from the project

Target Outcome	Research method/ data collection	Sample characteristics	Metric used	1st Return and date of collection	2nd Return and date of collection
Increased interest and motivation to teach physics	*Initial questionnaire, pre- and post-session evaluations, individual interviews, End of Year Survey*	*134 evaluation responses from 14 separate training events.* *6 participant interviews*	*Pre and post-session evaluations use 9 point scale:* *1 = no change* *3 = very little change* *5 = some change* *7 = noticeable change* *9 = significant change* *In most cases, figures quoted represent the average of all responses (see notes under 4.1)*	*Initial questionnaires collected January 2015* *Pre/Post session evaluations continuously collected* *Average pre-session judgement:* ***5.96***	*End of year interviews conducted August 2015* *End of Year Survey collated September 2015* *75% of course participants report increased motivation, post-CPD.* *Average grade: "improved perception of physics teaching" was 7.3*

Increased physics subject knowledge	*As above*	*As above*	*As above* ***7 = noticeable change***	*Average pre-session judgement:* ***5.91***	*Post-session average* ***7.6***
Awareness of new approaches and improved pedagogy in physics	*As above*	*Initial contact questionnaires analysed*	*As above* ***7 = noticeable change***	*Average pre-session judgement:* ***5.3***	*Average grade for increased awareness:* ***7.7***
Increased confidence in teaching physics	*As above*	*As above*	*As above* ***9 = significant change*** ***7 = noticeable change***	*Average pre-session judgement:* ***5.3***	*Average grade for overall helpfulness of CPD session:* ***8.27*** *Better perceptions of physics teaching?:* ***7.3***
Teachers have new relationships and a wider network of external contacts	*As above*	*Interview evidence + end of year survey*			
Pupils have access to a wider range of stimulating physics activities and opportunities	*As above*	*initial contact questionnaires analysed*	*As above* ***9 = significant change*** ***7 = noticeable change***	*Average pre-session judgement:* ***5.1***	*Average grade for likelihood of using new resources in future:* ***8.2.*** *Grade for likely improved pupil learning:* ***7.7***
Increased pupil subject knowledge in physics	*Not yet evaluated*				

Increased pupil interest and engagement in physics	*Initial questionnaire, pre- and post-session evaluations, individual interviews, End of Year Survey*	*As above*	***7 = noticeable change*** ***7 = noticeable change***	*Average pre-session judgement:* ***4.4***	*Average grade for likelihood of improved pupil learning opportunities:* ***7.6*** *Average grade for likely improved pupil learning:* ***7.7***
Schools & teachers are properly equipped and understand how to implement the curriculum	*As above*	*Interview responses + end of year survey*	*No numerical metric available – see text below*		
Teachers have access to more effective resources	*As above*	*Interview evidence + end of year survey*	*No numerical metric available – see text below*		

Further information

The project, to date, has been very effective in its objective of improving the motivation of physics teachers. The average of pre-course self-efficacy assessments of "how motivated are you to teach this topic?" was 5.9. This value exactly matched participants' pre-course assessment of their subject knowledge on each topic. However, 75% of participants, post-CPD report increased motivation. The average post-CPD grade for the question "do you have an improved perception of physics teaching?" was 7.3. The average grade for the helpfulness of the CPD sessions was 8.27. The average grade awarded for improved knowledge after the CPD sessions was 7.26. Overall, therefore, the impact of CPD sessions on the teachers themselves was very positive.

The above comments were confirmed and amplified via the sample interview process. One interviewee with between 2 and 4 years experience said, "It's made me braver and more willing to try things - also other members of the dept. Most colleagues' understanding of physics is low. They see it as boring, as maths. PF work shows it can be more fun. It's opened us up to advice." Meanwhile a teacher with little experience and whose concern was "about where students are in their understanding and my own lack experience of how to deal with it," reported that as a result of the Physics Factory they were, "more confident of teaching physics and therefore more motivated." Improvements in motivation were also reported by some experienced and leadership-level staff, whose comments included "staff were already motivated but are now more confident" and "levels of staff interest in physics have increased… the staff have requested more Physics Factory input next year."

A specific area of weakness identified (not only by non-specialists) was their inability to set physics issues into relevant contexts ("it's seen as only about maths"). This led to a lack of confidence in identifying practical tasks and experiments that would capture pupils' attention and enthusiasm. **All interviewees were clear that the project delivered significant improvements in these areas**.

Example comments from senior staff were: "PF has made these areas more concrete and easier to grasp" and "PF input is good as it helps provide real life contexts for learning and relevance of topics" and "We have begun to see how we might teach snippets of the curriculum. We have enjoyed the process." The same was reflected by teachers with little experience: "Some PF modules are explored in ways designed to make sense to non-specialists. I've been able to learn from this myself in terms of how to break topics down. I've also learned how to use relevant examples from other disciplines."

In taking the work forward into Year 2, **interviewees identified two linked areas that they hoped the project would address in more depth in future:**

- A stronger focus on how some traditionally difficult aspects (notably algebraic problem-solving) should be taught (for example, one respondent said, "we would like to see [Physics Factory] go deeper, however, especially on problem solving skills". Another said, "In future it would be good to have more on the upper levels of attainments.")
- The fleshing out of complete units so that the project's helpful approaches to practical work could be linked systematically to other aspects necessary to teach the complete topic thoroughly. A head of department said in interview, "Pedagogy is not only about how you teach a topic but also when. Would like to see PF specify a full suite of lessons across a topic because then it would be easier to evaluate impact via assessment data."

In addition, the End of Year Survey identified the following conclusions, information and/or suggestions for the future:

- An average grade of 7.6 for 'increased motivation to teach physics'
- An average grade of 7.3 for 'confidence to teach physics'
- 45% of respondents expressed willingness to deliver aspects of the project programme in Year 2 (either by hosting events or offering specific expertise)
- Respondents identified the CPD sessions and extension sessions, field trips and visits as the most useful elements of the programme in Year 1
- "More of the same" was the most common response to suggestions for how the project could improve in the future. However the most common additional suggestions were
  - i. a menu of workshops to choose from ("non-specialists don't always know what to suggest", "bespoke courses are excellent, but sometimes you just need to know what else is available" etc.) Some specific workshops (e.g. on Dark Matter) were also requested.
  - ii more emphasis on higher level extension work and sixth form provision (visits to HE institutions, guest / research speakers, gifted and talented extensions etc.)
  - iii opportunities for 1:1 work (e.g. with individual teachers, non-specialists or technicians)
  - iv online resource sharing e.g. via the project website

The ultimate focus for the project, however, is improved classroom experiences and outcomes for pupils. **It has not yet been possible to explore how new teaching materials**

and processes have been used in classrooms, or their impact on attainment. Teachers' intentions, post-CPD, are clear however. The average grade for teachers' likelihood of using the new resources in their classrooms is very high - at 8.2. Grades for the likely impact on pupils' learning and improved learning opportunities in future are also high - at 7.7 and 7.6 respectively. Teachers' **pre**-course assessment of pupils' overall enthusiasm for physics topics was just 4.9. Teachers rated their own overall **pre**-course enthusiasm for the target topics at 5.9. This presents a pre-course picture of moderately motivated teachers failing to enthuse a largely neutral (indifferent?) student body**. In this context the post-CPD predictions (see above) of improved teacher motivation and pupil opportunities are very encouraging**.

Although hard data on pupil enthusiasm, progress and achievement is not yet available a good deal of anecdotal evidence emerged from the interviews. For example, this included pupils (untypically) commenting how much they had enjoyed the lesson. Increased take-up has also been reported for lunchtime science clubs, alongside increasing popularity of physics within the GCSE option schemes. **More evidence will need to be gathered next year to evaluate whether this increased level of pupil interest and enthusiasm leads to improved outcomes in examinations.**

The project also aims to create new networks for teacher support and expose them to a wider range of high quality learning resources. 16 different schools, within a local geographical area have taken an active part in the project. 78 teachers have attended CPD sessions. The proportion of teachers attending only one session (54%) is slightly below the target of 50%. However, most of the people attending only one session did so at an event hosted at their own school. In most of these cases the whole department attended. On the other hand, the remaining 46% of participants comprise 70% of total attendances. This core group has made multiple attendances, therefore, and has been willing to travel in order to do so.

In comparing the Physics Factory to other support networks, one head of department said their team referred to Physics Factory as "the cool one" and the other as "the boring one". Other comments included:

- "Definitely use PF as a sounding board and source of support."
- "We already had some network links. PF is better in many ways - more flexible, more bespoke - e.g. we had separate aims for technicians, teachers and pupils. PF met them all. Our Academy link person from Newham is now starting to get involved with PF himself. This will help us more."
- "I'm in contact with Teach First people in London East but the only other physicist has left the programme. I created this group myself. PF is the only subject specific support network I know."

The basis of a sound local network has, we feel, been established. Pre-course efficacy data rated current school resources at 6.8. Post-CPD evaluations graded awareness of new resources at 7.7.

In interviews, respondents were very clear about the lack of effective support networks elsewhere. LA networks are perceived as being largely focused on administrative matters such as new legislation. The Stimulating Physics Network (SPN) is considered less flexible than the Physics Factory - limited by its contractual status with individual schools. Subject Knowledge Enhancement (SKE) is time-limited in relation to each participant. **There is a strong sense that participants value a flexible network, focusing on solutions rather than problems and, in particular, with a core focus on physics (rather than general science).** In addition, **several interviewees mentioned the positive impact of including technicians in Physics Factory activities.** Technicians, as a group, are not traditionally a focus of attention in networks sponsored by either LAs or academic bodies such as the Institute of Physics.

An additional dimension, revealed in interviews, is the value that practitioners place on the teaching resources provided by the Physics Factory. Repeatedly interviewees commented on the usefulness of the 'free' resources they had been given. An unexpected advantage, however, appears to be that **teachers are now more confident with and better able to use their existing resources**:

- "Our department is already well resourced and we have our own physics technician. The individual resources we have had from PF have definitely enhanced our provision, however."

- "We were already well resourced but too much equipment lay unused in cupboards because we (or the technicians) didn't know what to use it for or how best to use it. The PF training sessions with our technicians were really helpful in this regard and more resources are now used well. Also, of course, the PF has given out a lot of new resources, linked to their training sessions."

- "I've always wanted to do more practicals but lack of resources slowed me down. New resources were often bought without knowing when and where they would be used. The PF has given us some new resources (e.g. half life dice) but also made us clearer about targeting any new resources we buy."

- "Definitely - both in terms of suggestions that have enabled us to use our own resources better but also in terms of the resources they have given out."

- "We will replicate the PF's Physics Tour of London with both the 6th form and Y7 next term."

The full range of participant responses during interview to each of the project's intended outcomes is listed in Appendix 9.

Table 10 – Comparison data outcomes for Teachers *[if available]*

Target Outcome	Research method/ data collection	Sample characteristics	Metric used	1st Return and date of collection	2nd Return and date of collection
Data has been collected from project participants only. There is no comparable information in relation to teachers who did not take part in the project (and no cost-effective way of getting any).					

Further Information

No individual pupil performance data was collected in Year 1. Logistical difficulties make such an exercise impractical. For example:

- Different numbers of participants attended from each school
- Different staff attended different courses - some attending a single course, others attending several
- Physics Factory training courses were held at different times of the academic year
- Changes resulting from Physics Factory inputs will, in some cases, have been introduced by an individual teacher, in others by an entire department
- Schools plan (in their schemes of work) to teach different physics units at different times of the year
- Any changes to or improvements in teaching resulting from the project's input, therefore, would have begun at different points of the school year for different staff

It is impossible, under these circumstances, to attribute (in Year 1) a cause and effect relationship between any improvements in physics attainment and the specific input of the Physics Factory to specific members of staff or department. It is similarly difficult, within this context, to identify the impact on any particular pupil sub-group.

As a starting point we will look at the validated 2015 GCSE results of participating schools, benchmarked against their 2014 performance. In most cases, however, the physics elements of combined science GCSEs will need to be disaggregated and checked by each participating department before submission to the Physics factory. This will not have been completed by the deadline for this report.

8.2 Pupil Outcomes

Table 11 – Pupil Outcomes for pupils benefitting from the project

Target Outcome	Research method/ data collection	Sample characteristics	Metric used	1st Return and date of collection	2nd Return and date of collection
No pupil outcomes data has yet been collected. See notes above - 8.1.1					

Table 12 - Pupil Outcomes for pupil comparison groups *[if available]*

Target Outcome	Research method/ data collection	Sample characteristics	*Metric used*	1st Return and date of collection	2nd Return and date of collection
No pupil comparison groups have been identified. It is unlikely that this aspect will become a feature of the project. See notes above - 8.1.1					

8.2.1 Further Information

No quantitative data will be available for the intervention group. Qualitative data about pupil performance will emerge from book scrutinies, pupil interviews and learning walks planned for Year 2.

8.3 Wider System Outcomes

Table 13 – Wider System Outcomes

Target Outcome	Research method/ data collection	Sample characteristics	*Metric*	1st Return and date of collection	2nd Return and date of collection
Teachers develop new relationships and widen their network of external contacts	*Paper survey, interviews*	*30% EoY survey, interview sample: 6*	*Survey uses 9 point scale: 1 = no change 3 = very little change 5 = some change 7 = noticeable change 9 = significant change*		*45% of EoY respondents willing to deliver Project activities in Y2. Interviewees all value network existence & criticise lack of support elsewhere EoY Survey September 2015, Interviews August 2015*
Teachers have access to more effective resources	*CPD evaluations, paper survey, interviews*	*CPD surveys completed by all attendees; 30% EoY survey, interview sample: 6*	*As above.*		*CPD responses: grade for "likely to use CPD resources in future: 8.2, EoY survey grade for 'have you gained resources?: 6.5. Interviewees state that not only do they have new resources they now know how better to use old resources CPD evaluations ongoing. EoY Survey September 2015, Interviews August 2015*
Schools and teachers are properly equipped and understand how to implement the curriculum	*Paper survey, interviews*	*30% EoY survey, interview sample: 6*	*As above.*		*Grade for 'readiness to teach the new GCSE: 5.6 Interviewees state that much 'new syllabus' help is available else-where but that help with new requirements for practical assessments is not. This is a major area of Project success. End of Year Survey September 2015, Interviews August 2015*

8.3.1 Further Information

- Please see Appendices 5, 6, 7 and 8 for analysis of CPD survey responses
- Please see Appendix 10 for summary of interview responses
- 78 teachers attended CPD sessions, 46% attended more than one session. 25% of participants returned End of Year surveys.
- Interviewees were chosen to represent schools that had sent multiple attendees to Project activities. The End of Year survey was completed by teachers who had only attended a single session and some who attended several.

There is no doubt that the project has made a good start in its objective to create a wider, physics-based network. In interview, recently qualified teachers stated that there was no subject network other than the Physics Factory. More experienced teachers stated that, while there were other sources for Subject Knowledge Enhancement, these were time-limited and none provided ongoing network opportunities. All interviewees criticised the available LA networks as being (e.g.) boring, only interested in administrative issues and "opportunities for moaning". There is good support from participants for Project CPD and other activities. There have not yet been many opportunities for school-to-school networking, however.

It is encouraging that 45% of respondents to the End of Year survey offered to take responsibility for organising Physics Factory activities in Year 2. There is still some resistance (see interview notes) for direct school-to-school sharing on the part of schools that see themselves as directly competing with neighbouring schools for pupils and position in local league tables. Developing greater levels of peer to peer support, possibly via the project website, will be a priority in Year 2.

8.4 Impact Timelines

Physics is taught in all of the Physics Factory schools on a topic-by-topic basis and although there are some localised trends among members in terms of when certain topics are taught, there is no general pattern. Therefore, CPD sessions were organised to a topic-based programme, but the schedule wasn't tied to any preferred sequence.

Typically, a CPD session would be at twilight and run for around two hours, and cover the full breadth of the National Curriculum and exam board specifications for that topic. Therefore we anticipated three key impact points for each of the relevant project objectives: as the session took place/immediately afterwards; at the point in the year when the teacher would plan those particular lessons; then at the point of actual lesson delivery.

The results at each session were as expected: teachers readily reported ways in which the session would improve their teaching. There was a range of responses. Monitoring impact at the subsequent stages was more problematic, as each case happened at a different time, required the teacher to self-report and, separately and later, gather impact data when the topic was taught. However, end of project interviews with teachers (see Appendices) suggest that impact was similarly as expected.

Pupil impact was not expected to occur until the teacher taught the topic, which could easily be many months after training. However, clear evidence of impact would not emerge for another several weeks in turn, when the topic would be summatively assessed in class tests, for example. Therefore, the lead time for pupil impact data to emerge was anticipated to be of the order of months and this is what happened.

Wider school impact was anticipated to be of the order of at least an academic year, as it required summative data from enough individual classes to perform a department-wide comparison, and then cross-comparison with previous years (pre-project intervention). Sufficient time has not yet elapsed for such work to be carried out.

The Physics Factory is based on a continuing impact model. Rather than geared to achieving discrete class-by-class assessment results improvement, the project aims to achieve impact by building up teacher and department competencies. It is anticipated that the impact of this kind of approach will emerge in a range of ways, varying between student, teacher, class and year group. A single input to an individual teacher might yield improved test results in one student but better general practical ability in another, while perhaps increased engagement for the whole class, but broader take-up of higher-level physics for the year group. Yet the identical input for another teacher will probably yield an entirely different set of impacts. Until the required student data can be authentically gathered, it is not possible to confirm or refute these expectations.

9. Reflection on overall project impact

In Year 1 of the project, overall impact may be summarised as follows:

- There has been an increase in the interest and enthusiasm of participating teachers to teach physics;
- The subject knowledge of participating non-specialist physics teachers has been improved;
- Participating teachers are increasingly aware of new approaches to the teaching of physics and are more confident in those areas addressed by the project's CPD;
- A good foundation has been laid for a specialist physics support network across at least 4 boroughs;
- Through the project's demonstrations, exemplifications and resources, pupils in participating schools will have access to a wider range of physics activities;
- Teachers, technicians and physics departments are better able to make productive use of practical equipment and resources already in their possession;
- There is some, anecdotal evidence that pupils are enjoying their physics lessons more;
- It is too early to say whether pupil outcomes, in terms of attainment and progress, are improving as a result of the project's activities

In relation to the project's theory of change methodology all teacher-related outcomes have shown positive responses during Year 1. Appendix 6 summarises teachers' responses to CPD. Overall impact cores for the key teacher outcomes are as follows:

- To what extent has the CPD improved your level of subject knowledge? 7.3
- Has the CPD made you more aware of resources? 7.7
- Has the CPD given you a better perception of physics teaching? 7.3
- How likely are you to use the resources in the classroom? 8.2
- How likely is it that pupil learning opportunities will improve? 7.6

The scales used are shown in Section 8. A score of 7 equates to "high / noticeable change".

As noted above and in Section 8.1.1 however, it has not yet been possible to identify or analyse pupil outcomes. Pupil impact data will only become available in Year 2.

In relation to the aims of LSEF, the Physics Factory is, explicitly, a project that focuses on investment in teachers and subject specific pedagogy. It has produced and disseminated new teaching resources, which have been positively evaluated. Project events have been hosted in a wide range of schools and group visits have been taken to places directly relevant to the new physics curriculum. The combined impact of these activities has been the creation of a ‘climate of physics’: an emerging local network across several London boroughs. Improving the longevity and sustainability of this network is a priority for Year 2 (see Section 12).

Evaluation data collected during Year 1 clearly shows that there is an appetite from physics teachers for subject-specific, pedagogical networks. Interview evidence reveals that teachers are dismissive of many network meetings hosted by their LAs. These are seen as focusing too strongly on administrative issues and legislative changes. Other available networks, such as the Subject Knowledge Enhancement Programme are seen as time limited and largely theoretical. The project’s End of Year Survey shows very clearly that physics teachers’ key priorities are “practical work” and “new approaches”. These are the Physics Factory’s core priorities.

As noted in Section 7.1, however, teacher turnover in London is higher than elsewhere in the country. The average age of the physics teachers participating in the project is relatively low. Many are likely to move on over the next few years. From this perspective, especially in London, it is important that the project (and LSEF) forms lasting relationships with schools as well as with individual teachers, and that these are based on something substantially deeper than short-term assessment data. People move on but secure systems remain. The cultural changes that LSEF seeks to inspire require time to develop and embed. A priority for the project is to ensure that it is the first port of call for schools seeking support for physics teachers even if departmental personnel, including subject leaders, are constantly changing.

It is axiomatic, and indeed central to LSEF philosophy, that better teaching will lead to better pupil outcomes. LSEF evaluation frameworks require evidence of impact in relation to both elements. Our experience has been, however, that it takes a long time for a new project to become established, trusted and for new relationships to develop. Schools and teachers do not join en masse at a convenient starting point in the academic year. Participation expands incrementally and it is important that the project be seen to give before it starts to take. In particular, we did not feel that it was appropriate to request baseline pupil achievement data as a condition of joining the project. Similarly we have resisted making demands on schools to visit classrooms in order to see how materials are being used. We will focus more on these two elements in Year 2.

In relation to lead-in time, there is always a tension between a financial year beginning and ending in April and an academic year between September and September. In an ideal world, a project plan based on funding released in April would devote the whole of the Summer Term to introductory activities, marketing and networking.   For Year 1, the majority of CPD programmes took place from January 2015 onwards. By the end of the Spring Term GCSE classes were largely working towards their final exams. The timescale for seeking evidence of pupil impact, in this context, is highly restrictive. Now that the project is established, we would expect to make more rapid progress with the plan for Year 2.

10. *Value for Money*

10.1 Apportionment of the costs across the activity

Broad type of activity	Estimated % project activity	£ Estimated cost, including in kind*
Producing/Disseminating Materials/Resources	10	15000
Teacher CPD (including planning but excluding resources)	25	40000
Events/Networks for Teachers	10	15000
Teacher 1:1 support	8	12000
Events for Pupils	10	15000
Training	2	10000
Marketing and Promotion	5	9000
Evaluation, compliance, general management	30	69000
TOTAL	100%	£185000

*Note that this column does not equate to the total expenditure given in Section 5 as it includes the value of in kind costs

The biggest cost financially and in terms of time resource was due to evaluating the project and ensuring the correct management of finance in particular. Providing the necessary documentation to comply with the LSEF terms amounted to much more work than we had originally anticipated. The strength of this was that it aided the case we subsequently made for future funding; the weakness was that most weeks entailed losing some valuable project time to setting up evaluation or preparing information for the milestone stages. It is intended to find a more streamlined way of evaluating the project in future to reduce the time spent on more administrative activities.

Apart from this, the project organisers worked hard to ensure an appropriate balance of apportion of the time and financial resources available, for example ensuring that beyond CPD, teachers did not benefit from more project activity than students.

It is intended to increase the proportions devoted to core project activities, but a main reason for these being superficially low is because of the breadth of activity undertaken by the project (the most similar types of project usually only provide teacher CPD for example). It is important to note that we have achieved substantial success despite the relatively low proportions of non-core activities such as training for staff and marketing.

10.2 Commentary on value for money

As discussed in Section 5.1, the core project activities were delivered significantly more cheaply than originally budgeted, and we found many suppliers on one hand, and many teachers on the other, were prepared to offer in kind and free support because of the underlying aims of the project.

A major appeal to schools of the Physics Factory is its grassroots nature. This is reflected in the success we have achieved with CPD participation. Whereas a single CPD session from a commercial supplier would cost a single teacher around £500, we have been able to leverage our grassroots base to provide training of exactly the same quality free to the end user.

10.3 Value for money calculations

No comparison groups were identified. No control group was possible as the project, relied on voluntary participation and with schools / teachers joining at different times of year.

11. Reflection on project delivery

11.1 Key Enablers and Barriers to Achievement

- The greatest barrier to achieving the aims of the project in Year 1 was the time taken to establish a presence with schools and to publicise its aims. CPD activities did not begin in earnest, therefore, until January 2015.
- Because schools had to be encouraged to join the project, bureaucratic requests could not be made a condition of joining. It was not possible, therefore, to collect baseline data, for example on pupil prior achievement or in-house assessment information. Seeking evidence of improved pupil outcomes has had to be postponed until Year 2.
- For similar reasons it has not been possible to build a teacher database linked to pupils. Thus, although we know the broad age and experience spectrum of teachers participating we cannot link them to the teaching of specific classes or topics. This prevents us, for example, from distinguishing progress made by pupils taught by non-specialists from those taught by teachers with physics degrees.
- Physics is often taught by non-specialists, many of whom regard the subject with apprehension. They know that they lack confidence but may find it hard to articulate their specific difficulties. This made it difficult, in the early stages of the project, to clarify the bespoke nature of what was required by individual schools.
- The target boroughs contain a plethora of school types (academy, free, maintained, single sex etc.). There is also a wide variety of curricular organisations, both historical (e.g. “science” as opposed to single disciplines) and preparatory (e.g. schools planning early for new syllabus requirements and bringing elements of KS4 science into Year 9. This, again, makes the generation of a significant impact database difficult.
- None of these barriers proved terminal, however, because several factors have mitigated towards it being seen as ‘the right idea at the right time’. These factors include:
  a) new syllabus requirements involving obligatory practical activities and assessments
  b) a dearth of specialist physics support networks to address these difficulties
  c) a clear perception, on the part of physics heads of department, that non-specialists would struggle to come to terms with these issues

d) the shrinking capabilities of Local Authorities to provide such support structures for local schools, many of which have been established to be independent of LA influence

11.2 Management and Delivery Processes

- In general, we feel that the management of the project has been successful in overcoming many of the above barriers.
- Basing CPD sessions in a variety of schools increased attendance overall and widened knowledge of the project.
- Despite the difficulty, on occasion, of agreeing a bespoke focus, the fact that bespoke sessions were organised and were successful significantly enhanced the credibility of the project's trainers.
- The decision to focus on exemplification and teaching via practical activities was a clear success. Surveys asked participants to identify the main challenges they faced in teaching physics. The 2 most frequent responses, by a significant margin, were "practicals" and "new approaches". Offering potential solutions to these problems was a major factor in securing support.
- Linked to the above, the decision to locate and provide high quality practical resources was also successful. In interview and paper surveys, frequent mention is made of specific resources (e.g. the Gravity Well) that schools have valued.
- Offering CPD to technicians as well as teachers also proved successful. Many teachers identified technicians' lack of understanding of how to use physics practical equipment as a major barrier in their schools
- There may, however, be a trade-off between bespoke CPD courses and more widespread participation. Numerous respondents have requested a menu of Physics Factory solutions, advertised in advance, so that release (and travel) time can be planned well in advance.
- Equally, whilst the need for high quality, relevant practical activities is acknowledged, there is no guarantee that topics will be taught, *in toto*, at an appropriate level of challenge and depth. Requests have been made for the Physics Factory to offer fully-worked teaching units covering all aspects of the topic in addition to the practicals. This will also need to be considered in Year 2.

11.3 Future Sustainability and Forward Planning

In order to ensure future sustainability the following broad elements have been identified:

1. Consider suggestions made by participants in interview and the End of Year Survey (see 11.2 above)
2. Develop the facility to deliver cheaper, more flexible, comprehensive and numerous CPD and student lab experiences
3. Provide a well-publicised menu of opportunities in advance from which schools can select
4. Focus closely on the new syllabus requirements so that teachers will see Physics Factory support as being relevant to their current concerns
5. Given the high turnover of teaching staff in London (see above) increase longevity by widening the number of participants willing to contribute to (and deliver) elements of the Physics Factory programme

6. Create a more permanent web-based presence linked to the sharing of on-line resources
7. Gather persuasive evidence of positive pupil outcomes, via school based visits, that can be disseminated around the expanding network.

12. Final Report Conclusion

Key findings for assessment of project impact

In relation to the project's target outcomes, impact data suggests that:

1. There has been an increase in the interest and enthusiasm of participating teachers to teach physics;
2. The subject knowledge of participating non-specialist physics teachers has been improved;
3. Participating teachers are increasingly aware of new approaches to the teaching of physics and are more confident in those areas addressed by the project's CPD;
4. A good foundation has been laid for a specialist physics support network across at least 4 boroughs;
5. Through the project's demonstrations, exemplifications and resource donations, pupils in participating schools will have access to a wider range of physics activities;
6. Teachers, technicians and physics departments are better able to make productive use of practical equipment and resources already in their possession;
7. There is some, anecdotal evidence that pupils are enjoying their physics lessons more;
8. It is too early to say whether pupil outcomes, in terms of attainment and progress, are improving as a result of the project's activities

Key lessons learnt for assessment of project delivery

In relation to the Physics Factory's approaches and methodology:

1. The project has earned the trust and respect of practitioners. There are no significant criticisms of the project leaders or their CPD trainers;
2. Offering a bespoke CPD service (and proving capable of delivering it) has widened the numbers of participating teachers and schools;
3. The practical approaches demonstrated through CPD sessions have helped to set potentially 'dry' theoretical concepts into concepts that are interesting and relevant to pupils;
4. Potentially, expectations have been raised to the extent that the project is now being asked to provide curriculum support that extends beyond its original parameters;
5. More could have been done by way of initial data collection to enable systematic analysis of teacher and school participation. More will be done in Year 2 to identify concrete evidence of improved pupil outcomes.

Informing future delivery

1. The significant activity of Year 2 needs to be student data gathering. Engaging the headteachers of participating schools in this process would facilitate it - for example by enabling Project leaders to have access to school data officers.
2. The Physics Factory's CPD provision has proved a main driver for interest in the project. This should be expanded and enhanced, in the most cost effective way. To

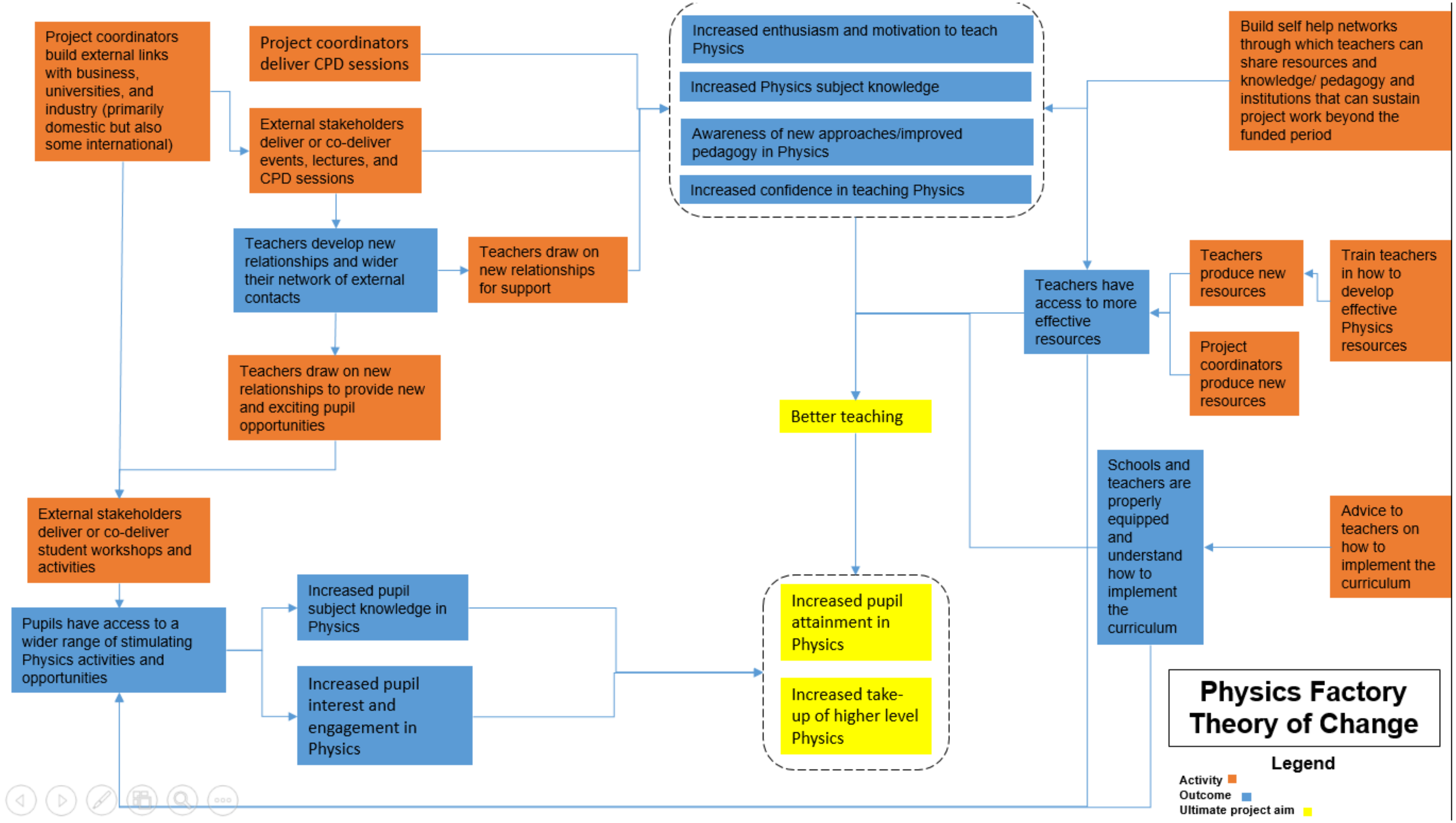
do this, the project needs to be independent of third party suppliers. This can only happen with a significant investment in building up a dedicated Physics Factory equipment stock. Such an investment would reduce contractor costs and enable the project to go anywhere and support learning and training independent of context. This equipment would also guarantee the life of the project into the future.

3. An investment in an equipment bank would also enable the project to deliver many more student lab experiences, free of the constraints of the school being visited, thus expanding the pupil-related area of our work.
4. The project's planned focus, in Year 2, on expanding the network – including to primary schools / Key Stage 2 – and giving increased responsibility to participants, requires a showcase event (eg Physics Factory conference) to act as a focus for the network and develop the understanding of the hub model among participating schools, especially in a regional context of high staff and subject turnover;
5. The difficulty of aligning industry and commerce with the project thus far indicates the need for a dedicated careers-focused event to which a number of high-profile companies and institutions could attach themselves and develop links with schools and the project itself
6. More could be done to set the improved, motivational practical activities into a robust series of topic / unit curriculum plans;
7. Better use should be made of a digital platform for the sharing of resources, planning and teaching ideas;

The Physics Factory project began with an attempt to address 'crisis in physics education' in London's schools. From the outset the perception was always that such a crisis could be resolved without the need for any grand new educational theory, but simply by utilising the knowledge of existing physics teachers and maximising its effect across more than just an individual local school. Although there is much work yet to do in terms of drilling down into the effect on pupil performance, we feel this report demonstrates that the founding principle of the project is sound and worthy of continued articulation.

List of Appendices

Appendix 1: Validated Theory of Change and Evaluation Framework



Outcome	Indicator	Baseline data collection	Impact data collection
1. Increased interest and motivation to teach Physics	Increase in teachers' self-reported motivation to teach physics by the end of the academic year- ratings on a survey scale (target is to see increase for ¾ of participating teachers) Attendance at Physics Factory events (target is for more than half of participants attend more than 1 physics factory event.) Improvement in teachers' self-reported attitudes to Physics- reduction in the number of teachers who report that they find Physics boring- ratings on a survey scale (target is for more than half of non-specialist teachers who initially reported that they find physics to be boring, to report that they do not find physics boring)	All participating teachers complete Physics attitude, knowledge, and confidence (Self-efficacy survey) survey at first point of contact with Physics Factory (self-developed survey that asks teachers to respond using a scale) All participating teachers complete Physics attitude, knowledge, and confidence (Self-efficacy survey) survey at first point of contact with Physics Factory (self-developed survey that asks teachers to respond using a scale)	All participating teachers complete Physics attitude, knowledge, and confidence (Self-efficacy survey) survey at end of project Physics Factory event attendance lists- lists will be analysed to calculate the percentage of attendees who participated in more than one event. All participating teachers complete Physics attitude, knowledge, and confidence (Self-efficacy survey) survey at end of project
2. Increased Physics subject knowledge	Teachers report increased subject knowledge in target areas in CPD evaluation forms (target is that majority of teachers will report significant improvement in target areas of knowledge) Increase in teachers' self-reported subject	Areas of difficulty discussed in initial meeting with schools. All teachers complete website survey on individual needs when joining the Physics Factory- insight into CPD required and areas to target All participating teachers complete Physics	All participating teachers complete a CPD evaluation form at the end of each session. The forms ask teachers whether they feel their subject knowledge has improved in target areas All participating teachers complete Physics attitude, knowledge, and confidence (Self-

	knowledge- ratings on a survey scale (Target is to see increase for majority of teachers)	attitude, knowledge, and confidence (Self-efficacy survey) survey (self-developed survey that asks teachers to respond using a scale) prior to CPD session. This asks for their view on their level of knowledge on the topic/s that are being covered in the CPD.	efficacy survey) survey at end of project
3. Awareness of new approaches and improved pedagogy in Physics	Teachers report awareness of new approaches/improved pedagogy in Physics in CPD evaluation forms Book scrutiny post-intervention evidences greater coverage, depth, and range of Physics topics relative to pre-intervention and other sciences Increase in teachers' self-reported pedagogy- higher ratings on a survey scale	As large a sample as possible of books with work completed by pupils in the year before the intervention who were taught by participating teachers- books will be analysed by our consultant, Steve Rowe, for coverage, range, and depth of Physics topics in comparison with the other 2 sciences All participating teachers complete Physics attitude, knowledge, and confidence (Self-efficacy survey) survey at first point of engagement	All participating teachers complete a CPD evaluation form at the end of each session. The forms ask teachers whether they feel they have become aware of new approaches As large a sample as possible of books with work completed by pupils during the intervention who were taught by participating teachers- books will be analysed by our consultant, Steve Rowe, for coverage, range, and depth of Physics topics in comparison with the other 2 sciences and before the intervention All participating teachers complete Physics attitude, knowledge, and confidence (Self-efficacy survey) survey at end of project
4. Increased confidence in teaching Physics	Increase in teachers' self-reported confidence- higher ratings on a survey scale Book scrutiny post-intervention evidences greater coverage, depth, and range of Physics topics relative to pre-intervention and other sciences	All teachers complete website survey on individual needs when joining the Physics Factory- this includes questions about confidence. All participating teachers complete Physics attitude, knowledge, and confidence (Self-efficacy survey) survey at first point of contact with Physics Factory (self-developed survey that asks teachers to respond using a scale)	All participating teachers complete Physics attitude, knowledge, and confidence (Self-efficacy survey) survey at end of project As large a sample as possible of books with work completed by pupils during the intervention who were taught by participating teachers- books will be analysed by our consultant, Steve Rowe, for coverage, range, and depth of Physics topics in comparison with the other 2 sciences and before

		As large a sample as possible of books with work completed by pupils in the year before the intervention who were taught by participating teachers- books will be analysed by our consultant, Steve Rowe, for coverage, range, and depth of Physics topics in comparison with the other 2 sciences	the intervention
5. Teachers have new relationships and a wider network of external contacts	CPD event attendance lists demonstrate contact between teachers from different schools Industry event attendance lists demonstrate contact between teachers and industry contacts Teachers report increased links with industry in industry event evaluation forms- response on a survey scale	Current links with other schools and how these manifest discussed in initial meeting with schools. Perceived areas of expertise and where teachers turn for external support discussed in initial meeting with schools	Physics Factory CPD attendance lists (will be collected from all CPD events)- will be analysed to see the range of schools represented at each session Physics Factory industry event attendance lists All participating teachers complete industry event evaluation form at the end of each event to express extent to which they have increased links with industry or not.
6. Pupils have access to a wider range of stimulating Physics activities and opportunities	Teachers report that they have new ideas that they intend to use in future lessons in CPD evaluation forms Increase in teachers' self-reported intent to change use of stimulating Physics activities and opportunities- response on a survey scale (CPD feedback form) Pupil attendance at industry/business-led events Pupil attendance on Physics Factory organised trips	All teachers complete website survey on individual needs when joining the Physics Factory-this includes questions about Physics activities and opportunities Target groups of students for industry/business-led help discussed during initial meeting with schools. Current trips being undertaken discussed during initial meeting with schools.	All participating teachers complete a CPD evaluation form at the end of each session. This form asks teachers whether they have gained ideas that they intend to use in their future lessons. All participating teachers complete CPD feedback form at the end of each session, which includes a question about the range of Physics activities and opportunities Pupil attendance at industry/business led events- attendance will be recorded at every event

			Description and number of industry/business led events Pupil attendance on Physics Factory organised trips- attendance will be tracked on every trip Description and number of Physics Factory organised trips
7. Increased pupil subject knowledge in Physics	An improvement in pupils' performance. An improvement in the quality of book work by pupils.	As large a sample as possible of pupil test data completed by pupils in the year before the intervention who were taught by participating teachers- will be analysed by our consultant, Steve Rowe, for demonstrated subject knowledge As large a sample as possible of books with work completed by pupils in the year before the intervention who were taught by participating teachers- books will be analysed by our consultant, Steve Rowe, for demonstrated subject knowledge	As large a sample as possible of pupil test data completed by pupils during the intervention who were taught by participating teachers- will be analysed by our consultant, Steve Rowe, for demonstrated subject knowledge As large a sample as possible of books with work completed by pupils during the intervention who were taught by participating teachers- books will be analysed by our consultant, Steve Rowe, for demonstrated subject knowledge
8. Increased pupil interest and engagement in Physics	Pupils show greater interest and engagement in physics Increase in pupil enthusiasm in lessons as reported by teachers- response on a survey scale (self-efficacy survey) Greater pupil uptake of A-level Physics	10% of pupils taught by participating teachers complete survey on their attitude and interest in physics before teacher attends Physics CPD All participating teachers complete Physics attitude, knowledge, and confidence (Self-efficacy survey) survey at first point of engagement Number of pupils studying Physics at AS and A2 at the start of the project (collected at initial	10% of pupils taught by participating teachers complete survey on their attitude and interest in physics before teacher attends Physics CPD All participating teachers complete Physics attitude, knowledge, and confidence (Self-efficacy survey) survey at end of project Predicted number of pupils who will take AS and A2 Physics in the academic year following the intervention

		meeting with schools)	(August 2015)
9. Schools and teachers are properly equipped and understand how to implement the curriculum	a) Improved accessibility to physics equipment. b) Improved implementation of coursework. c) Increase in sharing of knowledge of curriculum changes.	Access to equipment, need for equipment, and willingness to share what they have discussed at initial meeting with schools' department/department leader Ability to deliver KS4 and KS5 coursework and willingness to share expertise discussed at initial meeting with schools' department/department leader. Intended approach to implementing new KS3, KS4, and KS5 discussed initial meeting with schools' department/department leader	End of project surveys- include questions on access to equipment and understanding of recent/upcoming curriculum changes Focus group of 10 schools (1 or 2 teachers per school) on access to equipment All participating teachers complete a CPD evaluation form at the end of each coursework session. This form asks teachers whether they are more confident delivering KS4/KS5 coursework
10. Teachers have access to more effective resources	List of resources provided to teachers and made available through the website Teachers report that they have gained ideas/resources that they intend to use in their future lessons in CPD feedback forms Increase in teachers' self-reported use of resources- response on a scale (self-efficacy survey)	Access to resources and willingness to share discussed at initial meeting with schools' department/department leader All participating teachers complete Physics attitude, knowledge, and confidence (Self-efficacy survey) survey at first point of engagement- assesses the range of resources that they use whilst teaching the particular topic that the CPD will be on and pupils view of that topic All participating teachers complete Physics attitude, knowledge, and confidence (Self-efficacy survey) survey at first point of	List of resources made available on Physics Factory website List of resources provided to schools All participating teachers complete Physics attitude, knowledge, and confidence (Self-efficacy survey) survey at end of project All participating teachers complete a CPD evaluation form at the end of each coursework session. This form asks teachers whether they feel that they have gained ideas/resources that they intend to use in their future lessons.

		engagement	

Appendix 2: Exemplar initial contact questionnaire

Initial Questionnaire

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Section 1 - About you and your school:

1. Name
2. School
3. School address
4. Email
5. Landline
6. Mobile

Section 2 - Your teaching position:

7. Role
8. Full or part-time?
9. What is/are your current teaching role/s?

Section 3 - About you and physics:

10. How confident do you feel about teaching physics?
11. What inspires you about physics?
12. With which aspects of the curriculum would you most appreciate some help?
13. Do you think your pupils understand how important physics is to their careers?
14. What puts off students continuing with physics after GCSE?
15. What would help you most to enjoy your job?

Section 4 - Your education:

16. School

17. University

18. Degree

19. PGCE or equivalent

20. Other post-graduate qualification(s)

21. QTS?

22. Tell us about any additional experience you have which is relevant to physics.

Section 5 - About your school's physics curriculum:

23. In your school how is physics taught? (e.g. as a single subject.)

24. Tell us how the physics curriculum is delivered in your school at each key stage.
    i. KS3?

    ii. KS4?

    iii. KS5?

25. Typically, how often do you carry out class practicals?

26. Total no. technicians in your department

Appendix 3: CPD Pre-Session Self-Efficacy questionnaire

Pre-Session Self Efficacy

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Session type:

Session title:

Your school

Your name:

Session Objectives:

-

The following questions are about the topic of the session, which is in the Session title (written above).
Your name and school name on this survey will only be used to cross reference this survey with your evaluation survey.

	Not at all		Very little		Somewhat		Quite a bit		Very much so
How motivated are you about teaching this topic?	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
How enthusiastic are your pupils when learning about this topic?	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Do you consider this topic boring?	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
How good is your knowledge of this topic?	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
How confident are you in delivering the content of this topic?	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Do you draw upon a wide range of resources when teaching this topic?	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
How good is your pupils' attainment in this topic generally?	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**

Thank you.

Appendix 4: Post CPD Session Evaluation Form

Session Evaluation Form

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Session type:

Session title:

Your school

Your name:

Session Objectives

	Not at all		Very little		Somewhat		Quite a bit		Very much so
From your viewpoint, overall, how helpful was this session? Any comments:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
How much do you feel that your knowledge has improved in the subject areas delivered? Any comments:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
How much do you feel that your awareness of new approaches/improved pedagogy has increased because of this session? Any comments:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
How likely do you feel that ideas you have gained today will be used in your future lessons? Any comments:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
How much do you feel that your pupils will have more access to a wider range of stimulating physics activities/opportunities? Any comments:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
How effective do you think these new ideas will be in improving the learning of your pupils? Any comments:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Have your perceptions of physics and	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**

physics teaching improved?

Any comments:

How could we make the session better next time?

Appendix 5: Summary of CPD Unit Pre-Course Self-Efficacy Judgements

Topic	How motivated are you to teach topic?	Pupils' enthusiasm for this topic?	Do you consider the topic boring?	How good is your topic knowledge?	Confidence to deliver this topic??	A wide range of resources drawn on?	Pupils' level of attainment in topic?
Waves and Forces	5.9	4.8	4.1	6.8	6.6	6.3	6.1
Electric Circuits	5.9	4.3	4.9	5.5	4.8	5.8	4.8
Moments in P3	5.9	4.1	4.9	6.3	6.2	4.9	5.9
Energy	5.2	4.3	4.3	5.9	5.6	4.7	5.1
Generating & Transmitting	6.7	4.7	3.5	5.8	5.8	5.1	5.3
Static Electricity & Circuits	7.6	3.7	3.7	6.7	6.7	6.7	5.8
Momentum	5.4	4.7	4.7	3.6	4.3	5.7	6.0
Radioactivity	6.9	5.5	4.1	6.6	6.4	5.1	5.9
Space & Electromagnetism	7.5	6.8	2.5	6.8	6.2	5.2	5.9
Semiconductors	4.4	4.4	4.5	4.5	4.0	4.8	5.1
Lenses & Light	4.3	4.5	5.8	5.7	5.5	4.0	4.6
Average**	**5.96**			**5.91**	**5.66**		

**Note: 'Average' is not an average of the figures in the column. It is the average of all individual responses to that question across all topics

Appendix 6: Summary of Post CPD Session Evaluations

Topic	Helpfulness of session?	Gain in subject knowledge?	More aware of resources?	Likely to use resources in future?	Increased pupil opportunities?	Improved learning likely?	Better perception of physics teaching?
Waves and Forces	8.6	7.2	7.1	8.7	7.2	7.8	6.6
Electric Circuits	8.8	6.8	8.0	8.5	7.8	7.3	7.0
Moments in P3	8.7	7.9	8.3	8.7	8.3	8.6	8.0
Energy	8.3	6.4	7.5	8.2	8.0	7.7	8.0
Generating & Transmitting	7.4	6.1	6.8	6.9	6.7	7.0	6.3
Static Electricity & Circuits	9.0	7.3	8.0	8.5	7.5	8.0	7.8
Momentum	8.8	8.0	8.0	9.0	8.2	8.2	8.4
Radioactivity	8.4	7.7	8.4	8.4	7.6	7.7	7.7
Space & Electromagnetism	8.6	7.9	8.5	8.4	8.3	8.3	8.3
Semiconductors	8.7	7.9	7.4	8.3	7.7	7.7	7.3
Lenses & Light	7.8	7.2	7.5	7.8	7.8	7.8	7.8
Average**	**8.27**	**7.26**	**7.7**	**8.2**	**7.6**	**7.7**	**7.3**

**Note: 'Average' is not an average of the figures in the column. It is the average of all individual responses to that question across all topics

Appendix 7: pre-session self-efficacy evaluations, unit by unit

Note that responses to Question 3: "do you consider this topic boring?" requires a low numerical response in order to convey a positive answer. Thus a grade of 1 "not at all (boring)" is better than a grade of 9 "very (boring)". For all other questions, the higher the grade, the more positive the message.

Waves and Forces — 13.1.15

Participants and their responses

Evaluation Questions	1	2	3	4	5	6	7	8	9	10	11	12	13	Ave
Your own motivation for teaching topic?	7	5	5	9	5	6	3	7						**5.9**
Pupils' enthusiasm for the topic?	5	3	3	9	3	5	3	7						**4.8**
Do you think the topic is boring?	4	6	5	1	3	6	7	1						**4.1**
How good is your topic knowledge?	8	8	5	9	5	5	7	7						**6.8**
Confidence teaching the topic?	8	8	5	9	5	4	7	7						**6.6**
A wide range of resources drawn on?	7	5	6	8	7	4	8	5						**6.3**
How good is pupils' attainment in topic?		6	6	8	6	6	4	7						**6.1**

Electric Circuits — 13.1.15

Participants and their responses

Evaluation Questions	1	2	3	4	5	6	7	8	9	10	11	12	13	Ave
Your own motivation for teaching topic?	3	6	5	6										**5.0**
Pupils' enthusiasm for the topic?	4	6	3	5										**4.5**
Do you think the topic is boring?	5	2	5	5										**4.3**
How good is your topic knowledge?	5	7	6	4										**5.5**
Confidence teaching the topic?	4	7	4	4										**4.8**
A wide range of resources drawn on?	7	5	6	5										**5.8**
How good is pupils' attainment in topic?	5	5	4	5										**4.8**

Moments in P3 — 20.1.15

Participants and their responses

Evaluation Questions	1	2	3	4	5	6	7	8	9	10	11	12	13	Ave
Your own motivation for teaching topic?	4	7	3	8	7	5	7	5	7					**5.9**
Pupils' enthusiasm for the topic?	3	3	3	8	5	3	5	3	4					**4.1**
Do you think the topic is boring?	7	5	6	1	1	5	8	5	6					**4.9**
How good is your topic knowledge?	7	7	6	8	9	4	5	4						**6.3**
Confidence teaching the topic?	7	7	6	8	9	6	5	4	4					**6.2**
A wide range of resources drawn on?	5	4	3	7	8	4	4	3	6					**4.9**
How good is pupils' attainment in topic?	4		5	7	9	6	6	4						**5.9**

Energy

21.1.15

Participants and their responses

Evaluation Questions	1	2	3	4	5	6	7	8	9	10	11	12	13	**Ave**
Your own motivation for teaching topic?	5	5	8	5	7	3	6	5	3					**5.2**
Pupils' enthusiasm for the topic?	3	5		4	6	3	5	5	3					**4.3**
Do you think the topic is boring?	5	6	2	8	2	3	4	2	7					**4.3**
How good is your topic knowledge?	4	6	7	7	8	5	6	4	6					**5.9**
Confidence teaching the topic?	4	6	7	5	7	5	6	5	5					**5.6**
A wide range of resources drawn on?	5	5	5	4	3	5	5	2	8					**4.7**
How good is pupils' attainment in topic?	4	5	6	6	6	4	5	4	6					**5.1**

Generating & Transmitting Electricity

27.1.15

Participants and their responses

Evaluation Questions	1	2	3	4	5	6	7	8	9	10	11	12	13	**Ave**
Your own motivation for teaching topic?	9	7	6	5	8	9	6	7	5	6	6		6	**6.7**
Pupils' enthusiasm for the topic?	8	3	4	3	7	5	5	7	4	4	5	3	3	**4.7**
Do you think the topic is boring?	1	1	3	5	1	1	4	1	4	5	6	5	8	**3.5**
How good is your topic knowledge?	6	8	5	6	7	7	5	3	3	9	5	6	5	**5.8**
Confidence teaching the topic?	7	9	5	6	7	7	5	1	3	8	5	6	6	**5.8**
A wide range of resources drawn on?	6	4	3	3	8	5	3	9	3	6	6	5	5	**5.1**
How good is pupils' attainment in topic?	7		4	5	9		5	7	4	5	6	3	3	**5.3**

Static Electricity & Circuits — 12.2.15

Participants and their responses

Evaluation Questions	1	2	3	4	5	6	7	8	9	10	11	12	13	Ave
Your own motivation for teaching topic?	7	9	8	7		7								**7.6**
Pupils' enthusiasm for the topic?	5	7	8	6		5								**6.2**
Do you think the topic is boring?	4	1	1	6	7	3								**3.7**
How good is your topic knowledge?	8	7	6	6	6	7								**6.7**
Confidence teaching the topic?	7	7	7	6	6	7								**6.7**
A wide range of resources drawn on?	6	6	6	7	8	7								**6.7**
How good is pupils' attainment in topic?	5	6	6	6		6								**5.8**

Momentum — 25.2.15

Participants and their responses

Evaluation Questions	1	2	3	4	5	6	7	8	9	10	11	12	13	Ave
Your own motivation for teaching topic?	8	5	3	5	7	5	5							**5.4**
Pupils' enthusiasm for the topic?	7	3		5	5	5	5							**5.0**
Do you think the topic is boring?	1	1	5	5	5	7	9							**4.7**
How good is your topic knowledge?	9	3	3	3	3	3	1							**3.6**
Confidence teaching the topic?	9	5		3	3	4	2							**4.3**
A wide range of resources drawn on?	7	3		7	5	5	7							**5.7**
How good is pupils' attainment in topic?	8	3		5	5		9							**6.0**

Radioactivity 5.3.15

Evaluation Questions	1	2	3	4	5	6	7	8	9	10	11	12	13	Ave
	Participants and their responses													
Your own motivation for teaching topic?	5	9	5	5	9	7		8						**6.9**
Pupils' enthusiasm for the topic?	5	6	3	4	9	6	3	8						**5.5**
Do you think the topic is boring?	6	1	2	5	9	6	3	1						**4.1**
How good is your topic knowledge?	5	7	5	7	9	6	7	7						**6.6**
Confidence teaching the topic?	5	7	4	7	9	7	5	7						**6.4**
A wide range of resources drawn on?	5	5	2	6	9	3	4	7						**5.1**
How good is pupils' attainment in topic?	5	7	4	5	9		5	6						**5.9**

Space & Electro-Magnetism 11.3.15

Evaluation Questions	1	2	3	4	5	6	7	8	9	10	11	12	13	Ave
	Participants and their responses													
Your own motivation for teaching topic?	8	9	7	5	6	8	9	8	7	8	6	8	9	**7.5**
Pupils' enthusiasm for the topic?	8	5	7	6	6	9		5	7	5	7	7	9	**6.8**
Do you think the topic is boring?	3	1	6	6	6	1	1	1	4	1	1	1	1	**2.5**
How good is your topic knowledge?	7	9	7	4	7	7	9	7	5	6	8	6	6	**6.8**
Confidence teaching the topic?	7	7	6	5	6	7	5	7	5	5	7	7	6	**6.2**
A wide range of resources drawn on?	7	5	5	5	7	5	1	6	5	5	6	6	4	**5.2**
How good is pupils' attainment in topic?	7	6	6	4	7		9	6	5	5	5	6	5	**5.9**

Semiconductors 25.3.15

Evaluation Questions	1	2	3	4	5	6	7	8	9	10	11	12	13	Ave
Your own motivation for teaching topic?	3	7	5	3	1	5	5	5	2	7	5			4.4
Pupils' enthusiasm for the topic?	2	7	7	5	3	3	4	3	4	5	5			4.4
Do you think the topic is boring?	4	5	1	6	5	5	7	5	4	1	6			4.5
How good is your topic knowledge?	4	5	3	3	3	7	3	4	5	7	5			4.5
Confidence teaching the topic?	3	5	3	4	3	5	1	5	5	6	4			4.0
A wide range of resources drawn on?	5	6	3	5	5	9	2	3	4	7	4			4.8
How good is pupils' attainment in topic?	3	7	7	5	5	5	3	6	5	5	5			5.1

Participants and their responses

Lenses & Application of Light 25.3.15

Evaluation Questions	1	2	3	4	5	6	7	8	9	10	11	12	13	Ave
Your own motivation for teaching topic?	7	1	2	5	5	6								4.3
Pupils' enthusiasm for the topic?	6	3	4	5	5	4								4.5
Do you think the topic is boring?	6	9	5	5	5	5								5.8
How good is your topic knowledge?	5	5	5	6	5	8								5.7
Confidence teaching the topic?	6	5	4	5	5	8								5.5
A wide range of resources drawn on?	7	1	2	3	5	6								4.0
How good is pupils' attainment in topic?	6		2	6	4	5								4.6

Participants and their responses

Appendix 8: post- session evaluations, unit by unit

Note: the post-session evaluation proforma has 8 questions but only 7 are summarised here. The final question asks participants to suggest how the session might have been improved.

Waves and Forces 13.1.15

	Participants and their responses												
Evaluation Questions	1	2	3	4	5	6	7	8	9	10	11	12	**Ave**
Helpfulness of the session?	8	9	7	9	9	8	9	9	9				**8.6**
Subject knowledge gain?	7	7	8	7	7	5	8	8	8				**7.2**
Increased awareness?	7	7	8	9	8	6	8	3	8				**7.1**
Likely future use of material?	8	8	9	9	9	9	8	9	9				**8.7**
Pupils' increased opportunities?	7	8	8	8	7	5	8	7	7				**7.2**
Learning will be improved?	8	8	8	8	9	7	8	7	7				**7.8**
Better perceptions of physics teaching?	7	8	8	8	9	3	8	1	7				**6.6**

Electric Circuits 13.1.15

	Participants and their responses													
Evaluation Questions	1	2	3	4	5	6	7	8	9	10	11	12	13	**Ave**
Helpfulness of the session?	9	9	8	9										**8.8**
Subject knowledge gain?	9	5	5	8										**6.8**
Increased awareness?	9	9	7	7										**8.0**
Likely future use of material?	9	9	9	7										**8.5**
Pupils' increased opportunities?	9	7	7	8										**7.8**
Learning will be improved?	7	9	6	7										**7.3**
Better perceptions of physics teaching?	9	5	7	7										**7.0**

Moments in P3 20.1.15

Evaluation Questions	Participants and their responses 1	2	3	4	5	6	7	8	9	10	11	12	13	Ave
Helpfulness of the session?	8	9	8	9	9	9	9							**8.7**
Subject knowledge gain?	8	8	8	8	9	8	6							**7.9**
Increased awareness?	9	7	8	8	9	8	9							**8.3**
Likely future use of material?	9	8	8	9	9	9	9							**8.7**
Pupils' increased opportunities?	8	8	8	9	9	8	8							**8.3**
Learning will be improved?	9	9	8	9	9	8	8							**8.6**
Better perceptions of physics teaching?	8	8	8	5	9	9	9							**8.0**

Energy 21.1.15

Evaluation Questions	Participants and their responses 1	2	3	4	5	6	7	8	9	10	11	12	13	Ave
Helpfulness of the session?	8	9	9	7	9	9	8	8	9	7				**8.3**
Subject knowledge gain?	6	7	7	1	8	7	6	7	9	6				**6.4**
Increased awareness?	9	7	7	6	7	8	8	7	9	7				**7.5**
Likely future use of material?	8	6	9	9	8	8	9	8	9	8				**8.2**
Pupils' increased opportunities?	8	6	9	8	8	7	8	9	9	8				**8.0**
Learning will be improved?	8	8	7	8	8	7	8	6	9	8				**7.7**
Better perceptions of physics teaching?	8	7	5	6	7	8	6	6	9	8				**7.0**

Generating & Transmitting Electricity 27.1.15

Evaluation Questions	Participants and their responses 1	2	3	4	5	6	7	8	9	10	11	12	13	Ave
Helpfulness of the session?	9	7	7	8	8	4	5	9	8	9	9	8	7	**7.4**
Subject knowledge gain?	9	3	8	7	7	4	4	9	8	2	7	5	9	**6.1**
Increased awareness?	8	6	7	7	8	4	7	9	7	8	7	5	7	**6.8**
Likely future use of material?	8	7	8	7	8	5	5	7	7	8	7	7	7	**6.9**
Pupils' increased opportunities?	6	6	8	6	8	5	5	8	7	8	6	6	7	**6.7**
Learning will be improved?	8	6	7	7	7	5	5	9	7	7	8	9	7	**7.0**
Better perceptions of physics teaching?	8	7	7	7	6	1	4	9	9	5	7	7	7	**6.3**

Static Electricity & Electric Circuits 12.2.15

Participants and their responses

Evaluation Questions	1	2	3	4	5	6	7	8	9	10	11	12	13	Ave
Helpfulness of the session?	9	9	9	9	9	9								**9.0**
Subject knowledge gain?	4	8	8	8	8	8								**7.3**
Increased awareness?	9	8	7	8	8	8								**8.0**
Likely future use of material?	9	9	8	8	9	8								**8.5**
Pupils' increased opportunities?	7	7	7	8	8	8								**7.5**
Learning will be improved?	7	8	8	8	9	8								**8.0**
Better perceptions of physics teaching?	6	9	7	8	9	8								**7.8**

Momentum & Car Safety 25.2.15

Participants and their responses

Evaluation Questions	1	2	3	4	5	6	7	8	9	10	11	12	13	Ave
Helpfulness of the session?	9	9	9	9	8									**8.8**
Subject knowledge gain?	8	9	8	7	8									**8.0**
Increased awareness?	8	9	8	8	7									**8.0**
Likely future use of material?	9	9	9	9	9									**9.0**
Pupils' increased opportunities?	9	7	8	8	9									**8.2**
Learning will be improved?	9	7	9	8	8									**8.2**
Better perceptions of physics teaching?	8	9	9	8	8									**8.4**

Radioactivity 5.3.15

Participants and their responses

Evaluation Questions	1	2	3	4	5	6	7	8	9	10	11	12	13	Ave
Helpfulness of the session?	7	9	9	9	9	9	7	8	9	8	8			**8.4**
Subject knowledge gain?	8	9	8	8	9	8	5	8	7	8	7			**7.7**
Increased awareness?	7	9	8	9	9	9		8	8	8	9			**8.4**
Likely future use of material?	6	9	9	9	9	9		8	9	7	9			**8.4**
Pupils' increased opportunities?	6	9	8	9	9	9	5	7	8	7	7			**7.6**
Learning will be improved?	6	9	7	5	9	9	9	8	8	8	7			**7.7**
Better perceptions of physics teaching?	6	9	7	5	9	9	9	8	8	8	7			**7.7**

Space & the Electro-Magnetic Spectrum

11.3.15

	Participants and their responses													
Evaluation Questions	1	2	3	4	5	6	7	8	9	10	11	12	13	**Ave**
Helpfulness of the session?	8	8	9	9	9	9	9	8	8	9	9	8		**8.6**
Subject knowledge gain?	7		8	7	8	9	9	9	8	8	7	7		**7.9**
Increased awareness?	7	8	9	9	8	9	9	9	8	9	8	9		**8.5**
Likely future use of material?	7	8	9	8	8	9	9	9	8	8	9	9		**8.4**
Pupils' increased opportunities?	7	7	9	8	8	9	9	9	7	8	9	9		**8.3**
Learning will be improved?	7	9	8	8	9	9	9	9	8	7	8	9		**8.3**
Better perceptions of physics teaching?	7		8	9	8	9	9	8	7	8	9	9		**8.3**

Semi-Conductor Physics 25.3.15

	Participants and their responses													
Evaluation Questions	1	2	3	4	5	6	7	8	9	10	11	12	13	**Ave**
Helpfulness of the session?	9	9	9	9	9	7	9	8	9	9				**8.7**
Subject knowledge gain?	9	9	7	7	7	7	9	7	8	9				**7.9**
Increased awareness?	9	8	6	7	7	5	7	8	8	9				**7.4**
Likely future use of material?	9	9	9	7	9	8	7	8	8	9				**8.3**
Pupils' increased opportunities?	9	8	7	7	7	7	7	8	8	9				**7.7**
Learning will be improved?	9	9	6	7	7	7	8	7	8	9				**7.7**
Better perceptions of physics teaching?	9	8	7	7	7	5	7	7	7	9				**7.3**

Appendix 9: Interviews with Participants

PF Target	Senior / Experienced Staff / HoD	Staff with 2-4 years Experience	NQT / Inexperienced Staff
General issues / Comments	● Did an audit of physics literacy in the dept. It was poor. Staff were scared of it. Needed to act. (1) ● Also joined the Institute of Physics (SPF) programme. It is good but PF is more engaging (1) ● Contacted via social media and invited to attend a session. Separate sciences taught from Y9-13 (4) ● I hold a 'Lead Practitioner' role in my school and have responsibility for training & development in science. We got involved because we had already identified physics as an area of relative weakness. (6) ● We teach double & triple science to GCSE. We are an 11-16 school. No sixth form. We do not use subject specialists. One teacher, regardless of specialism, teaches all classes. My degree was in biochemistry. (6) ● Because it is difficult to get staff released for training we asked the PF to lead 2 sessions in our school, for our teachers. This worked well. Our HT is a stickler for child protection. It's not easy for staff from other schools to visit us without a lot of paperwork. Not sure how many 'outsiders' attended. (6)	● I got involved via an email from my HoD. Went to one event and liked it, so went to more. I'm not a physics specialist and have done SKE in the past. PF is much more involved and exciting than SKE - and it covers pedagogy as well. (2) ● I am 2 i/c in Science and physics lead. A physics specialist. 4 years experience. I joined PF because they made a visit to my local network meeting. I was more interested in the benefits for other non-specialist staff but what they offer is good. (5)	● Teach First recruit. Physics specialist. Not yet NQT. (3)

A: Increased motivation to teach physics	● Staff already motivated but now more confident. Gravity Well and Electromagnetic Induction model are understood and used well (1) ● Staff already motivated and department is successful. Physics taught by non-specialists only in Y9. None of these involved in PF. (4) ● Motivation was not an issue for us. Levels of staff interest in physics have increased, however. The staff has requested more PF input next year. 2 staff went to Brussels with the PF (European Space Agency). 2 joined the London Physics Walk. (6)	● It's made me braver and more willing to try things - also other members of the dept. Most colleagues' understanding of physics is low. They see it as boring, as maths. PF work shows it can be more fun. It's opened us up to advice. (2) ● My own motivation is high but I was looking for more creative approaches. Non-specialist staff have been reluctant to do practical work and many of the standard practicals are simply boring. PF has helped with this. (5)	● More confident of teaching physics and therefore more motivated. I worry about where students are in their understanding and my own lack experience of how to deal with it. (3)
B: Increased physics subject knowledge	● Our hardest topics are Forces (3rd Law), Solar System (gravity well, linear speed, radius of orbit etc.) and electromagnetic induction (1) ● PF has made these areas more concrete and easier to grasp. It will take longer to develop their pedagogical subject knowledge, however (i.e. how to respond flexibly to pupil needs and / or questions) (1) ● Subject knowledge and <u>teaching</u> subject knowledge not the same thing. PF input is good as it helps provide real life contexts for learning and relevance of topics. (4) ● By definition, our subject knowledge has increased - more in terms of <u>how</u> to teach it and exemplify it. We asked the PF to lead sessions on Electricity and Electronics because we knew these were areas of relative weakness for us. (6)	● No great gains in knowledge for most topics. I had already been through SKE to teach A level. Logic circuits are hard - but I know I can contact the network for help. (2) ● My own subject knowledge hasn't improved though I have seen some new connections between physics and the other sciences - better analogies to use (etc.) (5)	● My subject knowledge was already good I was less sure of how to use this in my teaching. Some PF modules are explored in ways designed to make sense to non-specialists. I've been able to learn from this myself in terms of how to break topics down. I've also learned how to use relevant examples from other disciplines. (3)
C: Awareness	● We have begun to see how we might teach	● My SKE work was about 'how' to teach at KS3	● New to teaching, therefore hard to comment.

of new approaches and improved pedagogy in physics	snippets of the curriculum. We have enjoyed the process. Would like to see some of the topics fleshed out so we could see how the whole topic might be taught. (1) ● Little previous training covered pedagogy (inc. SKE) other than in general terms (open vs closed questions etc.). PF is very good for practicals, contexts, models and demonstrations. Really good demonstration model for radioactivity using tennis balls, for example. (4) ● Would like to see PF deal with some key aspects in terms of "how should you teach it?". Good example might be 'how do you teach drawing graphs from scratch'? (4) ● Aside from gaining confidence to teach practicals (and move away from demonstrations) we have picked up on many tangential issues too. E.g. how to lay out the classroom; a box for faulty equipment; better analogies and so on. (6)	but mostly about 'what' to teach at KS4 & 5. The real gain, for me, is in how to contextualise physics to make it enjoyable and relevant. SKE would have used 'sticks and weights" to illustrate 'moments'. PF would use see-saws! (2) ● PF activities provide better contexts for physics topics. For example the Tower of Terror (Disneyworld) models is good. I have always wanted to teach physics in more active ways. (5)	(3)
D: Increased confidence in teaching physics	● Non-specialists, (biologists), struggle to teach problem solving using algebra - often over-simplified. Would like PF to do more on this aspect. Can't assume that teachers can do the maths & leave that part to them. (1) ● I am personally unconfident with particle physics, which I'd not done at A level or university. I contacted PF and have been promised something on this next year. Not happened yet, though. (4) ● Definitely - for the reasons given earlier. We	● Having the network to help me increases my confidence. (2) ● Not really. I have always been pretty confident with the subject. (5)	● Specifically I'm more confident now with practicals. I tend to do more physics practicals than chemistry or biology, though, because of my specialism. (3)

	have written 'more input from PF' into our development plan for next year. (6) ● Since our involvement with PF I'm no longer the only department member involved in external links. Someone else leads on our master class links with the Academy. Someone else is involved with organising physics walks. Neither is a physics specialist. This is evidence of their increased confidence. (6)		
E: Teachers have new relationships and a wider network of contacts	● Also part of the Stimulating Physics Network (SPF). This is working OK. However the Team calls PF "the cool one" and SPF "the boring one". Would like to see them go deeper, however, especially on problem solving skills. I like the contractual element of SPF (1) ● Have made use of YouTube resources - distributed to individuals (1) ● Definitely use PF as a sounding board and source of support. Have not yet made working contact with other schools, though. Would need to be clearer about the other schools' contexts before seeking help. Our school is quite high achieving. (4) ● We already had some network links. I've worked with the Stimulating Physics Network in the past. We now have a link with Newham's 6th form college (Academy of Excellence). PF is better in many ways - more flexible, more bespoke - e.g. we had separate aims for technicians, teachers and pupils. PF met them all. Our Academy link person from Newham is now starting to get involved with	● I had no previous physics network. The LA has a "science network meeting" but it's mainly about politics and exam boards, not about moving forward. I've now made informal contacts with people from other schools, for example by going on the 'Physics Walk of London'. (2) ● The local network is not very good - mainly about pooling ignorance and complaints about new syllabi. I attended the Prince's Trust Institute sessions on physics when I started teaching. These were very good - current research, good lecturers, high-end A level focus. PF is good too but it focuses mainly on GCSE and raising the confidence of non-specialists. In future it would be good to have more on the upper levels of attainments. (5) ● I don't make much use of PF as a network. I mainly contact one of the lead people directly. Sadly, our school is very competitive and doesn't like to share ideas with 'competitors'. Maybe an on-line forum would help? (5)	● I'm in contact with Teach First people in London East but the only other physicist has left the programme. I created this group myself. PF is the only subject specific support network I know.

	PF himself. This will help us more. (6)		
F: Pupils have access to a wider range of stimulating physics activities and opportunities	● Definitely. That's why we call them "cool" and the SPF "boring". (1) ● We have gained new equipment from PF and many new exemplifications and models. Their radioactivity unit has gone straight into our scheme of work so we will all use it. Next year Thursday afternoons are being freed up for local visits and trips. I will definitely be seeking ideas from PF for those. (4) ● Definitely - especially in relation to practical activities. Our technicians have also received PF training and are now more proactive in suggesting wider equipment that can be used. (6)	● Definitely! Racing straws to show forces, for example. Pupils very excited. Great for Newton's Third Law. We used to do joint planning and some colleagues were resistant to practical work. Less so now. (2) ● Definitely! It helps, however, that the syllabus changes required from next year strengthen the need for practical work. Reluctant staff won't be able to avoid it and it's good to have creative ideas to use. (5)	● An unequivocal yes! I'm looking forward to doing the Wave Motion session using jelly babies - it works well with 'moments' as well as 'waves'
G: Increased pupil subject knowledge in physics	● Pedagogy is not only about how you teach a topic but also <u>when</u>. Would like to see PF specify a full suite of lessons across a topic because then it would be easier to evaluate impact via assessment data. (1) ● Too soon to identify improvements in pupil performance. This will only come when we can trawl our in-house assessment data for next year. (4) ● It's too soon to identify this and it will be hard to disentangle the physics elements from the GCSE results. (6)	● I run the Young Scientists Group (for underachievers). All I've done with them is to try and make science fun for them - and have used lots of PF activities. Every one is now up to their target grade for this year. (2) ● No real evidence at this stage. We've only been doing it for part of a year. I will see if there is anything useful in our internal progress data and send it on if I find any. Anecdotally, I believe that my sets now understand the process of star formation rather than just regurgitating the facts. (5)	● Contextualisation of physics is much better under PF. For example the temperature effect on diffusion - PF illustrates using hot air balloons, weather systems and jelly. (3)
H: Increased pupil interest and engagement in physics	● We did a controlled assessment on Mechanics (topic supported by PF). The results in this were much higher than usual. I had to raise the grade boundaries so they were comparable with Chem & Bio assessments.	● Usually about 8% progress from GCSE to A level physics. Current Y11 is higher - circa 12%. Y11 are taught this year by non-physics specialists who have attended PF sessions. (2) ● Pupils definitely prefer practical activities. PF	● I've had students ask me questions in lessons and have responded using PF approaches. I help with Science Club - 15 students from Y7-9. There is a heavy emphasis on practicals and I make a lot of use of PF stuff. I love how it

	Usually it's the other way around. (1) ● A 'difficult' girl in my intervention group was captivated by the impact of radioactivity on 'real' people in the watch-making industry. No figures yet, but numbers expressing interest in A level physics for next year are definitely up. (4) ● This would only be anecdotal. Our pupils are well behaved and well motivated. They all have to do science (double or triple). We have no 6th form so we can't monitor post-16 options take up. One teacher told me, after teaching a PF-related unit, that several pupils had commented that they really enjoyed the lesson. According to the teacher, that had never happened before! (6)	promised earlier in the year that they would help us with issues such as visiting speakers and trips out. This hasn't happened yet. No real evidence at this stage. We've only been doing it for part of a year. I will see if there is anything useful in our internal progress data and send it on if I find any. Anecdotally, I believe that my sets now understand the process of star formation rather than just regurgitating the facts. (5)	increases their curiosity and keeps them fully engaged. All students have to join a club and membership changes every term. Numbers opting for Science Club are up next term. (3)
I: schools and teachers are properly equipped and understand how to implement the curriculum	● Improving as a result of PF but would like to see a few full topics broken down into milestone components. (See C above.) (1) ● I like the PF's contacts with publishers re the new A level curriculum. Potentially very helpful. (1) ● We haven't made much use of PF re next year's A level syllabus training. I attended a LA meeting on this issue (poor) but got most of our ideas from the Exam Board meetings. (4) ● We aren't involved with the A level changes. Many aspects of KS4 will now be introduced into KS3 and, because of our PF involvement, we now know how to do these things more effectively. (6)	● The PF organised a discussion group to consider textbooks for the new A level syllabus. Very helpful. (2) ● We were already pretty well organised in this area. We have been better able, however, to make use of the resources we have - many of which were in the store room unused - as a result of PF support. We definitely use more 'kit' now than we did previously. (5)	● Because of PF's help we have been able to target resources for the new, independently tested, A level practicals for next year. (3)
J: Teachers	● Our department is already well resourced and	● I've always wanted to do more practicals but	● We will replicate the PF's Physics Tour of

have access to more effective resources	we have our own physics technician. The individual resources we have had from PF have definitely enhanced our provision, however. (4) ● We were already well resourced but too much equipment lay unused in cupboards because we (or the technicians) didn't know what to use it for or how best to use it. The PF training sessions with our technicians were really helpful in this regard and more resources are now used well. Also, of course, the PF has given out a lot of new resources, linked to their training sessions.	lack of resources slowed me down. New resources were often bought without knowing when and where they would be used. The PF has given us some new resources (e.g. half life dice) but also made us clearer about targeting any new resources we buy. (2) ● Definitely - both in terms of suggestions that have enabled us to use our own resources better but also in terms of the resources they have given out. (5)	London with both the 6th form and Y7 next term. (3)

Appendix 10: End of year survey

End of Year Survey

the physics factory putting physics on the map in London

Your name:

Your school:

*Please indicate your responses to the following questions – in bold, with an 'X' or using highlighting or any other suitable means. Unless specified, all questions relate to your experiences of working with the Physics Factory **overall** (not linked to a particular event).*

	Not at all		Very little		Somewhat		Quite a bit		Very much
Has your interest in physics increased overall as a result of Physics Factory activities?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
How motivated are you about teaching physics?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Has your general physics knowledge increased as a result of Physics Factory activities?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Has the Physics Factory made you aware of new approaches to teaching physics?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
How confident do you feel about teaching physics?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
How prepared do you feel to teach the new physics curriculum at GCSE?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
How prepared do you feel to teach the new physics curriculum at A-Level?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Has the Physics Factory aided your preparation for the new curriculum changes?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Has the Physics Factory enabled you access to new equipment?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Have you gained teaching resources as a result of the Physics Factory?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
To what extent has the Physics Factory made an overall impact on your teaching?	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

Which Physics Factory activity has been the most important/valuable to you?

What you would you like to see us offer in the future?

What do you think we should do differently, and how?

What is/are the biggest challenge(s) you face in teaching physics at the moment? (Indicate all that apply)

- Subject Knowledge
- Practical Work
- Ofsted
- Leadership
- Demands from management
- Data management
- Pupil engagement
- Assessment
- Fresh approaches

Please comment here if you'd like to say more:

Would you be prepared to get involved in running your own Physics Factory activities?

Yes No

If yes, what would you like to do?

Thank you.

Appendix 11:

Summary outcomes from September 2015 End of Year Survey:

	Has your interest in physics increased overall as a result of Physics Factory activities?	How motivated are you about teaching physics?	Has your general physics knowledge increased as a result of Physics Factory activities?	Has the Physics Factory made you more aware of new approaches to physics teaching?	How confident do you feel about teaching physics?	How prepared do you feel to teach the new physics curriculum at GCSE?	How prepared do you feel to teach the new physics curriculum at A level?	Has the Physics Factory aided your preparation for the new curriculum changes?	Has the Physics Factory enabled you access to new equipment?	Have you gained teaching resources as a result of the Physics factory?	To what extent has the Physics Factory made an overall impact on your teaching?
Average Score: 18 responses	6.0	7.6	5.8	6.9	7.3	5.6	5.4	4.3	6.1	6.4	6.2

Note: Responses are drawn from across the spectrum of boroughs supported, not only the 4 targeted boroughs. The sample includes individuals whose attendance at CPD sessions ranged between 1 and 6.

Key:
1 = very low / no change
3 = low / very little change
5 = moderate / some change
7 = high / noticeable change
9 = very high / significant change