Department for Education

TLIF evaluation: The Institute of Physics Future Physics Leaders project

Final Report

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Key findings summary

- The Institute of Physics (IOP) Future Physics Leaders (FPL) project aimed to improve capacity and capability for physics teaching and leadership, and the retention of physics teachers. The FPL project provided professional development via four strands of support delivered by a network of IOP development coaches. This included: mentoring newly-qualified physics teachers (NQTs); developing physics teachers as future school-based development coaches (SBDCs) and deliverers of physics continuing professional development (CPD); developing the subject/pedagogical knowledge and leadership skills of specialist physics teachers; and developing the subject and pedagogical knowledge of non-specialist physics teachers.

- Recruitment and retention to the project was reasonably successful, although it fell slightly below targets in terms of participant numbers and priority schools. The main challenges of recruitment related to shortages of specialist physics teachers, competing priorities in schools, and staff turnover. However, the need for the support was generally well recognised. Recruitment was aided by the project's multi-strand design, network of contacts in the local areas, and organisational credibility.

- Delivery of the FPL project, broadly speaking, went as planned. The main modification was that some of the non-specialist CPD was delivered within Partner Schools rather than at the local hub venue (Lead School) in order to facilitate greater engagement. Feedback suggested that the FPL provision was of high quality as a result of a well-designed package of support, an expert delivery team, scope for customisation, and local hub delivery.

- There is considerable evidence that the project improved participants' physics subject knowledge, physics teaching pedagogy, confidence to teach physics, physics leadership knowledge and skills, and access to physics CPD. Teachers also perceived some positive impacts on pupils' physics behaviour, attainment and progress.

- There is little evidence that the project was effective in leading to improvements in participants' motivation to teach physics and engage with physics CPD, or on participants' physics leadership practices and motivation to progress into physics leadership.

- There is some evidence to suggest that the FPL project made some progress towards its aim to improve teachers' retention in the profession. FPL teachers were statistically significantly more likely to remain in teaching one and two years after the project than teachers who had not participated in FPL, although it is not possible to disentangle the effect of the project from other non-observed systematic differences between FPL participants and non-participants.

- FPL participants were statistically significantly more likely than non-participants to move school three years after the project. Participants were also statistically significantly more likely than non-participants to move to a non-challenging school (i.e. a school with a good or outstanding Ofsted rating) three years after baseline. These findings could indicate that the FPL project was upskilling science teachers; enabling some to secure opportunities in other, less challenging schools.

- There is no evidence that the FPL project achieved its aim to improve teachers' progression to middle leadership for either science teachers generally or physics specialists. This may reflect that a substantial proportion of FPL participants were non-specialist physics teachers, which limited opportunities for middle leadership in physics.

- The FPL project provides some learning about effective subject-specific CPD for schools in challenging circumstances. Although the delivery model for FPL was generally regarded as having worked well, more intensive and customised support may be required to address the scale of the physics specialist shortage and to effectively support physics teachers in challenging schools. School-based development coaches and physics specialists also need further support beyond the lifetime of the project to implement physics leadership practices.

- The findings from this report were drawn from baseline (n=371) and endpoint (n=124) surveys of FPL participants, telephone interviews with 16 FPL participants, 5 IOP development coaches, and the FPL project manager, the analysis of management information supplied by the DfE, and analysis of teacher retention and progression outcomes in the School Workforce Census (SWC). The survey analysis is limited by low response rates, particularly at endpoint, and hence findings should be interpreted with caution.

Glossary of Terms

IOP Development Coach – The IOP network of freelance physics experts who provide physics CPD, coaching and mentoring as part of the Future Physics Leaders (FPL) project. Each IOP development coach was assigned to a ‘hub’ to support participants in up to seven schools within a designated local area.

School Based Development Coach (SBDC) - SBDCs are physics specialists based in Lead Schools who were supported through the FPL project to develop as future school-based development coaches.

Priority areas - Category 5 or 6 Achieving Excellence Areas (AEAs) Local Authority districts, including the 12 Government Opportunity Areas – areas identified as having weakest performance and least capacity to improve.

Priority schools – Schools with an Ofsted judgement of 3 or 4 (Inadequate or Requires Improvement (RI)).

Teaching and Leadership Innovation Fund (**TLIF)** — DfE programme (2017-2020) aimed at improving pupil outcomes and support for pupil social mobility by improving teaching and leadership in priority areas and schools through outcome-focused, evidence-based and innovative professional development provision.

1 About Future Physics Leaders and the evaluation

The Institute of Physics (IOP) Future Physics Leaders (FPL) project aimed to provide a sustained programme of professional development to leave a legacy of increased capacity and capability for physics teaching, leadership and coaching, and subsequently an increase in the number, quality and retention of physics teachers. It was hoped that this would, in turn, impact positively on pupils' physics attainment at GCSE and progression post-16, including that of priority groups[1]. The FPL project began in September 2017 and ended in March 2020. It aimed to work with three regions (central, north and south[2]) and, within each region, eight hubs. Each hub was designed to comprise seven schools - one Lead School and six Partner Schools – convened for the purposes of the FPL project. Lead Schools were outstanding schools that received support through the FPL project to become hubs for physics teaching and support in their local areas, specifically developing their specialist physics teachers as future physics leaders. Partner schools were based in the hub areas, had a lower Ofsted rating, and received support through the FPL project to develop the subject and pedagogical knowledge of their specialist and non-specialist physics teachers.

In total, the project aimed to support 168 secondary schools and nearly one thousand teachers. The delivery team comprised a team of IOP development coaches based in each region and coordinated by an area lead, in addition to a small central management team. The project activities included four strands of support: mentoring newly-qualified physics teachers (NQTs); developing physics teachers as future school-based development coaches (SBDCs) and deliverers of physics continuing professional development (CPD); developing the subject/pedagogical knowledge and leadership skills of specialist physics teachers; and developing the subject and pedagogical knowledge of non-specialist physics teachers.

1.1 Theory of change

The FPL project had a number of intended outcomes and impacts. These are outlined in the project logic model in Appendix A. The logic model shown in Appendix A was created by the evaluation team, and reviewed by DfE. The logic model was based on: the theory of change (ToC) submitted by the IoP as part of the bid to the Teaching and Leadership Innovation Fund (TLIF); our understanding of the project's underlying rationale, activities, outputs and anticipated outcomes; and subsequent conversations with the project team.

The theory underpinning the project was that providing targeted CPD and mentoring support for teachers to develop physics subject knowledge, pedagogy and leadership

[1] Priority groups included girls, pupils from ethnic minorities, and pupils of low socio-economic status.
[2] These three regions cover the eight Regional Schools Commissioners (RSC) areas of England.

skills would result in a range of outcomes. Intended outcomes included improvements in the quality of physics subject leadership and teaching, enhanced teacher confidence and motivation, and increased capacity and demand for CPD through upskilling physics leaders and developing local physics networks. Intended impacts were improvements in physics teacher retention and progression and improved pupil attainment in physics.

The methods (project activities/outputs) by which IOP expected to achieve the intended outcomes and impacts are also outlined in Appendix A. These included providing:

- bespoke subject and pedagogical CPD for new and experienced teachers of physics
- leadership coaching support to develop specialist physics teachers as future school-based development coaches, who would continue to provide CPD support to local schools in their hub
- bespoke mentoring support to newly-qualified physics teachers
- CPD at a local hub venue to facilitate the future development of local physics communities of practice.

The context for the FPL project was that national recruitment and retention issues are particularly acute in relation to physics teachers, leading to a shortage of physics specialist teachers in UK secondary schools. This has resulted in a relatively high proportion of physics lessons being taught by non-specialist teachers (compared to other subject areas) (DfE, 2016). Additionally, non-specialist physics teaching is particularly prevalent in schools in the most challenging circumstances (e.g. Allen *et al*., 2016). The quality of teaching that a student receives has been found to be among the most influential factors on attainment and progression, and subject knowledge and pedagogy are important aspects of high-quality teaching (e.g. DfE, 2016, Burgess, 2016, Allen *et al.,* 2016). High-quality and sustained CPD and mentoring can enhance the quality of teaching (e.g. Cordingley *et al.,* 2015; Yoon *et al*., 2007) and improve the recruitment and retention of teachers (e.g. Gold, 1987; McIntyre and Hobson 2015; Bryant and Parish, 2016). Drawing on this evidence, FPL aimed to leave a lasting legacy of increased capacity and capability for physics teaching and leadership, and an increase in the quality, recruitment and retention of physics teachers.

1.2 Contextual factors

The FPL project was one of ten DfE-funded TLIF projects. The DfE wished to test out how effectively a variety of different CPD approaches could meet project-specific and fund-level outcomes; therefore each of the ten projects were commissioned to be intentionally different in design, scale, scope and delivery method. At fund-level, the evaluation sought to compare and contrast the relative effectiveness of these projects in meeting their stated aims and objectives – taking into account a range of factors related to their differences. These included:

- **impact focus and target group** (whether impact was intended to be at whole-school, individual-teacher level or both; and whether the project targeted leaders, teachers or both) – the FPL project had an individual-teacher level focus and targeted teachers and middle leaders
- **phase supported** (whether primary, secondary, or both phases) – the FPL project supported secondary schools
- **per-participant cost** (calculated by comparing the overall cost specified in the project's bid against the number of participants that the project was contracted to recruit[3]). Relative to the other TLIF projects, the FPL project was medium cost
- **intensity of the delivery model** (categorised by creating a combined score incorporating: duration of provision offered (in months), hours of provision offered (per participant); and proportion of school staff that the project aimed to engage[4]). Relative to the other TLIF projects, the FPL project had a moderate-intensity delivery model
- **range of delivery modes** (categorised into two groups: a wide range (five to six modes), and a moderate range (three modes[5]). The FPL project had a wide range of delivery modes relative to other TLIF projects.

In the fund-level report, we take the FPL project's contextual factors into account as we compare its progress in achieving outcomes with the progress made by the other TLIF projects.

1.3 Evaluation methodology

1.3.1 Overall evaluation methodology

The aim of the evaluation was to undertake a process and impact evaluation to explore indicators of effectiveness and to measure impacts (teacher retention and progression) and outcomes (including teaching and/or leadership quality – see Chapter 4, Tables 2-5 for full details). The objective was to draw out learning and best practice, test out the project's theory of change, and identify implications for the fund-level assessment, as well as educational policy and practice more broadly. Our original evaluation design also included an impact evaluation to assess the impacts of the project on pupil attainment.

[3] High-cost projects had a relatively high per participant budget, medium-cost projects had a relatively medium per participant budget and low-cost projects had a relatively low per participant budget.
[4] We do not have dosage data – so this assessment is based on intention rather than actual involvement, but it provides an indication of the nature of delivery. Our three resulting categories were: 'intensive'; 'moderate' and 'light touch'.
[5] No projects had four modes of delivery and no projects had fewer than three.

However, due to partial school closures as a result of the Covid-19 pandemic, and the cancellation of Key Stage 2 assessments and GCSE examinations for the 2020 cohort, DfE decided to remove this aspect of the evaluation. There will, therefore, no longer be a pupil impact analysis aspect to the evaluation.

1.3.2 Evaluation methodology for this report

This final evaluation report draws on secondary data from the School Workforce Census (SWC[6]), survey, and qualitative data. It provides a measure of the project's success in achieving the TLIF programme's impacts (SWC data), outcomes (survey and qualitative data) and project-specific outcomes (survey and qualitative data). SWC and survey findings are supported by rich qualitative data, which aids understanding of the recruitment, delivery and implementation factors that influenced achievement of these outcomes. The report explores the links between inputs, outcomes and impacts, analysing the appropriateness of the project's ToC in achieving desired results. The evaluation data sources underpinning this report are outlined below:

1) a comparison of secondary data from the SWC for FPL participants, and for a matched group of non-FPL participants[7]. FPL participants were identified via project MI data, which was collected by DfE and shared with NFER.
2) a baseline survey of 738 FPL participants which achieved responses from 371 participants (a response rate of 50 per cent) (April 2018-July 2019; administered as participants joined the project on a rolling recruitment basis)
3) an endpoint survey of 713 FPL participants, which achieved responses from 124 participants (a response rate of 17 per cent) (March-May 2020)[8]
4) three telephone interviews with the FPL project manager (March 2018, March 2019 and March 2020)
5) telephone interviews with five IOP development coaches (November 2018)
6) sixteen telephone interviews with FPL participants from across eight Partner Schools and two Lead Schools (June and July 2019).

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[6] This work was produced using statistical data from ONS. The use of the ONS statistical data in this work does not imply the endorsement of the ONS in relation to the interpretation or analysis of the statistical data. This work uses research datasets which may not exactly reproduce National Statistics aggregates.
[7] Non-FPL participants were defined as any teacher who was not enrolled on the FPL project, or any other TLIF intervention.
[8] The endpoint survey was launched shortly before schools in England went into lockdown as a result of the Covid-19 pandemic. This necessitated a pause in planned reminder activity, and with schools focused on dealing with the pandemic, the result was that response rates were considerably lower than expected. For the matched analysis, a maximum of 87 responses were matched between the baseline and endpoint surveys.

Appendix C describes the methods used for matching MI data to SWC data, and for constructing a comparison group. Appendix D provides the results of the impact analysis. In summary, the steps were as follows:

1) The MI data was matched to the SWC using Teacher Reference Numbers (TRNs), names and dates of birth. This matched 89 per cent of FPL participants as recorded in the MI data with at least one record in the SWC.
2) FPL participants were matched with non-participants using propensity score matching. Matching for the full sample used teacher and school characteristics (age, gender, years of experience, Ofsted rating, etc. – see Appendix C for the full list) observed in the baseline year, where baseline year for FPL participants was defined as the year the teacher was recruited to the project.
3) The retention rates in state-sector teaching among those in the treatment and matched comparison groups were compared using a logistic regression model, one, two and three years after baseline and controlling for the variables used for matching. The same process was followed to estimate the impact on retention within the same school/local authority (LA)/challenging schools.
4) Differences between the groups in progression rates (to middle/senior leadership) within the profession and within the same school/LA/challenging schools were estimated using a similar model as in step 3.

The survey sample characteristics are displayed in Appendix E. In summary, the achieved survey sample included responses from participants on all FPL project strands: physics specialists; physics non-specialists; school-based development coaches (SBDCs); and newly-qualified teachers (NQTs). Higher proportions of responses were received from specialists and non-specialists, although this reflects the numbers involved in the project overall as there were fewer NQT and SBDC participants. The matched survey sample included a smaller proportion of non-specialists and a higher proportion of specialists than the proportions of these respondents in the individual baseline and endpoint surveys.

The achieved survey sample included responses from participants in school roles of: class teacher; middle leader; and senior leader. The largest proportion of respondents were class teachers. Survey responses were received from schools from all four Ofsted categories, although higher proportions of respondents were from schools with Ofsted ratings of ‘good’ or ‘requires improvement’. This distribution appeared to be broadly in line with the overall FPL population, although the survey responses were slightly over-representative of schools rated as ‘good’ or ‘outstanding’ compared to the overall FPL population. Survey responses were also received from schools in all five quintiles of free school meals eligibility (i.e. proportion of pupils at the schools eligible for free school meals as an indication of deprivation), though a higher proportion were in the second to highest and highest quintiles.

Analysis of the survey data compared participants' responses at baseline and endpoint to explore the extent to which their views changed over the timeframe that they were involved with FPL. The most robust way to analyse any change over time is to analyse only the responses of those participants who answered at both baseline and endpoint as this provides greater control of individual differences between participants. Therefore, the majority of the survey analysis is based on a matched analysis of respondents who answered at both baseline and endpoint (N = 87). Any teacher, middle or senior leader that answered a third or less of the items in the survey were removed from the analysis. An analysis of the characteristics of all respondents who answered the survey at baseline (N = 371) and endpoint (N = 124), compared to the matched sample, can be found in Appendix E. This shows that the participants in the matched survey sample were similar in characteristics to those who only responded at either baseline or endpoint. Overall, the survey analysis is limited by low response rates and the sample was too small to enable analysis by sub-groups of respondents, and hence findings should be interpreted with caution. A description of the quantitative analyses undertaken on the survey data can be found in Appendix F and G.

The interviewee sample included contributions from interviewees participating in different strands of the project – school-based development coaches (SBDCs); specialists; non-specialists; and NQTs. The sample also included participants from each of the three regions, hubs in varying geographic contexts (i.e. urban, rural, coastal), and focused on priority areas (i.e. Opportunity Areas) and target schools (i.e. schools with Ofsted category 3 or 4[9], high proportions of pupils eligible for free school meals (FSM) (i.e. a sixth or more of the school population of pupils eligible for free school meals). Each interview was semi-structured and lasted around 45 minutes. Interviews were recorded where interviewees gave permission, and were analysed using the qualitative analysis package MAXQDA. Further details on the approach to qualitative sampling, together with selected characteristics of case-study participants and their schools, can be found in Appendix B.

The telephone interviews aimed to explore the experiences of participants who had been engaged in the CPD/mentoring in order to gather their feedback about the support they had received and any resulting implementation of learning and subsequent impacts. Therefore, this evidence does not include exploration of the experiences of participants who did not engage with the FPL offer and the reasons underpinning this. A limitation of the data is that, because we were not always able to speak to multiple teachers in a school, the findings focus predominantly on participant-level impacts. However, in four schools, we were able to speak to the head of subject/department to gather their more strategic perspective of the department-level impacts of the FPL project. A final limitation

[9] Ofsted Grading Scale judgements: Grade 1 = Outstanding; Grade 2 = Good; Grade 3 = Requires improvement; Grade 4 = Inadequate (https://www.gov.uk/guidance/being-inspected-as-a-further-education-and-skills-provider)

is that we were not able to secure any interviews with participants from maintained schools, however this reflects the overall FPL population, and indeed the national population of secondary schools, as the majority are academies[10].

1.4 Focus of this report

This report focuses specifically on:

Section 2 – Recruitment and retention (whether the project met its targets for school and participant recruitment, and the factors that supported this).

Section 3 – Delivery and implementation (whether this progressed according to plan; what worked well and not so well; and what lessons can be learned for future CPD offers).

Section 4 – Outcomes and impacts of the provision (the extent to which the project met, or had the potential to meet, the TLIF programme's outcomes and impacts, and its own bespoke project outcomes).

Section 5 – Sustainability (discussion of the potential for sustainability of new ways of working, new learning and outcomes in schools, which have come about through involvement with the project).

Section 6 – Evaluation of the Future Physics Leaders project theory of change.

Section 7 – Summary and indicative implications for policy and CPD development.

[10] In the academic year 2019-2020, 77 per cent of secondary schools were academies or free schools (Department for Education, Schools, Pupils and their characteristics: Academic Year 2019/20, https://explore-education-statistics.service.gov.uk/find-statistics/school-pupils-and-their-characteristics)

2 Recruitment

2.1 Progress towards recruitment targets

Over the lifetime of the FPL project, the target was to recruit 168 secondary schools and work with 924 participants. The project had a target of 100% of schools to be located in priority areas (i.e. AEA category 5 or 6[11]). Within priority areas, a minimum of 70 per cent of participants were expected to come from priority schools (i.e. Ofsted category 3 or 4 schools).

Management information (MI) submitted by IOP to the DfE in February 2020 can be found in Appendix I. The MI shows that IOP recruited a total of 172 schools. Hence, the project more than met its target for school recruitment. The MI shows that 99 per cent of schools recruited were in priority areas, very slightly below the target of 100 per cent. The MI shows that 58 per cent of participants were from priority schools, slightly below the target of 70 per cent. In a very small number of cases, schools that did not fit the target criteria were accepted onto the project as they were able to demonstrate need. These schools were approved on a case by case basis in consultation with the Department for Education (DfE). The MI shows that a total of 826 participants were recruited to the project, slightly lower than the target of 924. Decisions were made in consultation with the DfE to include some additional schools as 'priority', and some schools where the Ofsted rating changed during the project. In addition, the MI indicates that there were some problems with participant retention and that after removing participants who dropped out, a remainder of 649 participated in the project. However, the overriding target agreed with DfE for the FPL project was in relation to the number of schools, rather than the number of participants, and as such, the target was achieved.

The FPL project allowed schools to engage for as long as they felt was necessary for their school, and operated a rolling recruitment process to allow schools to join and leave as they wished.

The delivery team reported that, although recruitment of schools had been slow initially, recruitment improved to meet interim and final targets for school recruitment. Furthermore, the vast majority of schools (95 per cent based on MI data) were retained and remained engaged for the duration of the project. However, concerns were raised and possible explanations offered as to the slight under-achievement against participant target numbers. The original estimate for the number of physics teachers in each school,

[11] Schools in a local authority district in category 5 or 6 according to the Achieving Excellence Area composite indicator (1 being 'strong' and 6 being 'weak' on a composite indicator based on local performance and capacity to improve). For more details of the methodology, see here: https://www.gov.uk/government/publications/defining-achieving-excellence-areas-methodology

and the projection that *all* physics teachers in participating schools would participate, had not transpired in practice. Accordingly, an average of four participants per school was considered by the delivery team to be achievable, rather than the originally envisaged average of 5.5 teachers per school. Furthermore, the delivery team encountered fewer physics specialists in schools in target areas than they originally expected. This necessitated a relaxing of the notion of a 'physics specialist' to include, for instance, early-career physics teachers, and teachers with lower formal qualifications in physics, but substantial experience of teaching and leading physics. Progress towards recruitment targets also varied by hub; with some hubs being quicker to recruit the Lead School and six Partner Schools than others (the factors underpinning this variation are explored below in section 2.3).

2.2 Recruitment methods

The recruitment approach involved both the central IOP team and the network of 20 regionally based IOP area team leads and development coaches. Recruitment methods involved advertising the project via the IOP and DfE websites, running a number of 'taster' CPD events and hub planning meetings in each of the regions, and promoting the project through networks and contacts based in the regions. These networks and existing contacts included: IOP development coaches, IOP's Stimulating Physics Network coordinators, higher education liaison officers, regional schools commissioners (RSCs), opportunity area (OA) leads, and multi-academy trust (MAT) and teaching school alliance (TSA) leads.

Recruitment began by first targeting Lead Schools in order to identify the physical basis for each local 'hub' and the prospective school-based development coaches (SBDCs). Following this, Partner Schools were recruited. A senior leader in each of the participating schools was asked to sign a memorandum of understanding, which outlined the nature of the project and the commitment required. Project information was also provided to the head of science/physics and teachers in the science/physics department. Individual participants were asked to register and provide basic information to enable the administration of the support.

A number of challenges were encountered in recruitment (as outlined below). As a result, recruitment was continuous from the start of the project, rather than in two distinct cohorts, as originally intended. Learning about what was working well in recruitment was applied as recruitment progressed.

2.3 What enables and hinders effective recruitment?

A number of themes emerged through the analysis, which had an enabling or hindering impact on recruitment. These are summarised below and then explained in more detail. They include:

- perceived relevance of the offer
- establishing key local contacts and networks
- commissioning and contracting
- credibility of IOP
- taster CPD sessions
- cost
- geographic location.

Perceived relevance of the offer

One of the challenges of recruitment was the relatively crowded landscape of science, technology, engineering and mathematics (STEM) support available to schools in the target areas. An important aspect of recruitment was, therefore, identifying the unique selling point of FPL to distinguish it from the plethora of alternative interventions (e.g. STEM Learning Aspire to STEM programme; Science Learning Partnerships CPD; Ogden Trust CPD). The delivery team quickly identified and highlighted the distinctive aspect of FPL in offering a package of support that could improve physics teaching from a number of angles; namely, both providing direct training for non-specialist physics teachers *and* building the leadership capacity of physics specialists to provide longer-term support for physics teaching. Numerous interviewees, both from the delivery team and participants themselves, reported that the FPL offer resonated with schools' needs.

> A lot of the schools I work with in [Hub name] don't have specialist physics teachers, so as soon as they saw that the IOP could come in and support with their physics CPD, they were like 'yes, please come and whatever you can give us we'll have'. - *IOP development coach*

Participants' reasons for engaging with the project reflected that they considered it highly relevant to their needs to improve physics teaching. For SBDCs in Lead Schools, this need was to help improve physics teaching in their local schools, which would, in turn, enhance student interest in physics. All interviewed SBDCs highlighted that their schools were located in deprived, under-performing areas with relatively poor uptake of A-level physics. Specialist physics teachers were keen to develop their physics pedagogy, leadership skills and links with other physics teachers in the area. Non-specialist physics teachers saw physics as their weakest science subject and wanted to improve their physics knowledge and pedagogy. NQTs valued the opportunity to network with, and receive support from, more experienced physics specialists.

Heads of science and other participants from Partner Schools reported that additional department/school reasons for taking part in FPL were to improve physics practice and standards in the department, and to support non-specialist physics teaching, as schools often struggled to recruit physics specialists. Heads of department also found the NQT mentoring appealing in providing additional subject-specific support that they might otherwise have not been able to provide in school.

In contrast, delivery staff reported instances of schools that did not perceive FPL as highly relevant, and where physics development was not a priority, in these cases, this was a hindrance to recruitment. This was common in schools in challenging circumstances that were dealing with fundamental challenges across the school, concentrating on other core subject areas, and where there was a risk of over-burdening staff with additional CPD.

Establishing key local contacts and networks

Delivery staff regarded identification of, and communication with, key local contacts as an enabler to effective recruitment. At a strategic level, this involved building relationships and raising awareness of the offer with influential people in each locality, such as MAT and TSA leaders, and gathering intelligence to enable the targeting of specific schools who might benefit from the support. At an operational level, this involved targeting key individuals within schools, often the physics lead or head of department, who had the greatest investment in developing physics and could champion this within their own setting. Ensuring the IOP development coaches were confident and skilled in networking and building these relationships locally was a key enabling factor in successful recruitment.

Conversely, initial recruitment was hampered by a lack of capacity in the delivery team to establish local contacts and networks whilst development coaches were still being appointed. There was also some early uncertainty about the process for recruiting schools in OAs and working with DfE OA leads. As an organisation, the IOP did not have an established reputation working with priority schools in priority areas, so it took time to raise schools' awareness and build confidence and trust in the FPL offer. The FPL project manager also reflected that recruitment would have benefited from even greater strategic networking, such as with MAT leaders.

Sustaining engagement with FPL was also hindered by relatively high levels of churn in schools, with key contacts leaving participating schools, which sometimes resulted in inconsistent commitment to the project. This necessitated ongoing recruitment to replace lost contacts.

Finally, in at least one hub, establishing a local physics network had been hindered by a lack of collaboration between schools. For example, one school did not wish to attend training hosted at a neighbouring school, which it considered itself to be in competition with in terms of pupil recruitment and performance.

Commissioning and contracting

Several members of the delivery team identified contractual requirements and targets as a challenge. This was particularly an issue in the early stages of recruitment, which focused on identifying Lead Schools to become 'hubs' of physics specialist support for local Partner Schools. Lead Schools were typically rated as 'outstanding' by Ofsted and, therefore, did not meet the target criteria for FPL. As Partner Schools with the targeted Ofsted category 3 or 4 were recruited, this challenge abated somewhat. Additionally, schools with an Ofsted category 3 or 4 located slightly out of the target geographic areas could not be recruited.

While the recruitment target set for the project allowed for 30 per cent of participants to be from non-priority schools in recognition of schools' varying contexts, the requirement to target Ofsted category 3 or 4 schools remained something of a challenge (see Appendix I). In some cases, the requirements inhibited recruitment of schools with an Ofsted category 1 or 2 but with justifiable needs for physics support (e.g. high levels of non-specialist physics teaching). Consequently, some schools that might have benefited from the physics support were not able to be recruited to the project. This indicates that it is important to consider physics needs specifically as a factor in targeting highly specialised support such as FPL.

Credibility of IOP

Both delivery staff and participants identified the credibility of the IOP and local development coaches as an enabling factor in recruitment. Many physics specialist participants were aware of the IOP, often having engaged with their support previously, and were reassured that FPL would offer high-quality support and help to address needs in developing physics teaching. The IOP development coaches were sometimes known in their local areas and were highly regarded for having strong subject knowledge and experience of teaching physics in schools. None of the interviewees identified concerns or barriers in relation to IOP as the FPL provider.

Taster CPD sessions

Taster CPD sessions and initial hub planning meetings were a valued means of providing participants with insight into the quality and content of FPL, and of gathering intelligence regarding participants' specific needs for the support. These factors reinforced the relevance and responsiveness of the provision, resulting in a high level of commitment to it.

Cost

Some delivery staff and participants also highlighted the cost of FPL as enabling recruitment. The FPL support was free to schools and the project offered to reimburse cover costs for staff to attend specialist training, which mitigated any potential cost barriers. Alternatively, when provision was out-of-school hours, there were, again, no financial obstacles to participation. Often participants could attend the training relatively independently without necessarily justifying this through a formal CPD application process, or the school was happy to support participation as there were very few adverse consequences to assuage, such as costs and staff absence from teaching.

Geographic location

Some delivery staff and participants suggested geographic location of FPL enabled recruitment. The FPL support was delivered in local ‘hub’ schools and at participants’ own schools so involved minimal travel time commitment. Occasionally, geographic location was a hindering factor as the local hub location was not sufficiently accessible for some participants, for instance those located in rural areas or in traffic-congested cities.

3 Delivery and implementation of learning

3.1 Progress in delivery

Overall, FPL was **delivered as planned** from spring 2018 to spring 2020, with only minor adaptations in practice. As a result of recruitment challenges, delivery was on a rolling basis rather than as two discrete cohorts, as was planned at the outset. It was originally envisaged that each participant would access one strand of specific support, however, in practice, participants often received support via more than one strand (e.g. NQTs attended CPD designed for specialist physics teachers).

One **substantial modification** to the delivery model was that not all of the CPD took place at the hubs' (Lead Schools') premises. Some of the CPD was, instead, hosted at Partner Schools' premises and, in one case, at a higher education institution (HEI) in a central location. Moreover, in several hubs, IOP development coaches visited Partner Schools to deliver bespoke CPD sessions to the whole science department during departmental meetings or school CPD time, and helped teachers and technicians better understand the equipment they had in their school.

Our qualitative analysis indicated that there was a **reasonable degree of consistency in the nature and standard of delivery across the regions and hubs**, although some hubs took longer to be established and start delivery. However, interviewee evidence also indicated some occasional instances where delivery was variable across the hubs depending on particular conditions, such as the physics capacity to build upon in some areas (e.g. a paucity of physics specialists in a position to develop and fulfil a role as future physics leaders).

Due to the Covid-19 pandemic, delivery was disrupted in the very final stages. Although the project always planned to conclude at the end of March 2020, some face-to-face CPD sessions that had been planned for March were disrupted due to Covid-19, which resulted in social distancing measures and school closures. However, during this time, IOP development coaches offered online and remote support to participating schools as an alternative.

The following sub-sections describe the nature of delivery in relation to each of the four strands of FPL, as described by interviewees.

3.1.1 FPL support for school-based development coaches (SBDCs)

SBDCs were physics specialists based in Lead Schools who were supported through the FPL project to develop as future school-based development coaches. As part of FPL, SBDCs were seconded to the role for six days a year from their day-to-day role in their school. Support for SBDCs usually began with a discussion with the IOP development coach to ascertain the SBDC's background in physics leadership and CPD delivery. Following this, the IOP development coach devised an appropriate package of support and coaching opportunities through the FPL project. SBDCs helped IOP development coaches to plan the specialist and non-specialist CPD sessions for their schools and teachers, including identifying the content, equipment and aspects they would take responsibility for delivering. At CPD sessions, SBDCs initially observed IOP development coaches leading delivery and gradually took ownership for delivering the training themselves at a pace which reflected their level of confidence. At CPD sessions, SBDCs ran break-out groups, helped with practical activities and delivered parts of the sessions themselves. SBDCs also attended central training days (for all FPL SBDCs) focusing on mentoring skills and physics leadership, and supporting physics teaching in their local areas. Finally, some SBDCs were also involved towards the latter part of the project in providing coaching support to FPL NQTs and RQTs (recently-qualified teachers), gradually taking over responsibility for this role from the IOP development coaches.

3.1.2 FPL support for specialist physics teachers

Specialist physics CPD sessions were run as intended, delivered at a local hub (usually the Lead School) for a full day per term. These sessions were tailored towards the needs of the group of specialist teachers in each hub – identified at an initial hub planning meeting and modified on an ongoing basis. The sessions were normally topic-based (e.g. focused on electricity, forces, or energy) or theme based (e.g. focused on mathematics in physics) and were often linked to examination specifications or evidence-based and practical approaches to physics teaching. They focused on how physics specialists could support their non-specialist colleagues in teaching the topics they found challenging, for instance, by devising training modules and schemes of work to include clear explanation and simple practicals. Towards the latter part of the project, and as planned in order to build physics teaching and leadership capacity in target areas and schools, physics specialist participants were also increasingly involved in providing coaching support to FPL NQTs and RQTs.

FPL support for non-specialist physics teachers

As planned, non-specialist CPD sessions were delivered as one twilight session (one and a half hours after school) per term. These were intended to be delivered at the hub (Lead School), although also took place at various Partner Schools in response to individual school requirements. Non-specialist CPD sessions focused on developing subject and pedagogical knowledge by helping non-specialists to better understand common physics misconceptions and the appropriate language to use when teaching. They also introduced them to simple activities, resources and practicals that could be used to deepen pupils' understanding of a topic.

FPL support for physics NQTs

As planned, NQTs received one-to-one mentoring from an IOP development coach. This involved face-to-face meetings in the mentee's school, as well as ongoing remote email contact and support as required. The frequency of support was tailored to NQTs' needs and availability, though tended to involve several interactions each term. The focus of the mentoring sessions was tailored towards each individual's needs. Examples of the support requested and provided included: support with ideas and resources for teaching up-coming topics and concepts, and how to make them more engaging; help with teaching A-level physics; help with setting up experiments; advice on behaviour management during practical physics activities; and observing and reviewing physics teaching practice. In one case, the mentoring also focused on supporting the NQT, as the only physics specialist in their department, to train non-specialist physics teachers in their department on specific physics topics. Some NQTs also attended the specialist CPD sessions, although they were not always able to be released by their school to attend every session available. Support for NQTs also included a sympathetic timetable – which concentrated their time on teaching physics lessons to repeat year groups as much as possible - to enable them to hone their specialist teaching practices, build confidence, and reduce their planning time. While the survey responses indicated that some NQTs had this in place (see Table 62, Appendix H), this was not a prominent feature of the support for the NQTs interviewed as part of the evaluation, revealing that it was not always possible for the schools to facilitate this requirement due to wider timetabling and staffing considerations. However, feedback from the FPL project manager, based on internal evaluation data, indicated that NQTs valued this aspect for consolidating their physics planning time and reducing their workload. At the time of interviewing, none of the interviewed NQTs had involvement with the SBDC as part of their mentoring support. However, as part of FPL, SBDCs were trained to mentor physics NQTs and early-career teachers in the future and the endpoint survey, conducted near the end of the FPL project, indicated that this was beginning to happen for a couple of NQT respondents.

3.2 Participant engagement and satisfaction

The endpoint survey asked participants, which of the aspects of FPL they had engaged with, to what extent, and whether the activity had met their needs. The frequencies of responses are provided in Appendix H. Respondents were routed to specific questions depending on the strand of FPL they had registered to engage with: school-based development coach; specialist physics CPD; non-specialist physics CPD; and NQT subject-specific mentoring. The number of responses is too small to support robust findings by sub-group, but there are several noteworthy observations from the responses:

- not all participants engaged with all aspects of the project available to them (e.g. some SBDCs did not attend national CPD sessions; some physics specialists were not involved in supporting physics NQTs). While the flexibility of the project – to enable participants to access the elements most relevant to their needs – was praised by interviewees, this does mean that not all participants may have benefited from the full package of support available through the project
- the majority of participants had engaged either ‘moderately’ or ‘fully’ with the main aspects of the project
- the majority of participants reported that the elements of the project that they had engaged with either ‘moderately’ or ‘fully’ met their needs.

The endpoint survey asked participants to rate their overall experience of being involved in FPL on a scale of 1 to 8 with 1 being ‘very poor’ and 8 being ‘very good’. Table 1 below shows that **95 per cent of participants rated the project as either good or very good**, with the largest proportion of responses being in the latter category. This evidence resonates with the project’s internal monitoring customer satisfaction data, which showed that more than 80 per cent of participants rated the provision as good or above.

Table 1 Satisfaction with the FPL project

	Very poor	Poor	Good	Very good	Total
Likert scale	1-2	3-4	5-6	7-8	
Number of respondents	0	5	28	78	111
Percentage of respondents	0	5	25	70	100

A total of 13 participants did not see this question as they were routed out of the survey at an earlier question – responding that they were ‘not at all’ involved in the FPL project.

Interviewed participants were unanimously positive about the support they had received through FPL, with most commenting that they were extremely satisfied with the provision overall:

> …how delighted and grateful we’ve been to have the opportunity to work on the Future Physics Leaders course and the subsequent things that we’ve benefited from, it’s been an absolute joy to have and I would be very sorry if it came to an end. - *FPL participant*

> I’m not sure I could have asked for more. I was terrified that I was going to drown under everything this year because everyone told me that my NQT year would be the hardest and I think without the programme, it would have been. But always having the support and someone to turn to has been great. - *FPL participant*

> Really pleased with it. The fact that it's for free and so valuable and it's had an impact. - *FPL participant*

3.3 Progress in the implementation of learning

The FPL project provided opportunities for learning to be implemented through its provision, but it did not offer structured school-level support. The FPL project supported implementation by including practical, ready-to-implement and 'quick win' physics pedagogical strategies in the training, and, for mentors, by scaffolding their increasing ownership for delivering CPD sessions.

School-based interviewees described **numerous examples of implementing learning from FPL in their physics teaching and leadership practices**. They explained how this had led to positive impacts regarding the quality of their physics teaching and leadership, and subsequently to beneficial impacts on their colleagues and pupils (explored in Section 4 – Outcomes and impacts of the provision).

3.3.1 Implementing new knowledge and ideas in physics teaching practice

Participants reported implementing knowledge gained from FPL into their practice regarding alternative ways to explain physics to pupils. For example, one teacher described a case of learning some simple, but effective, ways of explaining magnetism and electricity, explaining that these were "very innovative ideas that work really well, the students really love them".

Other participants reported drawing on knowledge gained in the CPD sessions about cross-curricular links and the physics curriculum for different key stages, to enhance their physics teaching:

> Being able to scaffold all the Key Stage 3 schemes of work, because you are much more confident in what you are building towards in the Key Stage 4 physics topics, you can produce a better range of lessons for Year 7 and 8 that are touching on the right information and building them towards that more effectively. - *FPL participant and Head of Science*

Some participants reported changing the way they taught particular topics based on the latest evidence-based practice introduced during the project. For instance, teachers altered the language they used to explain the topic of forces to explain this concept to their pupils. Very often, the CPD had introduced participants to new ideas for practicals and demonstrations, which they could use with their pupils to convey particular concepts that could be more easily understood using a visual example, as opposed to explaining verbally:

> It’s developed my knowledge, my practice and teaching skills. The way I explain the topic. Great ideas to explain quite difficult concepts in a more simple way and things that apply to our students – so getting on their level a bit. And misconceptions, because we don’t always know what the misconceptions might be, because we’re not specialists and they point them out for us and that’s lovely. - *FPL participant*

Interviewees explained that the FPL support provided the resources they needed to be able to readily implement the new ideas in their practice. Often the practicals demonstrated during the sessions included simple, everyday equipment so that participants could replicate these in their own settings. The FPL project manager and IOP development coaches also reported insights from training evaluation forms, highlighting that the majority of participants intended to use the physics practices that they had been introduced to during training in their classroom practice.

3.3.2 Implementing new knowledge and ideas in physics leadership practice

As a result of acquiring new knowledge and skills from FPL training and mentoring regarding how to effectively lead physics development, some participants were beginning to implement changes to their physics leadership practices. In some cases, the physics specialists were starting to deliver increased support and CPD within their departments, and to feed back learning and new practice ideas to their colleagues. Similarly, SBDCs reported feeling more equipped with the knowledge and skills to provide physics training, mentoring and support to colleagues in their local schools:

> Once the funding is over, our role within [the locality] is to help other physicists. I feel FPL has made me ready to lead that role from here on. - *FPL participant*

3.3.3 Sharing new knowledge and ideas with colleagues

Learning from FPL had also been implemented in the form of sharing new ideas with colleagues, which was leading to enhancements in colleagues’ physics knowledge and practice. In one school, the process for sharing new ideas had been formalised at the weekly departmental meeting. This implementation was particularly aided by the FPL model, whereby numerous staff in the department had received the support first-hand and, therefore, all had something to share and were similarly inspired by the ideas, creating a culture of sharing support for physics. This was felt to be more effective than the typical model of a single member of staff attending external training and then trying to cascade what they had learned, which can lead to a dilution of the original knowledge and inspiration:

> Staff are more likely to try new ideas and then share whether they've worked or not, which is not something that has happened in the past. - *FPL participant*

> The whole department have the feeling that we are doing something to improve ourselves. - *FPL participant*

3.4 Challenges and enablers in effective delivery and implementation of learning

Interviewees reported a range of challenges and enablers to effective delivery and the implementation of learning. These are grouped under key headings below.

3.4.1 Factors related to the provider/provision

Through the analysis of interviews, a number of themes emerged about the project's features and how they enabled or hindered delivery and implementation of learning. These themes are:

- content, focus and resources
- tailoring and customisation
- quality of the delivery team
- local hub model and collaboration
- structure, timing and cost.

Each of these themes is explained in more detail below.

Content, focus and resources

The **content, focus and resources** of FPL were frequently noted across all types of interviewees as enabling effective delivery.

Firstly, delivery staff and participants considered the **content** of the CPD and mentoring support to be very relevant to the curriculum and examination specifications, and to addressing pupils' common misconceptions.

Secondly, the **focus of the support** on different groups of participants and flexibility to access different and multiple strands of support was widely welcomed. This flexibility enabled holistic support for physics teaching and leadership in participating schools. The four distinctive strands of the project were valued and thought to complement each other and enable numerous physics teaching staff in schools to access the support that was appropriate to their needs.

In particular, the support for both physics teaching *and* leadership was highly valued. SBDCs and specialist participants particularly praised the focus of the support they received for leading physics. This was achieved through direct training on coaching and leadership skills, opportunities to observe, design and deliver physics CPD in collaboration with IOP development coaches, and discussion about developing physics in schools:

> My mentor from the IOP held my hand through the delivery the first couple of sessions, because I'd never done one before - this is what you've got to say, this is the language you use, this is where you should stand and look. To moving back a little now to 'you're going to lead the first bit, I will chip in'. Really, properly mentoring me to deliver that. That's been amazing. There wouldn't have been any other opportunity for me to have that, if you're working in a school no one is going to come and mentor you to mentor anybody else, so the FPL has really given me that opportunity to be mentored to become a mentor. - *FPL participant*

The focus on non-specialist physics teachers – providing pragmatic solutions and practical ideas to enhance their teaching - was similarly commended by participants and delivery staff, who recognised the high demand for this support given the physics specialist shortage. NQT physics teachers also valued their bespoke strand of support, which provided practical help with teaching physics and an alternative perspective to the line management they received in school.

Third, interviewees praised the FPL **resources**, which included easy to implement, evidence-based, practical ideas and resources to improve physics teaching. For instance, CPD sessions were very practically focused and involved demonstrations of how to teach a particular topic or concept, with a range of practicals using inexpensive equipment that participants were able to have a go with themselves and then easily replicate in their own teaching. One participant explained:

> The ideas and resources to use in lessons are very effective. I've used a lot of the resources in my lessons. - *FPL participant*

In some contrast to this, one of the main suggestions for improving FPL related to its content, focus and resources, although, typically, this amounted to an **appeal for *more* FPL support**, rather than a change of focus. For instance, several non-specialists wanted more comprehensive coverage of the physics curriculum or to go into greater depth on topics than it was possible to cover in three twilight sessions per year. There was also the occasional suggestion from physics specialist participants that the FPL support could have had an even greater emphasis on mentoring and leadership skills to support career development. Other isolated comments from participants called for sessions to be even more practical, for resources to be available in a central location or as a checklist of core physics resources, or to ensure that the resources used in demonstrations were widely available in schools. The recurrence of feedback relating to content, focus and resources may suggest the need to concentrate on this aspect of delivery in any future development of FPL; it will be important to ensure that the enabling features are consistently delivered across localities, and the inhibiting features addressed wherever feasible.

Tailoring and customisation

A strong theme across numerous interviews was the extent of **tailoring and customisation** of FPL. The delivery of FPL support was reportedly very responsive to participants' needs and there were opportunities for participants to shape the support in various ways. This included accessing different strands of support, discussion with the IOP development coach to inform CPD content, and feedback evaluation forms at the end of every session to explore what further support participants would like. Participants explained that this was distinctive from other forms of CPD they had experienced, and ensured it was highly accessible and relevant to their needs:

> They [the IOP development coach and SBDC] have got a plan for what they're going to do, but if we think 'no I don't get that' they are quite happy to stop what they'd planned and go where you need. You can ask 'why are you doing it that way?' I really valued that. - *FPL participant*

Occasional comments suggested that, in some cases, there was a lack of tailoring and customisation of FPL provision. For instance, at hub CPD sessions there was a degree of compromise to focus on the collective needs of schools attending, and some interviewees felt that the process for participants to influence the CPD could have been more explicit and democratic. These findings suggest that scope for tailoring and customisation should be a strong, and possibly more formal, feature of any future FPL model. However, interviewees were also realistic about the costs and feasibility of sustaining this type of support in any future FPL model.

Quality of the delivery team

The perceived **quality** of IOP development coaches and, where applicable, the school-based development coaches, was an enabler of effective delivery. Participants commended coaches' physics subject knowledge, and school teaching and leadership experience:

> It's really great to get out of school and discuss ideas with other people who've got the same level of understanding. With [the IOP development coach] and [SBDC] it's really good physics, really high quality, whatever they give us actually works and by the end of it we've got confirmed answers. The quality of the coaches is absolutely top notch – both of them have been outstanding. - *FPL participant*

Participants also praised coaches' highly **proactive, practical and responsive approaches**. For instance, SBDCs appreciated the way IOP development coaches structured and scaffolded the support; providing considerable input and modelling initially and gradually reducing this to transition increasing responsibility for delivering the CPD to the SBDCs. Several participants also noted IOP development coaches' personal qualities in creating positive environments for teachers' development, such as listening and being open to participants' own ideas and experiences, and being supportive, encouraging and approachable.

The project manager and IOP development coaches explained that the standard of the delivery team had been facilitated by **careful recruitment of development coaches and effective training and support**. All members of the team had strong backgrounds in physics, teaching and delivering CPD. Development coaches were provided with additional coaching training, as well as training on some of the specific content of the project, such as the gender imbalance in physics and recommended approaches to teaching specific aspects of physics informed by the latest research evidence. All five of the IOP development coaches interviewed felt that they were well prepared for, and supported in, their role in FPL.

Consistent delivery across the hubs was facilitated by a **central bank of project materials,** which was developed and peer-reviewed by the coaches themselves. The materials acted as a guide for IOP development coaches and SBDCs, although they were adapted to suit different coaching styles and hub audiences. Coherent delivery was also enabled by **ongoing support for the network of development coaches** through regional and national meetings and line management by a team leader in each region. These meetings provided an opportunity for networking with other coaches and sharing of best practice. In addition, development coaches were encouraged to shadow colleagues delivering CPD sessions and valued this support:

> Part of the time allocation to this job was to allow us to go and visit other coaches, either to support them or watch what they do. That was brilliant, I made use of that. You get a feel from those who have been doing it for a long time, you get to see the experts in action as it were and see how they cope. - *IOP development coach*

The quality of the delivery team was further substantiated by observation of an FPL CPD session, conducted by the DfE contract manager (presented in Box 1 below). Although just one isolated case may not be representative of all FPL delivery, the observer commented on the high quality of the coach in this case, and their effective communication and delivery skills, understanding as a teaching practitioner, and flexibility to adjust the content and focus of their support to meet the needs of participants.

Box 1: Observation of FPL CPD

This was a workshop open to all teachers of science (including non-physics specialists), teaching electricity to Key Stage 3 and Key Stage 4 students.

The facilitator was very experienced, with excellent communication and delivery skills. As an active practitioner in a local school, he also had a very good understanding of the local context and challenges facing individual schools. It was also evident, from references made to previous contacts between the facilitator and participants, that the facilitator had made prior visits to individual participants in their school settings and that this had helped establish good working relationships and trust.

Only one participant was able to attend the workshop, however, I was impressed by the flexibility of the facilitator, who set aside his planned delivery session to focus on the needs and preferences of the attendee. This resulted in 1.5 hours of one-to-one tuition which covered theory and practical examples tailored to the specific needs of the attendee. The participant was highly engaged and I observed lots of in-depth, two-way discussion.

The purpose built venue was also impressive and created an excellent learning space for both discussion and practical work.

It was unfortunate that only one participant (out of four who had registered) was able to attend. This undoubtedly impacted on the wider discussion and breadth of experience that a larger peer group would have brought.

The facilitator thought that the late-January slot was potentially a busy time for schools in the lead up to the exam period and that this had impacted on attendance. Reflecting on the poor turnout the facilitator suggested that his next workshop (scheduled for March) could be reworked to focus on revision topics.

Having a good, working knowledge of local schools, the facilitator was able to make links with the practical methods used by high-performing schools. For example, he recommended that the participant got in touch with a contact at [another local school] to potentially share specialist equipment, which would otherwise be expensive (per usage) for the participant's school to purchase.

None of the interviewees reported that the quality of the delivery team was a barrier to effective delivery.

Local hub model and collaboration

Participants and delivery staff reported that the local hub model enabled effective delivery of FPL for two main reasons.

First, CPD sessions tended to be delivered at a central location within each hub area that was **accessible for local schools**, thus reducing travel time and costs, and increasing participation. Where the Lead School was not so central in the locality, alternative arrangements were often made to ensure accessibility, for example, hosting the CPD at a local HEI venue or at various Partner Schools.

Second, participants noted that the local hub model enabled teachers of physics in local schools to **network and share good practice**. This was particularly valued by physics specialists who developed relationships with other local physics teachers while attending hub CPD. This networking opportunity was particularly appreciated by specialists as they were often quite isolated as the only physics specialist in their school. Yet, the local hub model was also mentioned by non-specialists who regarded the CPD sessions as a 'melting pot' of ideas for teaching physics effectively. Another related enabling feature was having two SBDCs in a hub, or several SBDCs across a region who could network together, as this facilitated collaboration, exchange of ideas and sharing responsibility for the role:

> Something that worked well last academic year and got feedback, and what's different about the FPL scheme, is getting schools to work together. They get to talk to teachers from other schools – 'how do you do this?' That's been one of the best things that's happened – getting teachers together, and they really seem to value that. - *IOP development coach*

In contrast, some participants and delivery staff were sceptical about the local hub model and, in particular, the sustainability of this model. Some acknowledged that it takes time to build a network and proposed that this would require greater emphasis in the final stages of the project to **facilitate stronger networks** and more sustained collaboration between local schools in order for any networking to continue beyond the lifetime of the project. Although participants thought that sharing within the CPD sessions was effective, some identified that this was not sufficiently facilitated beyond and in-between the sessions. In addition, one participant thought there was limited scope for **connecting physics NQTs** in the locality to provide mutual support. The model was also hindered by a shortage of physics specialists to participate in sustainable local hub networks. One suggestion for overcoming this challenge was to link nearby hubs within a region. Finally, some participants disliked local hub delivery, preferring **the more bespoke and accessible approach** of delivery in their own school. This raises a question about how the much-valued customised elements of the project can be integrated with the similarly valued opportunities for networking and collaboration.

Further questions were raised by both delivery staff and participants in relation to the **logistics of the future role of SBDCs**. While the project appeared effective in developing their skills to adopt a future role in providing local physics support, the logistics of how this could be achieved required clarification. One possibility being explored by the delivery team towards the end of the project was to coordinate with existing structures for local CPD delivery and subject support in the localities, for instance, CPD provided by Teaching Schools and MATs. Options for delivering some of the support remotely, such as mentoring, were also being explored. Finally, the IOP project manager was also keen to see how the SBDC role could potentially grow and be sustained with links to Chartered Physics Status and National Professional Qualifications (NPQs).

Structure, timing and cost

Occasionally, participants commented on the **structure and timing** of FPL. Enabling factors included that: the full day training for specialists gave participants the opportunity to focus on their development; and twilight sessions for non-specialists were short and easy to access since they were delivered out of school hours. The structure of the training also worked well where the content of sessions coincided with a topic that the participant was about to teach, so they could immediately apply the new idea and learning. Although the core content of the FPL project was pre-determined by IOP based on their prior experience of schools' needs, to some degree the timing and content of the training sessions were shaped by participants, as they had opportunities at the start and throughout the project to request additional topics they wished to cover. Participation in FPL was also enabled by it being **free of charge to schools,** which reduced competition with other priorities.

However, interviewees also identified a number of hindrances related to the structure and timing of FPL. First, they reported that the project did not provide sufficient time to support non-specialists, who sometimes required more intensive and in-depth coverage of physics topics. Second, the often low levels of attendance at **non-specialist twilight CPD** sessions at the hub indicated an issue with timing – delivery staff indicated that non-specialists were often unable and/or unwilling to commit their own time after school to travel to hub locations and attend sessions, and to prioritise physics above competing demands. The observed FPL training session, where only one participant attended, provided further evidence that getting teachers out of school to attend CPD, particularly non-specialists was in some cases challenging. This challenge was often surmounted by the IOP development coach and SBDC providing bespoke CPD in individual schools to the whole department during departmental meeting or training time. One participant suggested that video recordings of training might also provide a conveniently accessible resource. Interviewees explained that certain times in the school calendar were better for CPD than others, for instance, avoiding the late spring and early summer term when schools were focused on revision sessions and examinations. It was suggested that a key enabler in encouraging attendance was having training dates scheduled in advance for the full academic year.

3.4.2 Factors related to the school climate/context

In addition to the various project-related factors that were perceived to have contributed to, or hindered, effective delivery, there were also a smaller number of school- and participant-level factors identified by interviewees that either enabled or hindered effective implementation.

The most frequently mentioned school-level factor was **senior support for participation** in FPL. Key staff to involve were the head of science (or physics) and a senior leader of the school or MAT. School support for FPL included encouraging teacher participation, releasing staff to participate in the training, or reducing some of their other commitments to enable them to attend, such as attending the FPL CPD in place of departmental meetings or other CPD:

> I find that so much depends upon the head of the department. If they can rally the troops and say ‘hey come on folks this is going to be really important for us, this is really good, if possible I’d like you all to be there’ then you can pretty much get the whole department. - *IOP development coach*

Conversely, this factor soon became a hindrance to implementation where support was absent or where there was no encouragement to prioritise a focus on physics and staff professional development. Changes of senior leader and key contact staff were reported to have a substantial effect on maintaining this level of senior support. Although FPL offered funding to cover the cost of supply cover to enable staff to attend CPD during school hours, some participants implied that their school leaders preferred to keep their teachers in the classroom.

Another influential factor was **teacher engagement**. Where this was strong and the individual participant could see the relevance of FPL for developing their physics teaching, implementation of learning was more effective. In one example, teachers of physics across a department had been encouraged to see greater relevance in the FPL training as the head of science had conducted an audit of physics teaching and consulted with teachers about their physics support needs, then liaised with the IOP development coach to design a bespoke package of support to address these. Some participants, particularly non-specialists who were not necessarily teaching that much physics or particularly passionate about the subject, had less motivation to engage with FPL or implement the learning to change their practice. Teacher engagement also influenced the extent to which participants were inclined to use the ideas from FPL training and mentoring to develop physics teaching practice across the department.

Implementation of the learning from FPL involved participants **embedding the learning, ideas and resources** into their lesson plans and schemes of work and having **time** to do this. **Collaboration and support from the head of department and school senior leadership** also enabled effective implementation of learning. Where several staff in the department had engaged with the FPL training, the task of implementing the learning could be shared – with each teacher taking responsibility for trialling a particular idea or practical, organising resources and writing the activity into a lesson plan, and perhaps modelling the delivery to others. Teachers were more likely to adopt the ideas if they had seen them used in practice with good effect. In one case, this collaborative involvement had included staff from across a MAT. Collaboration also facilitated reflection and consolidation of ideas and meant that the learning from the FPL training could be discussed within the department and a collective decision made about whether and how to change teaching practice. In several cases, the head of science or physics in the school attended the FPL training along with their colleagues to encourage participation and development as a department:

> It was nice that we [the department] all did it together, because we weren't all physics specialists, we could get a collective idea of it all at the same time. Some of us would take it from one perspective and some of us would need a bit more of a hands on approach, but it meant when we got back to school we could all discuss it and suggest how we'd plan the curriculum going onwards, because we all had the same ideas and could adapt to what we'd seen at the session or could go with a few questions. It put us all on a level

> playing field, rather than one person getting all the knowledge and having to filter down; one person's notes is never as good as actually being there. - *FPL participant*

Workload and competing priorities were a common hindrance to effective implementation, presenting a challenge to teachers' time to engage with the CPD and mentoring and then implement the learning to change their practice. Again, where participants could see the relevance and value of the support, it competed more favourably with other commitments.

Implementation was also facilitated and hindered by the **role of the participant.** Where the participant was in a role that enabled them to implement the learning from FPL more directly, the impact was greater. For instance, physics specialists who had responsibility for leading the subject were more inclined to capitalise on the influx of new ideas from FPL. On the other hand, while the participants interviewed were well engaged, delivery staff indicated that where participants did not have a directly relevant role, they were less likely to benefit as much from the FPL training. For instance, non-specialists who were not teaching much physics.

Finally, the **wider policy context** was also reportedly conducive to engagement with, and implementation of, FPL learning. For instance, the introduction of the new Ofsted Framework, Standard for Teachers Professional Development and Early-Career Framework, were reported to have helped to raise the profile of subject-based professional development, and mentoring.

4 Outcomes and impacts of the provision

This section considers the extent to which FPL achieved its intended project outcomes (see Appendix A and Tables 2-5) as well as the contribution it made to the TLIF programme's intended impacts and outcomes. It draws on survey data to report changes from baseline to endpoint on a number of outcome measures and secondary analysis of SWC data to report changes in teacher retention and progression. These findings are supported by qualitative data, which adds insight into different stakeholders' perceptions of the outcomes of the project, and provides context for the interpretation of outcomes.

The analysis of impacts utilises a comparison group design. This enables us to estimate counterfactual retention outcomes for teachers, and infer whether or not changes in teacher retention and progression might have come about in the absence of FPL. However, we did not adopt a comparison group design for the survey. We measured changes between baseline and endpoint in participants' views and experiences. This means that, while we can show an association between the project and observed outcomes, we cannot provide evidence to support a causal link. It is possible that any reported outcomes might still have come about in the absence of the project.

4.1 Context for interpretation of outcomes

Although we have attempted to collect comparable fund-level outcome data for all TLIF projects, in practice the projects' intentions, with regard to achieving these outcomes, differed. The FPL project attempted to achieve most of the fund-level outcomes, but not improvements in school culture, reduced pupil exclusions/improved attendance, or improved school Ofsted rating. This should be borne in mind when interpreting the outcomes reported in Section 4.4 below.

4.2 Context for interpretation of impacts

The FPL project attempted to achieve fund-level and project-level impacts to improve teacher retention and progression, and also improve pupil attainment in physics. In relation to progression, it should be noted that, given the focus of the FPL project on developing teachers' physics teaching and leadership, it would only be feasible for the project to impact directly on progression in terms of increased responsibility for, and leadership of, physics specifically. Therefore, it is possible that such progression would not be captured in the analysis of progression to middle leadership posts recorded in the SWC. It is also worth highlighting that pupil impacts were explored via teacher perceptions conveyed in survey responses, rather than attainment data, which was unavailable for the respective cohorts due to the Covid-19 pandemic.

4.3 Observed outcomes

In this section, we report findings from a statistical technique called factor analysis that summarises information from a number of items asked in both the baseline and endpoint surveys into a smaller set of reliable outcome measures. By exploring whether there were statistically significant[12] changes in the mean scores of these factors between baseline and endpoint, we explored whether the FPL project had had an impact on participating teachers. This allowed for a more robust and straightforward analysis than comparing single items from the surveys. The factor analysis was based on a matched analysis of the same respondents who answered at both baseline and endpoint. Further information about how the factors were constructed can be found in Appendix F. In instances where individual survey items did not form a factor, but were deemed to be particularly noteworthy, these have been reported separately.

Some caution should be undertaken in interpreting the findings. Overall, the response rates to the survey were low. The overall matched sample of participants who completed a baseline and endpoint survey was 87. For factors specific to the role of respondents (i.e. class teachers (CT); middle leaders (ML); and senior leaders (SL)), the number of cases available for analysis was reduced further (CT N=51; ML N=28; SL N=8). The number of cases was also reduced for specific factors if some respondents did not provide a response. Due to the very small underlying number of respondents in the matched analysis, it was not possible to undertake subgroup analysis (for example to explore any variations in impact by type of FPL participant or years in teaching).

The survey findings are supplemented with the findings from qualitative interviews with FPL participants, IOP development coaches and the FPL project manager. These interviews explored respondents' perceptions of the outcomes of involvement in the project on different stakeholder groups (FPL participants, other school staff and pupils). It should be noted that, at the time of interviewing, participants had not yet reached the end of their involvement with FPL, so the outcomes they describe may be more intermediate. We have extrapolated from both the qualitative and quantitative data to illustrate where there are indications of fund-level outcomes having been achieved, or not.

4.4 TLIF and bespoke project outcomes and impacts

The tables below detail the outcomes (most of which we expected to see earlier i.e. within a year of project involvement) and impacts (which take longer to realise) that the FPL project intended to achieve.

[12] Results were considered statistically significant if the probability of a result occurring by chance was less than five per cent ($p = < 0.05$).

Table 2 Intended project outcomes for teachers

Theme	Outcome or impact
Subject knowledge (including tackling pupils' physics misconceptions)	Outcome
Subject pedagogical knowledge (including running engaging practicals, ensuring gender balance and gender neutral contexts, developing mental resilience)	Outcome
Knowledge of engaging and managing pupils	Outcome
Sense of community amongst physics teachers	Outcome
Changes in teaching practice	Outcome
Motivation for teaching physics	Outcome
More likely to stay in the profession	Outcome
Increased confidence in seeking out leadership roles/additional responsibility in next three years	Outcome
Subject leadership confidence	Outcome
Subject leadership knowledge	Outcome
Coaching and CPD delivery skills	Outcome

Table 3 Intended project outcomes for schools

Theme	Outcome or impact
Improved/sustainable capacity for providing CPD	Outcome
Increased engagement in/demand for CPD and aspiring middle leader development	Outcome
Improved NQT/teacher retention/decreased churn (and in comparison to teachers in parallel jobs)	Impact
Increased teacher quality e.g. measured by achievement of Chartered Physics Status (this intended project impact was not covered by the evaluation)	Impact

Table 4 Intended project outcomes for pupils

Theme	Outcome or impact
Increased pupil attainment in physics (number achieving a good pass increased by 5 percentage points)	Impact
Improved participation in physics post-16 including different groups e.g. girls, black and minority ethnic pupils, pupils of low socio-economic status (the proportion of pupils eligible for free school meals was used as a proxy) (progression to A-level increased by 15 per cent).	Impact

Table 5 Intended project outcomes for the local area/region

Theme	Outcome or impact
Increased number of physics specialist teachers in the Opportunity Areas targeted by the project	Impact
Improved teacher retention	Impact

The following sections reflect thematically on the extent to which there is evidence of progress towards these project-specific outcomes and the contribution of the project to achieving the TLIF ‘mediating outcomes’.

The participant baseline and endpoint surveys included a set of core-questions (i.e. items that were asked in all TLIF project evaluation surveys to measure fund-level outcomes), and bespoke project-questions (i.e. items that were asked in the FPL project evaluation survey only to measure project-level outcomes).

Analysis of the core question items was conducted in two stages. First, it was conducted on the core question items that were asked of all respondents in exactly the same way. This resulted in Factors 1 to 4 (see Appendix F) for all respondents. Second, it was conducted on core question items that covered consistent themes, but where the wording, or the inclusion, of items varied slightly depending on the role of the respondent (CT, ML, and SL). This resulted in Factors 5 to 8 for CTs; Factors 9 to 12 for MLs; and Factors 13 and 14 for SLs (see Appendix F). The FPL project evaluation included questions for classroom teachers, middle leaders, and senior leaders, although most of the respondents fell into the category of classroom teachers. Respondents were asked to rate a series of items on a scale of one to eight, where one was ‘Strongly Disagree’ and eight was ‘Strongly Agree’. The responses were then converted into a point score, with ‘Strongly Disagree’ being worth -4.0 points, and ‘Strongly Agree’ +4.0 points. Items were combined to produce a mean score, and compared between baseline and endpoint. To help interpret the mean scores, the maximum and minimum scores possible using this methodology were also calculated and are presented. A detailed description of the factor analysis undertaken on the core questions can be found in Appendix F.

Where question items did not form part of factors, these are reported separately in the relevant outcome sections below. Single items compare change over time by analysing any change in mean responses, on the eight-point rating scales, between baseline and endpoint.

The survey also included various questions and items that were bespoke and specific to the project focus on physics to measure project-level outcomes. Quantitative analysis included factor analysis of the bespoke question items. Factor analysis resulted in four project-level outcome measures (Factors 15 to 18) (see Appendix G), which are reported in the sections below. Where question items did not form part of factors, these are reported separately in the relevant outcome sections below.

The results of the survey responses are reported in tables that provide the number (N) of responses analysed. The maximum N for the analysis of the matched sample is 87. The maximum N for the analysis of the endpoint only questions is 124. The N may vary from these total figures where responses were missing (i.e. the respondent did not provide a response to the specific item/question); where particular response options were not analysed (e.g. 'don't know' or 'not applicable' responses) and/or where only certain types of respondent were shown a question (e.g. SBDCs were asked slightly different questions to non-specialists).

4.4.1 Participants' views on key outcomes related to the aims of FPL

This section reports the findings from surveys and interviews in relation to the FPL project aims outlined in Tables 2-5 above and the FPL project ToC (see Appendix A). Table 6 below displays a summary of the findings from the surveys, which explored whether there had been any statistically significant change over time (i.e. between baseline and endpoint) in respondents' views in relation to the project-specific outcome measures. Each project-specific outcome theme is explored in more detail in the following sub-sections along with the qualitative evidence.

Table 6 Project-level outcomes - summary of outcomes

Theme	Factor/item	Number of respondents	Statistically significant change over time ($p = <0.05$)
Quality of physics teaching	Physics subject knowledge	70	Yes (positive)
Quality of physics teaching	Confidence to teach physics	70	Yes (positive)
Quality of physics teaching	Physics pedagogy	70	Yes (positive)
Quality of physics subject leadership	Physics leadership knowledge and skills	78	Yes (positive)
Quality of physics subject leadership	Physics leadership practices	78	No
Demand and opportunities for physics CPD	Access to physics professional development	83	Yes (positive)
Demand and opportunities for physics CPD	Motivation to engage in physics professional development	83	No

Pupil physics participation and attainment	Pupil behaviour, attainment and progress in physics	70	Yes (positive)
Motivation for physics teaching and to remain in the profession	Motivation to teach physics	83	No
Motivation for physics teaching and to remain in the profession	Motivation for physics career progression	83	No

Quality of physics teaching

The FPL project ToC identified aims to improve the quality of participants' teaching, with a specific focus on physics teaching. Analysis of survey responses provides **evidence of improvements in FPL participants' physics subject knowledge, confidence to teach physics, and physics pedagogy** (including engaging pupils and putting new physics teaching strategies into practice) between the start and end of the project.

FPL participants responding to the survey were significantly more positive about their 'understanding of physics theory' at endpoint, compared to baseline. Table 7 below displays the analysis of participants' responses to the survey questions.

It should be noted that this question was asked to NQTs, specialists and non-specialists participating in FPL so it could be that the responses are inflated by high levels of physics subject knowledge among physics-NQTs and specialists. The response rates are too small to enable statistical analysis of any differences in responses by FPL participant groups, however, qualitative evidence indicates that impacts on participants' subject knowledge are likely to have been strongest on non-specialists.

Table 7 Project-level outcomes - physics subject knowledge

Item	Mean score Baseline	Mean score Endpoint	Mean score Change	N	Statistically significant change (p = <0.05)
I have a good understanding of physics theory	1.90	2.31	0.41	70	Yes (positive)

Item	Mean score Baseline	Mean score Endpoint	Mean score Change	N	Statistically significant change (p = <0.05)
I have knowledge of a range of recent developments in the applications of physics	0.47	0.89	0.41	70	No

Due to rounding, there may be small differences between the figures presented.

Insights from interviews with FPL participants indicated that improvements in physics subject knowledge were a particularly noticeable outcome discussed by non-specialist physics teachers. They reported acquiring new physics knowledge as a result of the FPL training and mentoring, which had: helped them to overcome their misconceptions of certain physics topics; deepened their understanding of physics; and provided new and simplified strategies for explaining physics concepts to pupils. Interviewees also reported gaining improved knowledge of the physics curriculum for different age groups, helping them to make more connections in their teaching.

As can be seen from Table 8 below, FPL participants responding to the survey were generally significantly more confident in their ability to teach physics at endpoint than they were at baseline. This was the case for teaching physics to Key Stage 3 and 4 pupils, teaching practical physics lessons and answering pupils' physics questions. However, respondents were generally less confident teaching physics to Key Stage 5 at both time points.

Table 8 Project-level outcomes - confidence to teach physics

Item	Mean score Baseline	Mean score Endpoint	Mean score Change	N[13]	Statistically significant change (p = <0.05)
Confidence in ability to teach physics lessons to Key Stage 3 pupils	3.31	3.54	0.23	70	Yes (positive)

[13] A total of 87 respondents who were in the matched sample (i.e. responded to baseline and endpoint surveys) saw this question. The number of respondents for each item is lower as response options included 'don't know' and 'not applicable', which are not displayed in the table.

Item	Mean score Baseline	Mean score Endpoint	Mean score Change	N[13]	Statistically significant change (p = <0.05)
Confidence in ability to teach physics lessons to Key Stage 4/GCSE pupils	2.33	2.86	0.53	70	Yes (positive)
Confidence in ability to teach physics lessons to Key Stage 5/A-level pupils	-0.41	-0.48	-0.07	54[14]	No
Confidence in ability to teach practical physics lessons (e.g. experiments, demonstrations, investigations)	2.17	2.69	0.51	70	Yes (positive)
Confidence in ability to answer pupils' physics questions	1.97	2.56	0.59	70	Yes (positive)

Due to rounding, there may be small differences between the figures presented.

In interviews, non-specialist physics teachers, in particular, reported feeling more confident as teachers since the FPL training, for example in their ability to teach physics and extend pupils' understanding through wider discussions around physics topics. They were more confident that they could adequately answer pupils' questions and deal with practical demonstrations not going to plan. NQTs also commented on how the mentoring support had helped them to more quickly feel confident as a teacher, having more strategies, knowledge and ideas to draw on to engage pupils in physics learning.

To explore the impact of the FPL project on participants' physics pedagogy, the survey asked questions about the extent to which aspects of quality teaching practice were incorporated into lessons. This relates to the 'changes in teaching practice' and 'engaging and managing pupils' elements in the teacher outcomes table above. The question included a range of practices that reflect quality teaching: the use of a variety of materials and practicals; providing relevant examples; rectifying misconceptions; effectively engaging pupils; ensuring safe working; and appropriately pitching the level of

[14] N is lower for this question as more respondents selected 'not applicable' to this item and were removed from the analysis.

challenge. These items were combined to create an overall measure of ‘physics pedagogy’ (see Appendix G, Factor 15).

The results of the analysis show that FPL participants reported using these aspects in their physics teaching to a greater extent at the end of the FPL project, than at the beginning, and this change was statistically significant (see Table 9). This finding suggests that FPL participants’ physics teaching pedagogy was significantly improved over the timeframe of the FPL project.

Table 9 Project-level outcomes - physics pedagogy

Factor	Range Min	Range Max	Mean score[15] Baseline	Mean score[15] Endpoint	Mean score[15] Change	N	Statistically significant change (p = <0.05)
Physics pedagogy	-28	28	13.26	15.96	2.70	70	Yes (positive)

Improvements in physics pedagogy were also reflected in qualitative interviews, as all interviewed participants reported improved physics teaching practice, having implemented the new ideas introduced at the FPL training. Several participants said that the CPD was particularly useful in providing them with simpler ways of delivering the practicals required for their syllabus and exam specification, and explaining physics concepts to their pupils, which had helped to increase understanding and address pupils' misconceptions. Despite existing physics knowledge, all participant groups reported gaining valuable new ideas for practicals, using new and alternative equipment to teach physics concepts, and integrating evidence-based approaches and strategies to link concepts across the physics curriculums for different age groups and key stages. Examples of ways in which participants enacted these new ideas in practice are provided in Section 3.3.

There was also qualitative evidence to indicate that, in some cases at least, positive impacts on physics pedagogy might have spread beyond direct FPL participants to other colleagues in participants’ departments. Participants described how FPL had a positive impact on the overall strength of physics knowledge and teaching in their schools’ science departments. This impact occurred either where all physics teachers in the department participated directly in FPL training, or where FPL participants fed back to the colleagues in their school about what they had learned from the CPD they had attended:

[15] See section 4.3, page 28, for details of how the mean scores were calculated.

> The resources I've got, not only have I used them, I've shared them with the wider team so it's had that knock on effect as well. Quite often providing a bank of things that can and have been used. - *FPL participant*

There were also reports of improvements to physics schemes of work, which could be used by all staff in the department teaching physics, as a result of embedding practicals and demonstrations from the FPL training and mentoring. In addition, participation in FPL had also prompted participants and heads of science to refresh their physics equipment based on recommendations from the IOP development coaches, or they had received support to review and understand how best to use the equipment they already had.

Among those interviewed, there were reports of increased knowledge sharing and support between colleagues in schools as a result of FPL. The FPL training and mentoring had provided a source and influx of new ideas for teaching physics, which prompted greater discussion and enthusiasm in science departments for how to teach particular physics topics. Examples of how the ideas from FPL were acted upon and led ultimately to this impact on departmental knowledge sharing and support for teaching physics, were explored above in Section 3.3.

Several heads of science/heads of physics felt that their school's participation in FPL had resulted in teachers in the science department feeling more confident and positive towards teaching physics:

> I'm happy with the direction the department is heading now in terms of physics, everyone is excited and I'm hoping that comes across in lessons to students, so students are excited and then hopefully they get the grades that they deserve. There is a buzz around it, whereas before it was seen with an element of fear. - *FPL participant and head of science*

Quality of physics subject leadership

The FPL project ToC identified aims to improve the quality of participants' leadership, with a specific focus on physics subject leadership. Analysis of survey responses provides some **evidence of improvements in FPL participants' physics leadership** between the start and end of the project.

Firstly, participants were significantly more positive at endpoint, than they had been at baseline, that they understood how to, and had the skills to, support the development of their colleagues' physics subject knowledge and teaching practice (see Table 10). This is promising evidence and is an indication that the FPL project was achieving its aims to develop physics subject leadership capacity, and capacity to deliver subject-specialist

Table 10 Project-level outcomes - Physics leadership knowledge and skills

Item	Mean score Baseline	Mean score Endpoint	Mean score Change	N	Statistically significant change (p = <0.05)
I understand how to effectively support the development of my colleagues' physics subject knowledge and teaching practice	1.05	1.79	0.74	78	Yes (positive)
I have the required skills to effectively support the development of my colleagues' physics subject knowledge and teaching practice	0.94	1.63	0.69	78	Yes (positive)

Interviewed SBDCs and specialist physics teachers also reported improvements in their leadership skills as a result of FPL, acquiring skills in how to be an effective coach and how to deliver CPD. SBDCs and specialists also reported feeling more aware of the aspects of physics that non-specialists might require support with. Finally, FPL project internal evaluation feedback revealed that the majority of IOP development coaches were confident in the capabilities of SBDCs to run quality physics CPD sessions in the future, as were participants themselves, as one interviewee explained:

> I know what non-specialists struggle with a lot more so it's given me the confidence to be able to help them with their lessons or help them with equipment. - *FPL participant*

In order to explore the impact of the FPL project on the quality of subject leadership, the survey asked a series of questions about the extent to which respondents incorporated a range of physics leadership practices into their roles.

Firstly, a question was asked about the extent to which participants supported the development of other physics teachers in their school. Table 11 displays the results of the analysis and shows that there were no statistically significant changes between baseline and endpoint in this element of physics leadership practice.

Table 11 Project-level outcomes - Physics leadership practices – support for NQTs

Item	Mean score Baseline	Mean score Endpoint	Mean score Change	N	Statistically significant change (p = <0.05)
Support the development of physics teachers (e.g. newly-qualified teachers (NQTs)/early-career teachers (ECTs)/non-specialist physics teachers) in my school	1.05	1.44	0.38	55	No

Due to rounding, there may be small differences between the figures presented.

Secondly, the survey asked participants about a broader range of physics leadership activities, and these were combined to create a 'physics leadership' factor measure (e.g. coaching colleagues, providing physics professional development, sharing physics teaching resources) (see Appendix G for further details of the items included in Factor 16 'physics leadership'). Table 12 displays the results and shows that there was no statistically significant change over time in the extent to which FPL participants reported undertaking these physics leadership activities.

Table 12 Project-level outcomes - Physics leadership practices

Factor	Range Range Min	Range Range Max	Mean score Baseline	Mean score Endpoint	Mean score Change	N	Statistically significant change (p = <0.05)
Physics leadership	-44	44	3.95	7.06	3.12	78	No

Due to rounding, there may be small differences between the figures presented.

Impact on participants' physics leadership may have been constrained by the extent to which participants had opportunities in their schools to undertake such physics leadership activities, and was beyond the control of the project. Indeed, for some participants, their role may not have enabled them to undertake such physics leadership activities (e.g. non-specialist physics teachers) or, for others, they may have already been undertaking these practices to a great extent at baseline (e.g. SBDCs), leaving little scope to change their physics leadership practice. Furthermore, the strand of FPL support respondents engaged with may not have focused on physics leadership (e.g. non-specialists) and, therefore, we may not expect to detect a change in this outcome.

However, qualitative evidence provides deeper insights and indicates that specialist physics teachers in particular reported changes in the quality of their leadership practice, predominantly in providing greater support for non-specialists when planning physics lessons and schemes of work. Several physics specialists and NQTs felt that participating in FPL had raised their confidence in their own subject knowledge and ability to support other colleagues, and they were taking on more of a role providing advice and support to colleagues in their department:

> I feel that people have started to respect me a bit more, because they know I'm on this course and they know that I've learnt a lot. They seem to really respect me in terms of what advice I give and they approach me. - *FPL participant*

The FPL project manager suggested that the extent to which SBDCs could fulfil a growing physics leadership commitment and embed the leadership practices developed during FPL may be limited in some cases. This was because of restrictions on the time they had to dedicate to this role and to be released from their other school commitments.

Demand and opportunities for physics CPD

The FPL project ToC identified aims to improve the demand and opportunities for physics CPD. Analysis of survey responses provides **some evidence of improvements in FPL participants' opportunities for physics CPD** between the start and end of the project, **although no changes in their motivation to engage with CPD.**

The survey included several items exploring participants' access to physics teaching and leadership professional development, and professional networks. In the analysis, these items were combined to create a factor measure: 'access to physics professional development' (see Appendix G, Factor 17 for further details). The survey responses indicated that FPL participants were significantly more likely to agree that they had access to physics professional development opportunities at the end of FPL, than they were at the beginning (see Table 13). This is promising evidence and is an indication that the FPL project was achieving its aim to increase opportunities for physics CPD in the areas where FPL has been delivered.

Table 13 Project-level outcomes - access to physics professional development

Factor	Range Min	Range Max	Mean score Baseline	Mean score Endpoint	Mean score Change	N	Statistically significant change (p = <0.05)
Access to physics professional development	-12	12	2.20	3.98	177	83	Yes (positive)

Due to rounding, there may be small differences between the figures presented.

However, there was no significant change in participants' motivation to engage in physics professional development between baseline and endpoint (see Table 14), indicating that the FPL project may not have achieved its aim to increase demand for physics CPD. Participants were reasonably keen to engage with physics professional development at baseline and remained so at endpoint. It is also possible that FPL participants regarded any demand for physics CPD as being met by the FPL project, and, therefore, there was reduced need for further physics CPD.

Table 14 Project-level outcomes - motivation to engage in physics professional development

Item	Mean score Baseline	Mean score Endpoint	Mean score Change	N	Statistically significant change (p = <0.05)
I am keen to engage in professional development focusing on physics teaching or leadership	2.36	2.33	-0.04	83	No

Due to rounding, there may be small differences between the figures presented.

Interviewed SBDCs, specialists and NQTs reported an increased sense of community, networking and support amongst physics teachers in their local area as a result of attending the CPD sessions. Participants appreciated the opportunity to meet colleagues in their local area who were also teaching physics to share ideas, good practice and resources. This was particularly helpful for teachers who were relatively new to their role, and for physics specialists and NQTs who could have otherwise been relatively isolated in their respective schools as the only subject specialist:

When I went to the specialist training there were about three heads of department there as well – so that was a good networking opportunity, not only in terms of physics, but also as someone who was new to the role of head of department. I know if I had any problems or wanted to share equipment, for example, I could drop one of them an email and now at least they know who I am. - *FPL participant*

This qualitative evidence indicates that some progress was made in building the capacity for physics CPD in local areas supported by the FPL project.

Pupils' physics participation and attainment

The survey included several items exploring participants' perceptions of pupil behaviour, attainment and progress in physics. In the analysis, these items were combined to create a factor measure: 'pupil behaviour, attainment and progress in physics' (see Appendix G, Factor 18 for further details). The survey responses indicated that **FPL participants were significantly more likely to agree at endpoint than at baseline that their pupils: enjoyed learning physics; understood the careers physics study could lead to; were well behaved; were making good progress; and were motivated to study post-16 physics** (see Table 15).

This is promising evidence and is an indication that the FPL project could achieve its longer-term aim to improve physics GCSE attainment. The qualitative findings, described below, indicated that this sign of pupil impact could be as a result of reported improvements in the quality of physics teaching pedagogy of FPL participants.

Table 15 Project-level outcomes - Pupil behaviour, attainment and progress in physics

Factor	Range Min	Range Max	Mean score Baseline	Mean score Endpoint	Mean score Change	N	Statistically significant change (p = <0.05)
Pupil behaviour, attainment and progress in physics	-20	20	4.50	6.60	2.10	70	Yes (positive)

Most interviewed participants felt that, as a result of FPL, pupils were more engaged during physics lessons, because teachers were explaining physics concepts more clearly, doing more exciting practicals and demonstrations, and were more enthusiastic about physics, which was having a knock-on effect on pupils' enthusiasm towards the subject:

> I think it makes it easier to be more enthusiastic about the subject, kids buzz off teachers talking enthusiastically and passionately about something. - *FPL participant*

Some interviewed participants felt that their pupils' understanding of physics concepts had improved as a result of the new ideas and strategies for teaching physics that they had gained through FPL. Participants also felt that because their own understanding of physics was better and they were more aware of the aspects of physics that pupils may misunderstand, they were better prepared to explain physics concepts, answer pupils' questions, and predict which aspects they may find challenging and how to address any issues. Participants thought that this was helping some pupils to understand physics better and more quickly, which in turn helped them to enjoy the subject more as they found it less complex:

> I've changed my ways of explaining things and I find that has helped students overcome misconceptions a lot sooner. - *FPL participant*

Several interviewed participants reported that their pupils were now more interested in pursuing physics as a result of their improved physics teaching and enthusiasm following participation in FPL. Participants acknowledged that it was too early to see if this led to increased uptake of physics GCSEs and A-levels, but recalled that some pupils had expressed more of an interest in this than they had previously. Participants also explained that it was logical that if their pupils found physics more interesting, engaging and easier to understand – due to enhanced teaching – then participation was likely to improve longer term:

> I feel more of them are going on to STEM degrees at university this year than any of the previous years I've taught, by looking at their applications. It comes down to the fact they feel they've got a better grasp of the subject, therefore, they feel they can do something with it. I can't put it down just to the FPL, but it contributes without a doubt. - *FPL participant*

Some interviewed participants mentioned that they had been making more links between physics topics and real-life careers, based on ideas they had picked up from FPL training. One participant added that this had *"sparked an interest"* among pupils and that they were more aware of the opportunities with physics. This aspiration-raising impact was felt to be particularly important given typically low aspirations in the FPL target areas:

> I can't recommend it enough, for us it has worked brilliantly, I really hope it continues, especially for a city like ours - quite deprived - we need it, we need teachers to stay in schools, be motivated and engage with their subject, and programmes like these really help our students without a doubt. - *FPL participant*

FPL training had also provided teachers with strategies to improve girls' interest in physics, which they were incorporating in their practice. Predominantly, this involved the physics teachers being more reflective about how girls might be influenced by perceptions of physics as being male-dominated, which they might be inadvertently perpetuating:

> It reminded us to make sure that we always give girls in science a really positive edge. There is so much more we can be doing, when we're doing displays at least include equal numbers [of men and women] – make a point that these people [women] are really good physicists as well, discuss why they had amazing ideas. - *FPL participant*

Motivation for physics teaching and to remain in the profession

The FPL project ToC identified aims to improve teachers' motivation to teach physics and remain in the profession, and their interest in physics career progression. Analysis of survey responses provided no evidence that FPL participants were more motivated to teach physics and remain in the profession, or more inclined towards physics career progression at the end, than before the start, of the project. We discuss these findings in greater detail in Section 4.4.3, alongside the findings from the analysis of SWC data into the impact of FPL on teacher retention and progression.

4.4.2 Findings related to fund-level goals – outcomes

In addition to questions/items that directly related to the aims of the FPL project discussed above, cross-cutting fund-level factors were also created to explore the extent to which FPL contributed to fund-level goals. Areas explored included participants' views of: school leadership quality; school teaching quality; effectiveness of, motivation for, and frequency and nature of professional development; career progression opportunities; school culture; and use of research evidence in practice.

The analysis indicates that there were no significant changes in participants' views on any of these areas between baseline and endpoint, with just one exception described below (see all results in Appendix K). Several of these outcome areas may be considered beyond the expected impact of the FPL project. The FPL project did not target school senior leaders, and hence would not be expected to influence school-wide leadership practices directly. Similarly, change to school culture was not an intended outcome of the project-level ToC, and the FPL project did not involve the breadth or depth of participation that may be considered appropriate to achieve cultural change in an organisation. Furthermore, the FPL project did not have involved the breadth of staff likely to be required to influence perceptions of school-wide teaching quality.

A significant change over time was detected in relation to class teacher respondents' perceptions of their opportunities for career progression; class teachers regarded their 'opportunities for career progression' significantly less positively at endpoint than at baseline (see Table 68, Appendix K). This finding perhaps raises concerns about participants' perceptions of the scope for teaching and subject-focused career development and middle leadership. Qualitative evidence from interviews with participants suggested that physics specialists were most likely to report the benefits of FPL for their career progression in physics. These findings are discussed in greater depth in Section 4.4.3, alongside the findings from the analysis of SWC data into the impact of FPL on teacher retention and progression.

While changes were not detected in the fund-level outcome measures, there is evidence that the FPL project may have contributed to the fund-level outcomes, albeit with a specific focus on physics. Project-level outcome analysis (reported in section 4.4.1) indicates that the project improved the quality of participants' physics teaching and leadership – thus contributing to these broader aims of the Fund.

4.4.3 Findings related to fund-level goals – impacts

This section explores the extent to which the FPL project achieved its impacts. It measures the impact of the project on teacher retention and progression (through analysis of teacher outcomes in the SWC). It also explores participants' perceptions of the impact of the project on teacher retention and progression, and on pupil outcomes (through analysis of survey responses and qualitative data).

Retention and progression analysis

The evaluation aimed to explore the impact of the FPL project on the fund-level goals to improve teacher retention and progression. As outlined previously, the FPL project intended to achieve teacher-level, rather than whole-school level impacts and therefore this analysis is conducted on FPL participants and a matched comparison sample of teachers, rather than on all teachers from FPL schools.

The analysis uses the set of FPL participants compared to non-FPL science teachers matched on a range of key characteristics (see Appendix C) to estimate what counterfactual retention and progression rates might have been with and without the FPL project. Teacher retention was analysed in terms of:

- retention in the state-funded sector in England
- retention in the school
- retention in the same LA
- retention in challenging schools

Teacher progression was analysed in terms of:

- progression in the state-funded sector in England
- progression in the school
- progression in the same LA
- progression in challenging schools.

Teacher retention

The tables below summarise FPLs estimated impacts across the four retention measures analysed.

Retention in the state-funded sector in England

Table 16 Difference in the estimated rate of retention in state-funded teaching in England between treatment and comparison teachers

	Treatment teachers	Comparison teachers	Difference	Statistically significant?
Estimated retention rate in state-funded teaching 1 year after baseline (%)	93.6	88.3	5.3	Yes
Number of teachers	**707**	**4828**		
Estimated retention rate in state-funded teaching 2 years after baseline (%)	85.6	82.4	3.2	Yes

	Treatment teachers	Comparison teachers	Difference	Statistically significant?
Number of teachers	**661**	**4437**		
Estimated retention rate in state-funded teaching 3 years after baseline (%)	80.4	78.3	2.1	No
Number of teachers	**427**	**2798**		

Note: Estimated retention rates are the average predicted retention rates from a logistic regression model for treatment and comparison teachers, controlling for observed characteristics. The difference in average predicted retention rates is the marginal effect. Statistical significance of this difference is assessed at the five per cent level. Due to rounding, some estimated marginal effects may not exactly equal the difference between treatment and comparison teachers.

Table 16 shows that the FPL project is associated with a statistically significant higher rate of retention within the state-funded teaching profession one and two years after baseline; with treatment teachers between 3.2 and 5.3 percentage points more likely to be retained in teaching one and two years after the baseline date, than comparison teachers (this difference was not significant three years after baseline). This suggests that the FPL project had a positive impact on teacher retention in the profession. However, the presence of a significant difference just one year after baseline indicates that there may have been systematic differences between the treatment and comparison samples at baseline that are not accounted for in this analysis. As recruitment to the project was on a rolling basis and the analysis does not observe specific end-dates of the treatment for each participant, it is likely that many participants had either received minimal training or were still enrolled in the training when the census data was collected and the impact on retention estimated at one year after baseline. This makes the project's estimated effect of improving retention by 5.3 percentage points within one year of baseline seem implausible.

This difference in retention rates among science teachers generally is also apparent for physics teachers specifically, although to a lesser extent. As can be seen in Appendix L, physics teachers[16] involved in the FPL project were more likely to be retained in teaching than physics teachers who did not participate in FPL – this difference is statistically significant one year after baseline, but not after two and three years from baseline.

[16] The analysis was also run specifically on teachers who were identified as physics teachers in the SWC.

Retention in the school

Table 17 Difference in the estimated rate of retention in the same school between treatment and comparison teachers

	Treatment teachers	Comparison teachers	Difference	Statistically significant?
Estimated retention rate in the same school 1 year after baseline (%)	87.8	87.6	0.2	No
Number of teachers	**563**	**3888**		
Estimated retention rate in the same school 2 years after baseline (%)	76.6	79.9	-3.3	No
Number of teachers	**519**	**3449**		
Estimated retention rate in the same school 3 years after baseline (%)	66.8	73.7	-6.8	Yes
Number of teachers	**333**	**2054**		

Note: Estimated retention rates are the average predicted retention rates from a logistic regression model for treatment and comparison teachers, controlling for observed characteristics. The difference in average predicted retention rates is the marginal effect. Statistical significance of this difference is assessed at the five per cent level. Due to rounding, some estimated marginal effects may not exactly equal the difference between treatment and comparison teachers.

Table 17 shows that there was a statistically significant difference between treatment teachers and matched comparison teachers in the rate of retention within the same school they were in at baseline, but only three years after baseline. Specifically, the estimated retention rate within the same school for treatment teachers was 6.8 percentage points *lower* than for the comparison group three years after baseline. The estimated difference was also negative two years after baseline but not statistically significant and it was small and not statistically significant one year after baseline.

Retention in the same local authority

Table 18 Difference in the estimated rate of retention in the same local authority district (LAD) between treatment and comparison teachers

	Treatment teachers	Comparison teachers	Difference	Statistically significant?
Estimated retention rate in the same LAD 1 year after baseline (%)	91.2	90.6	0.6	No
Number of teachers	**563**	**3888**		
Estimated retention rate in the same LAD 2 years after baseline (%)	83.8	84.8	-1.0	No
Number of teachers	**519**	**3449**		
Estimated retention rate in the same LAD 3 years after baseline (%)	77.4	80.3	-2.9	No
Number of teachers	**333**	**2054**		

Note: Estimated retention rates are the average predicted retention rates from a logistic regression model for treatment and comparison teachers, controlling for observed characteristics. The difference in average predicted retention rates is the marginal effect. Statistical significance of this difference is assessed at the five per cent level. Due to rounding, some estimated marginal effects may not exactly equal the difference between treatment and comparison teachers.

Table 18 shows that, like the estimated differences in rates of retention within the same school, the FPL project appears to be associated with lower retention of teachers within the same LAD. However, this difference is not statistically significant one, two, or three years after baseline.

Retention in challenging schools

Table 19 Difference in the estimated rate of retention in challenging schools between treatment and comparison teachers

	Treatment teachers	Comparison teachers	Difference	Statistically significant?
Estimated retention rate in challenging schools 1 year after baseline (%)	93.4	91.6	1.7	No
Number of teachers	**558**	**3839**		

Estimated retention rate in challenging schools 2 years after baseline (%)	84.2	86.6	-2.4	No
Number of teachers	**509**	**3372**		
Estimated retention rate in challenging schools 3 years after baseline (%)	76.6	82.1	-5.6	Yes
Number of teachers	**324**	**1997**		

Note: Estimated retention rates are the average predicted retention rates from a logistic regression model for treatment and comparison teachers, controlling for observed characteristics. The difference in average predicted retention rates is the marginal effect. Statistical significance of this difference is assessed at the five per cent level. Due to rounding, some estimated marginal effects may not exactly equal the difference between treatment and comparison teachers.

Table 19 shows that there was a statistically significant difference between treatment and comparison teachers in the retention rate in challenging schools three years after baseline. Treatment teachers were 5.6 percentage points *less* likely to remain in a challenging school three years after the treatment baseline date than teachers without the treatment, although the difference was not statistically significant one and two years after baseline. This finding aligns with the finding presented in Table 17 on teacher retention in the same school and indicates that treatment teachers were more likely than comparison teachers to move schools three years after the baseline date, and were more likely to move from challenging to less challenging schools when they did so.

Overall, while these results provide some evidence that the FPL project has had a positive impact on teacher retention in teaching, it is possible that the strength of the estimated effects in Table 16 are somewhat overstated. There may have been systematic differences between treatment and comparison teachers that existed prior to the project that the analysis has not been able to account for (e.g. personality traits, or motivation towards physics CPD). These systematic differences could lead to overestimation of the effect of the project if they are inadequately controlled for (see Appendix C for further discussion). Additionally, during the baseline year recruitment was ongoing rather than the year the treatment ended, so it is not clear how much of the FPL project participants had experienced by the first measure of impact one year after baseline. The retention effect also drops below the level of statistical significance three years after baseline, suggesting any effect is short lived. Ultimately, while the estimates in Table 16 can be interpreted to suggest that the FPL project has indeed increased retention rates for teachers, the true effect of the project is likely to be somewhat smaller than the estimates suggest.

In sum, there are two ways that the FPL project appears to have impacted teacher retention. First, it may have helped retain teachers in the profession, although the magnitude of this effect is likely to be somewhat overstated. Second, it appears to have impacted on teachers' movement to other schools, and from challenging to less challenging schools. This could indicate that the FPL project was upskilling science teachers, which enabled some of them to secure opportunities to move to other, less challenging schools. This may have been to the detriment of the originating schools. The findings for both of these retention impacts should be regarded with caution as the analysis does not control for all possible differences between treatment and comparison teachers regardless of the FPL project.

Teacher progression

The tables below summarise FPL's impacts across the four progression measures analysed. Progression rates are defined as the proportion of teachers who moved from either a classroom teacher to a middle/senior leader role, or a middle leader role to a senior leader role within one, two, and three years of baseline.

Progression in the state-funded sector in England

Table 20 Difference in the estimated rate of progression in state-funded teaching in England between treatment and comparison teachers

	Treatment teachers	Comparison teachers	Difference	Statistically significant?
Estimated progression rate in state-funded teaching 1 year after baseline (%)	10.3	9.7	0.6	No
Number of teachers	**542**	**3727**		
Estimated progression rate in state-funded teaching 2 years after baseline (%)	15.9	16.7	-0.8	No
Number of teachers	**501**	**3308**		
Estimated progression rate in state-funded teaching 3 years after baseline (%)	21.8	20.3	1.5	No
Number of teachers	**320**	**1966**		

Note: Estimated progression rates are the average predicted progression rates from a logistic regression model for treatment and comparison teachers, controlling for observed characteristics. The difference in average predicted progression rates is the marginal effect. Statistical significance of this difference is assessed at the five per cent level. Due to rounding, some estimated marginal effects may not exactly equal the difference between treatment and comparison teachers.

Table 20 shows that there were no statistically significant differences between treatment and comparison teachers in the progression rates of teachers who stayed in teaching either one, two or three years after baseline. This is also the case for the sub-sample of physics teachers (see Appendix L). These findings suggest participation in the FPL project had little impact on progression in teaching for either science teachers generally or physics teachers specifically.

Progression in the school

Table 21 Difference in the estimated rate of progression in the same school between treatment and comparison teachers

	Treatment teachers	Comparison teachers	Difference	Statistically significant?
Estimated progression rate in the same school 1 year after baseline (%)	9.6	8.6	1.0	No
Number of teachers	**473**	**3275**		
Estimated progression rate in the same school 2 years after baseline (%)	13.9	14.7	-0.7	No
Number of teachers	**378**	**2654**		
Estimated progression rate in the same school 3 years after baseline (%)	18.9	17.6	1.4	No
Number of teachers	**209**	**1466**		

Note: Estimated progression rates are the average predicted progression rates from a logistic regression model for treatment and comparison teachers, controlling for observed characteristics. The difference in average predicted progression rates is the marginal effect. Statistical significance of this difference is assessed at the five per cent level. Due to rounding, some estimated marginal effects may not exactly equal the difference between treatment and comparison teachers.

Table 21 shows that there were no statistically significant differences in the progression rates of treatment and comparison teachers who stayed in the same school, either one, two or three years after baseline.

Progression in the same local authority

Table 22 Difference in the estimated rate of progression in the same local authority district (LAD) between treatment and comparison teachers

	Treatment teachers	Comparison teachers	Difference	Statistically significant?
Estimated progression rate in the same local authority 1 year after baseline (%)	9.6	9.0	0.6	No
Number of teachers	**494**	**3392**		
Estimated progression rate in the same local authority 2 years after baseline (%)	13.9	15.3	-1.4	No
Number of teachers	**418**	**2825**		
Estimated progression rate in the same local authority 3 years after baseline (%)	18.4	18.8	-0.4	No
Number of teachers	**246**	**1594**		

Note: Estimated progression rates are the average predicted progression rates from a logistic regression model for treatment and comparison teachers, controlling for observed characteristics. The difference in average predicted progression rates is the marginal effect. Statistical significance of this difference is assessed at the five per cent level. Due to rounding, some estimated marginal effects may not exactly equal the difference between treatment and comparison teachers.

Table 22 shows that there were no statistically significant differences in the progression rates of teachers who stayed in the same LAD between treatment and comparison teachers, either one, two or three years after baseline.

Progression in challenging schools

Table 23 Difference in the estimated rate of progression in challenging schools[17] between treatment and comparison teachers

	Treatment teachers	Comparison teachers	Difference	Statistically significant?
Estimated progression rate in challenging schools 1 year after baseline (%)	9.8	9.1	0.6	No
Number of teachers	**500**	**3379**		
Estimated progression rate in challenging schools 2 years after baseline (%)	13.7	15.7	-2.0	No
Number of teachers	**410**	**2805**		
Estimated progression rate in challenging schools 3 years after baseline (%)	17.9	19.1	-1.2	No
Number of teachers	**236**	**1570**		

Note: Estimated progression rates are the average predicted progression rates from a logistic regression model for treatment and comparison teachers, controlling for observed characteristics. The difference in average predicted progression rates is the marginal effect. Statistical significance of this difference is assessed at the five per cent level. Due to rounding, some estimated marginal effects may not exactly equal the difference between treatment and comparison teachers.

Table 23 shows that there were no statistically significant differences, between treatment and comparison, in the progression rates of teachers who stayed in challenging schools, either one, two or three years after baseline.

In sum, there is no evidence that the FPL project had any impact on teachers' rates of progression to middle leadership positions.

Interpretation of retention and progression findings

Both the TLIF programme ToC and the FPL project ToC identified longer-term aims to improve teacher retention and progression.

[17] For the purposes of this analysis, 'challenging' schools were defined as schools rated by Ofsted as 'requires improvement' or 'inadequate'. A teacher was defined as progressing in a challenging school if they move to a middle/senior leadership position from a classroom teaching position or a senior leadership position from a middle leadership position *and* either stayed in their baseline school or moved to a challenging school.

The SWC retention analysis provides some evidence to suggest that the FPL project may have made some progress towards its aim to improve teachers' retention in the profession. FPL participants were more likely to be retained in the teaching profession one and two years after baseline than comparison teachers. However, the presence of a significant difference just one year after baseline when some participants may have still been involved in the training, suggests that this effect may be influenced by unobserved participant characteristics, and therefore somewhat inflated. Any retention impact also appears to have been relatively short term, as three years after baseline there is no statistically significant difference between FPL participants and comparison teachers in rates of retention in the profession. In interviews, several NQTs reported feeling more inclined to remain in teaching as a result of the support from the FPL project, which had helped to reduce their workload, improve their teaching, and given them confidence in their practice. However, this finding was not supported by the survey results, which indicated that there was no significant change in participants' intentions between baseline and endpoint in terms of plans to continue as a teacher/leader of physics (see Table 24).

The SWC retention analysis also shows that FPL participants were more likely than comparison teachers to move schools, and to move from challenging to less challenging schools. This indicates that, while the FPL project may have achieved success in upskilling science teachers, this may have been to the detriment of target schools.

The SWC progression analysis provides no evidence that the FPL project achieved its aim to improve teachers' progression to middle leadership. This finding is supported by the survey findings, which showed no significant change in participants' intentions between baseline and endpoint in terms of motivation to seek additional responsibility/leadership/career development in physics (see Table 24). Additionally, in the survey, FPL class teachers were significantly less positive about their opportunities for career progression at endpoint compared to baseline.

One possible explanation for this lack of impact is that a substantial proportion of FPL participants (approximately two-thirds) were non-specialist teachers of physics, and it may be that their motivation for teaching and career development related to their area of teaching specialism, rather than physics. However, there was also no evidence that the FPL project impacted on the progression rate of physics specialists. This may reflect limited opportunities for middle leadership progression in physics specifically – the aspect of science that FPL participants had developed. Yet, insights from qualitative data suggested there were cases where participation in FPL had a positive impact on career development as a result of improvements to teachers' physics knowledge, skills and practice. Physics specialists were most likely to report the benefits of FPL for their career progression in physics, although interviewed non-specialists also reported improvements in their satisfaction and motivation to teach physics as a result of FPL. Taken collectively, these findings indicate that the FPL project may not have achieved its aim to improve teachers' motivation and interest in physics career progression, at least not at scale.

Table 24 Project-level outcomes - motivation to teach physics and physics career progression

Item	Mean score Baseline	Mean score Endpoint	Mean score Change	N	Statistically significant change (p = <0.05)
I plan to continue working as a teacher/leader of physics (as appropriate) for at least the next three years	2.16	2.10	-0.06	83	No
I would like to seek additional responsibility/leadership/career development in physics in school/s in the next three years	-0.06	-0.27	-0.21	83	No

Perceived impacts on pupils

Both the TLIF programme ToC and the FPL project ToC identified longer-term aims to impact on pupil attainment, with the FPL project specifically focused on impacts on pupils' physics attainment. This outcome was not measured by the survey core-questions, although bespoke project survey questions explored impact on pupils in relation to physics specifically. The findings are promising as we observed a significant improvement over time in participants' views of their pupils' enjoyment, understanding, behaviour, progress and motivation in physics. This is a tentative indication that the FPL project had the potential to achieve a longer-term aim to improve physics GCSE attainment, and thus contribute to the TLIF longer-term outcome of improving pupil attainment.

4.4.4 Findings related to fund-level goals – wider outcomes

It should be noted that not all of the TLIF's wider outcomes have been identified as intended impacts by all projects. For example, FPL was designed to ultimately lead to improvements in teacher retention and progression and improved pupil attainment (through improved quality of teaching). It was not, however, designed to lead to improvements in pupil attendance/reduced exclusions, improved school Ofsted ratings, social mobility or school culture. Therefore, there is no data to report on these areas.

4.5 Interpretation of outcomes and impacts

Overall, there are signs that the project had some success in achieving its anticipated impacts. The SWC analysis shows that the FPL project may have positively impacted on participants' retention in teaching, although it may also have contributed to participants moving from more, to less, challenging schools. There is no evidence of impact on teachers' progression.

In terms of outcomes, there is evidence from the surveys and qualitative interviews that, where participants engaged with the support, it improved their physics leadership knowledge and skills, physics subject knowledge, teaching pedagogy and confidence to teach physics to Key Stage 3 and 4/GCSE pupils. It also improved their confidence to teach practical physics and address pupils' physics questions. Participants also felt they had improved access to physics CPD through FPL.

The project may have been expected to achieve greater impact on participants' physics leadership pedagogy given the emphasis on this outcome for SBDCs and specialist physics teachers. Although there are numerous qualitative indications of such impacts, and quantitative signs of impacts on participants' leadership knowledge and skills, there was less evidence in the survey analysis that this had transpired into detectable quantitative changes in physics leadership practices. It is unfortunate that the low survey response rates and number of matched respondents impeded the scope to analyse outcomes by the different types of FPL participant groups, as this may have revealed stronger outcomes related to the bespoke strands of the project, for instance, physics leadership emphasis for SBDCs and specialists.

There were signs that impacts on enhanced physics teaching quality was, in turn, impacting on pupils' behaviour, attainment and progress in physics. There was also some evidence that engagement had been variable and, although the flexibility of FPL was highlighted as one of its strengths, the project's delivery design meant that any drop below optimal engagement was likely to diminish the outcomes it was capable of achieving.

The data suggests that there were positive impacts of the FPL project on participants in relation to physics specifically (as outlined in section 4.4.1). In this sense, the FPL project contributed to the broader fund-level aims to improve teaching and leadership quality. However, there is little evidence to suggest that the impacts of the FPL project were sufficient to influence leadership and teaching quality, school culture and CPD attitudes more broadly across the school, or more broadly beyond subject-specific aspects. This finding is perhaps to be anticipated given the specific focus of FPL on physics teaching and leadership.

5 Sustainability

Interviewed participants envisaged that their learning from participating in FPL would be sustained as they intended to continue to use and embed the physics teaching practices and ideas learned from the training and mentoring. There was considerable evidence, as summarised in the sections above, that the project was successfully equipping participants with an increased repertoire of ready-to-use physics teaching strategies and ideas, and leadership skills. Wider impacts on science departments had been facilitated by the engagement of the head of science and by several members of staff in the department engaging with the various strands of FPL – which enabled learning from the training to be shared and more efficiently implemented.

There was an appetite for the support to continue beyond the lifetime of the project in the form planned – with SBDCs providing local physics support. However, there were numerous questions raised about how this would work in practice, for instance, whether SBDCs would have time to deliver CPD and whether there would be sufficient uptake of CPD delivered at a local hub. One issue was whether Lead Schools would be able to continue to release SBDCs to fulfil the role and whether SBDCs would have capacity for this given their school-based commitments. Comments suggested that further input from IOP would be required to sustain the support. Interviewee evidence suggested there was some variation in the sustainability of the local hubs. Around half were considered established, having effectively developed the capacity of local SBDCs to support future physics development in the area, and had plans for how to sustain the local support. Yet, other hubs were considered more at risk of not being sustainable. This was due to factors such as a lack of physics leadership capacity to develop in the local area, and losing promising SBDCs from working in the local areas. In these cases, IOP attempted to provide some form of additional continued support.

Developing a sustainable local hub delivery model to build on the local networks initiated by the project was a stronger focus of the final phase of FPL, and responsibility for delivering the support transitioned increasingly from the IOP development coaches to the SBDCs throughout the project. SBDCs and specialists were being upskilled to provide support in the future. Although some sustainability plans were in place for the hubs and SBDC support, implementing them was disrupted to some extent by the Covid-19 pandemic. Having invested in developing SBDCs, the FPL Project Manager was keen that the IOP continue to provide support and further enable the capacity for quality physics teaching in all schools. One strategy to support this was that Lead Schools would be given the opportunity to apply to IOP to continue their role and second their SBDC to support physics teaching in other schools as part of the IOP's sister project – Stimulating Physics Network. Secondly, IOP were providing guidance to Lead Schools on various approaches and models for the SBDC role. This potentially could involve providing CPD through Teaching Schools and MATs, providing mentoring support remotely, and linking the SBDC role to the Chartered Physics Status and National Professional Qualifications (NPQs). Thirdly, IOP had also changed its support structure, and rather than being project-based, support was latterly regionally based, led by regional education managers, to help develop local communities of physics professional practice that support physics teaching through a range of IOP projects. There were also opportunities for SBDCs to continue working with IOP on additional freelance contracts, for instance developing programme materials. Participants from across Lead and Partner schools would have access to these local communities of physics practice beyond the lifetime of FPL. Finally, at the end of the FPL project, IOP had contacted all participants to draw their attention and signpost them to other opportunities for support and engagement, including from IOP and other STEM organisations (e.g. free IOP bi-annual regional CPD days; free local workshops; free access to TalkPhysics online physics learning community; free downloadable physics teaching resources and guidance at IOPSpark; and subscription to IOP school affiliation and membership).

6 Evaluation of the FPL project ToC

The FPL project was largely delivered as planned according to the project activities and target outputs outlined in the ToC (see Appendix A). One modest deviation from this was that the project was not able to gain quite the scale of traction in each school as planned; an average of four participants per school took part compared to the planned target of five participants per school. In addition, monitoring information indicated that retention to the project was a challenge, hence potentially undermining the scale of impact beyond immediate and fully engaged FPL participants. The project's ToC assumed a substantial element of flexibility in the focus of the support offered, opportunities for participants to engage with different elements of the support, and localised delivery model. One modification to the delivery model was that not all of the CPD was delivered at local hubs as planned. In practice, a more customised approach was delivered with instances of bespoke support for individual schools. The evidence supports the value of this flexible and localised delivery model, though suggests an even more customised approach may be required in future delivery than was anticipated in the original ToC. Overall, participants reported high levels of satisfaction with FPL.

There is evaluation evidence that the project activities were successful in leading to a range of outcomes for participants – namely in terms of their physics leadership knowledge and skills, capacity to deliver physics CPD, physics subject knowledge, confidence to teach physics, and physics teaching pedagogy, as well as signs of positive impacts on participants' pupils. There is also evaluation evidence that the FPL project activities may have been successful in leading to impacts for participants in terms of improving their retention in the teaching profession one and two years after joining the project, although this impact appears to have been relatively short-term as it is not observed three years after baseline. The evidence is more limited in terms of the project's effectiveness in leading to improvements in participants' motivation to teach physics and engage with physics CPD, as well as physics leadership practices, and progression into physics leadership. There is no evidence the project was successful in leading to impacts on participants' rates of progression.

The latter finding may be explained, at least in part, by a limitation in the analysis of responses from separate participant groups - imposed by low response rates to the survey at endpoint and small sample sizes for the SWC analysis - as impacts on physics leadership may not have been equally applicable to all respondents. As the project sought to support physics teaching from a number of angles, participants entered it with different physics development needs. Therefore, for several outcome areas measured in the survey, participants' responses tended to be already positive at baseline, making it difficult to achieve significantly more positive responses over time or explore differential impacts on different participant groups.

However, the evaluation evidence does indicate that the emphasis on leadership support may need to be intensified or broadened for some participants in order to build capacity for physics leadership longer-term. And, while leadership skills and knowledge may have been effectively developed by the project, for this to have a longer-term impact on physics leadership and the supply of physics expertise and CPD in local areas, school-based physics leaders will need the opportunities and capacity to fulfil this role.

7 Learning about effective CPD for schools in challenging circumstances

7.1 Recruiting and engaging schools

The FPL project has demonstrated that there is demand for specialist support programmes for teachers and leaders of physics, and that, with an effective communications strategy and local partners, considerable numbers of teachers of physics and schools can be recruited to interventions of this sort. The local hub delivery approach was effective in ensuring that the CPD was accessible and supported the development of physics communities of practice and networking. However, this evaluation has also found that delivering subject-specific CPD is challenging and schools and participants were not always able to prioritise and commit to the project. This challenge may be accentuated further given the shortage of physics specialists in schools. The project effectively anticipated this challenge and had flexibility built in from the start to ensure the core support was adaptable and accessible to participants' needs. During delivery in practice, aspects of customisation were further accentuated. This was a highly valued element of the delivery model, yet there is evidence from the evaluation that an even more customised school-based model may be required, particularly to support non-specialist physics teachers and schools in challenging circumstances that may be less effectively engaged by the local hub model.

7.2 Characteristics of effective CPD

Coe (2020) drew together a list of practical implications for the design of CPD. Although his review focussed on subject-specific CPD, it was based on the broad congruence of evidence found in reviews about the characteristics of effective CPD both within a subject-specific and wider context. These characteristics support changes in teachers' classroom practice, which, in turn, are likely to lead to substantive gains in pupil learning. These are set out in Appendix J. The first purpose of this section is to highlight key features of the FPL project, which appeared to lead to positive outcomes indicative of effective CPD that align with Coe's list. The second is to identify any key features of the FPL project that appeared to lead to positive outcomes indicative of effective CPD, which are not included in Coe's list.

The FPL project shares many of the components that Coe (2020) identifies regarding CPD that are most likely to lead to substantive gains in pupils' learning. For example, FPL support focused on evidence-based teaching practices, involved input over several terms (i.e. more than a one-off session), provided new ideas and practices modelled by experts (i.e. IOP development coaches and SBDCs were physics experts and experienced physics teachers), and included opportunities for collaboration with other teachers of physics in similar contexts (i.e. local hub CPD sessions for physics specialists and non-specialists respectively, and opportunities for multiple staff in participating schools to engage with the support).

There are a couple of aspects of Coe's suggestions that the FPL project did not entirely align with. Perhaps most importantly, the frequency of input of the FPL project (i.e. one CPD session per term for most participants) is less than advocated by Coe (i.e. fortnightly). The evaluation evidence indicated that, in particular, the scale of non-specialist physics teaching remains a challenge and may warrant more comprehensive and targeted support than that offered in the current FPL model. Furthermore, while the feedback and coaching elements of the support for SBDCs (and some specialist physics teachers developing leadership and mentoring roles), and NQTs were valued, these elements could have been strengthened further.

7.3 Summary

Overall, the project had a good deal of success. Although there were challenges in recruitment and engagement, the project successfully supported its target number of schools. There is considerable evidence that the project achieved a number of the outcomes of the ToC – particularly physics subject knowledge, confidence to teach physics, teaching pedagogy, and physics leadership knowledge and skills. Moreover, it seems likely that these new approaches had, or would, become embedded within participating teachers' practice, suggesting that the impacts could be sustained. Indeed, in the survey at the end of the project, teachers' responses indicated they perceived an increase in their pupils' enjoyment, understanding, behaviour, progress and motivation in physics.

While there is evidence that the project may have achieved a key impact - improving participating teachers' retention in the teaching profession, there was no measurable impact on teachers' progression, and the project also appears to have influenced some movement of science teachers away from challenging schools. Additionally, there is limited survey and qualitative evidence in relation to enhanced physics leadership practices, or motivation for teaching and leading physics. This may suggest that CPD with a more intensive and/or sustained focus on these aspects would be required in future to offer the potential to achieve these impacts.

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Appendix A: Future Physics Leaders project logic model

Rationale and Evidence

The national shortage of high-quality physics teachers, due to recruitment and retention issues particularly in schools in the most challenging circumstances (e.g. Allen *et al*., 2015), is having a detrimental effect on pupils' physics attainment at GCSE (DfE, 2015) and progression post-16. The quality of physics teaching can be enhanced with high-quality, sustained CPD and mentoring support (e.g. Cordingley *et al*., 2015; Yoon *et al*., 2007) to improve the recruitment and retention of specialist physics teachers (e.g. Gold, 1987; Hobson and McIntyre 2015).

Project activities

NQTs:
- marketing campaign
- sympathetic physics-focused timetable
- mentoring from IOP development coaches/SBDCs
- bespoke subject and pedagogical CPD (1 day per term or half a day per half term for minimum of a year).

SBDCs:
- working with IOP development coaches, delivering physics CPD and mentoring NQTs, to develop the skills to become future school-based physics development coaches (minimum involvement a year)

Specialist physics teachers
- bespoke subject and pedagogical CPD (1 day per term for minimum of a year).

Non-specialist physics teachers
- bespoke subject and pedagogical CPD (half a day/twilight per term for minimum of a year)

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Outputs
- 168 secondary schools recruited across 8 hubs in each of three regions (144 Partner Schools and 24 Lead Schools)
- Minimum of 924 participants recruited (assuming average of 5.5 participants per school)
- 100% of schools from DfE priority areas; 70% 3 or 4 Ofsted rating
- 95% of schools complete the project
- 80% of participants rate the programme as good or above overall
- Annual teacher CPD hours across priority schools: Year 1 – 850; Year 2 – 6,100; Year 3 – 6,500
- Annual teacher CPD hours across priority areas: Year 1 – 1,600; Year 2 – 9,200; Year 3 – 9,800

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Outcomes

Leaders e.g.
- Improved quality of subject leadership (e.g. confidence; knowledge; coaching and CPD delivery skills; sense of physics community)
- Increased capacity to deliver subject-specialist physics CPD
- Increased demand for middle leader development

Teachers e.g.:
- Improved quality of teaching (e.g. subject knowledge; subject/general pedagogical knowledge; achievement of Chartered Physics Status)
- Improved motivation for teaching (e.g. teaching physics; staying in the profession; seeking additional responsibility)
- Increased demand and opportunities for physics CPD

Pupils e.g.:
- Improved interest in physics post-16, including girls, BME groups, pupils with low socio-economic status

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Impacts: Schools
- Improved teacher retention in target areas (decreased churn)
- Improved teacher progression (e.g. to middle leadership, teaching and learning responsibilities)
- Increased pupil physics attainment at GCSE (e.g. number achieving good pass increased by 5% points)

Impacts: Region
- Increased number of physics specialist teachers
- Improved teacher retention

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Contextual issues
- Specific needs of individual schools and participants
- Prior knowledge, experience, beliefs and attitudes of participants
- School readiness and capacity for change

Appendix B: Qualitative sampling strategy

Selection of hubs

We interviewed five IOP development coaches from five different hubs, covering two of the three regions where FPL operates. We prioritised speaking to IOP development coaches in hubs that were at the stage of delivering the FPL CPD at the time of data collection, hubs in high priority areas, such as Opportunity Areas, and hubs that represented different geographical characteristics - urban, rural and coastal areas. The IOP project manager provided information on the stage of development of hubs and assisted in liaising with IOP development coaches to invite their participation in the evaluation once the research team had selected which hubs to prioritise.

Selection of schools

We interviewed 16 FPL participants[18] from across all three regions, seven hubs and 10 schools (two Lead Schools and eight Partner Schools). We initially began by approaching schools in the five hubs where we had spoken to the IOP development coaches, but subsequently identified a further two hubs (applying the above hub selection criteria) in order to increase response rates. We asked the IOP development coaches in each of the seven hubs selected to categorise each school's level of engagement with FPL on a simple scale of high, medium and low. We prioritised approaching: schools with high engagement so that participants could comment on the CPD they had received; schools in challenging circumstances (e.g. high proportion of pupils eligible for Free School Meals); schools with an Ofsted category of 3 or 4; and schools of different types (e.g. academy sponsor led, academy converter, maintained, free school).

We originally intended to interview up to three teachers from each of five schools involved in FPL. However, in order to gather the views of participants from across all four strands of FPL (SBDCs, Specialists, non-specialists and NQTs), and because schools could not always accommodate multiple telephone interviews, we broadened our approach to a greater number of schools. Participants were initially approached via email, followed by a telephone call to invite them to participate in the evaluation. We predominantly contacted participants individually and directly and at the end of each interview we asked the interviewee if there was anyone else in the school who we could consult as part of the evaluation.

[18] We received brief email feedback from a 17th FPL participant who could not accommodate a telephone interview, but wished to contribute their views to the evaluation. The participant, from a Partner School in Hub F, had experienced the non-specialist FPL CPD. Throughout the report their views are incorporated, as applicable.

A clear limitation of the qualitative evidence is that it only captured the experiences of those participants who were engaged in the CPD/mentoring. The evidence does not include insights about the experiences of participants who were not engaged by FPL and any reasons underpinning this. A further limitation of the data is that because we were not always able to speak to multiple teachers in a school, the findings focus predominantly on participant-level impacts. However, in four schools we were able to speak to the Head of subject/department to gather their more strategic perspective of the department-level impacts of the FPL project. A final limitation is that we were not able to secure any interviews with participants from maintained schools, however this reflects the FPL population generally and the wider national population of secondary schools in England, most of which are academies.

Table 25 below provides a summary of the achieved participant sample.

Table 25 Achieved participant sample

Hub	School	Type of FPL participant	Type of FPL school
A	1	Specialist	Partner
A	2	Specialist	Partner
B	3	Non-specialist	Partner
B	3	Specialist (Head of	Partner
C	4	School-based development	Lead
C	4	School-based development	Lead
C	5	NQT	Partner
C	5	Specialist (Head of physics)	Partner
D	6	School-based development	Lead
E	7	NQT	Partner
E	8	Non-specialist	Partner
E	8	Non-specialist (Head of	Partner
E	8	NQT	Partner
F	9	Non-specialist	Partner
F	9	Specialist (Head of	Partner
G	10	Non-specialist	Partner

Appendix C: SWC matching and comparison group construction

Data sources

The main data source used for the retention and progression analysis was the School Workforce Census (SWC). The SWC has been collected annually on the first Thursday of November since 2010 and it observes teaching staff and their characteristics from all state-sector schools in England. The key teacher characteristics recorded in the SWC and used for the analysis comprised gender, age, qualification date and role, while key school characteristics include school phase, type and region.

Each teacher in the SWC is assigned a unique identifier, which enables analysis of the same individual over multiple censuses. This allows observation of key pieces of information about teachers' careers, such as whether they leave state-sector teaching, move school/ area, or progress into a more senior role. The SWC records the school in which each teacher is employed, meaning it is also possible to identify teachers who move to different schools, LAs and regions.[19] However, since the SWC does not include teachers in private sector schools or schools outside of England, any teachers who move to one of those schools will appear to have left teaching, even though, in reality, they may not have.

The data quality and response rates to the SWC are very high, so the data has good coverage and few gaps. However, it has some gaps due to schools not submitting returns or individual teachers missing from submitted returns, so to minimise the influence of errors and data gaps, and improve the reliability of the retention outcomes, records were imputed where gaps or errors were evident.[20] While this is unlikely to have completely eliminated all instances of SWC data gaps it is unlikely to affect the interpretation of the

[19] Teachers may have contracts in multiple schools, but the file that we used for this evaluation contains one record per teacher per year of the 'main school' that a teacher is working in. The school changes that we observe are therefore changes in the 'main school', as recorded in the SWC.

[20] Cases where data gaps are obvious include the observations in which a teacher is not recorded in a school in a year after which the SWC records them as having started in a particular role. For example, if the SWC shows a particular teacher is working in a school in the 2017 census year and they are recorded as having started in their current role in the 2016 census year, where they have no SWC record, then the missing record for 2016 is imputed. In these cases, it is assumed they were teaching in the same school as in 2017, and their time-variant characteristics are imputed as appropriate (reducing their observed age, experience, etc. by one year). School-level characteristics and teacher-level characteristics that do not vary by time (i.e. gender, ethnicity), are set to their observed value in 2017. This imputation affects relatively few records and does not apply to any records in which role start date is not observed.

findings as they are very likely to affect treatment teachers/ schools in a similar way to comparison teachers/ schools.

In addition to the teacher-level variables, school-level data was used for the analysis including region, phase, Ofsted rating and Achieving Excellence Area (AEA) category, all data which is published by the DfE.[21]

The final data source consisted of the management information (MI) data collected by the TLIF providers on the teachers participating in each project, and collated by DfE. The MI data observes teachers' personal details, participation in TLIF projects, along with the provider, the name of the school in which the teacher participated in the training and, for some projects, the training start and end dates.

Each teacher in the MI data was linked to their SWC records using their name, Teacher Reference Number (TRN) and birth date. Across all TLIF projects, 97 per cent of teachers in the MI data were matched to at least one record in the SWC. Match rates varied somewhat across the different projects, although were generally very good, even after accounting for teachers in the MI data who linked to multiple teachers in the SWC, or did not link to an SWC record in the year in which they were recruited to the project.[22]

Table 26 shows that the match rate for teachers listed in the MI data as participating in the FPL project was 84 per cent to an SWC record in the year in which, according to the MI data, they were recruited to the project.

Table 26 Matching MI data to the SWC

Stage of matching	Frequency of teachers
Total FPL participants identified in the MI data	851
Total FPL participants matched to at least one SWC record	758
Total FPL participants matched to an SWC record in the year they were recruited to FPL	711
Match rate (%)	84

[21] The latest data is available here: https://www.get-information-schools.service.gov.uk/
[22] Cases such as these where the match was clearly wrong were removed from the analysis.

Methodology

After linking the MI data to the SWC, the group of comparison teachers was derived whose retention and progression outcomes were compared to FPL-participating teachers. Both general science and physics teachers were included as potential comparison teachers (defined as having spent at least one of their teaching hours teaching either general science or physics) who did not participate in any TLIF project.

For each treatment and comparison teacher, a baseline year was defined, relative to which subsequent retention and progression outcomes were observed. For FPL participant teachers, this was defined differently based on the SWC census year in which the teacher began the CPD training. For those recruited to the project in calendar year 2017, it was assumed they began the training within two months, and for those recruited in the 2018 and 2019 calendar years, it was assumed they began the training within one month of being recruited.[23]

With this full set of potential comparator teachers, a statistical technique called *propensity score matching* was used to ensure that the treatment and comparison teacher groups were highly comparable in observable characteristics. First, the probability (propensity score) that a particular teacher with given characteristics was part of the treatment group was estimated. FPL participant teachers were then matched with up to ten of their 'nearest neighbours' – comparison teachers with the most-similar likelihood of being in the treatment group, and therefore with the most similar observed characteristics.

When propensity score matching is able to match on all of the variables that influence selection into the treatment group, then the only remaining difference between the treatment and matched comparison group is the effect participating in the project had. However, variables can only be included in the matching if they are observed in the data. If other unobserved variables influence selection into the treatment group, and also affect retention (for example personality traits such as the desire to improve teaching skills, passion for physics or teaching, etc.), then this may partially explain some of the differences in outcomes between the two groups. The potential for this 'selection bias' means caution should be exercised about interpreting the differences between the groups as only representing the causal impact of the project.

[23] Date of recruitment to the project is one of the variables recorded in the MI data. In practice, this meant that the baseline SWC census year was identical to the census year of recruitment for most teachers, with the exception of those teachers who were recruited with one month (or two months for 2017 participants) of the November SWC census date.

Both teacher and school characteristics (observed at the baseline year) were used as variables in the matching. The teacher characteristics included age, gender, years since qualification,[24] full-time/part-time status, post and baseline year. The school characteristics used for matching included Ofsted rating, AEA category, quintile of free school meal (FSM) eligibility, quintile of attainment[25] and region. Since the FPL project was targeted only at secondary teachers, phase of the school was not included as a matching variable.

The quality of the match was assessed by examining cross-tabulations of the matching variables across the treatment and comparison groups. Where the variables are balanced – meaning the distribution of characteristics is similar between the treatment and comparison groups – the propensity score matching can be said to have performed well (see Tables 25 and 26 for the matching output).

As all of the outcome variables are dichotomous (i.e. yes or no), the differences in retention and progression outcomes between the two groups were estimated using logistic regression modelling. Retention and progression are considered separately from four different perspectives:

1. Within the same school one, two and three years after baseline
2. Within the same LA one, two and three years after baseline
3. Within the profession as a whole one, two and three years after baseline
4. Within a ‘challenging’ school one, two and three years after baseline.

A teacher was considered to have been ‘retained’ in the same school/LA if they were teaching in a particular school/LA in a given year, and were then recorded as teaching in the same school/LA (based on URN and LA codes) one, two, or three years later. Similarly, a teacher was considered to have been ‘retained’ in the profession if they were recorded as teaching in a state-sector school in England in a given year, and then were also teaching in a state-sector school in England one, two, or three years later.[26]

‘Challenging schools’ were generally defined as schools that were rated by Ofsted as ‘requires improvement’ or ‘inadequate’. However, it was also assumed that all FPL participant teachers were teaching in a ‘challenging school’ when they were recruited to

[24] We used years since qualification as a stand-in for experience as the variable observing year of entry into the profession (which was used to calculate years of experience) had a substantial amount of missing observations.
[25] Attainment was measured as the proportion of pupils in the school that met the minimum requirements in Reading, Maths and Science at Key Stage 2 (for primary schools) or GCSEs (for secondary schools). Schools were assigned to an attainment quintile based on this proportion.
[26] To reiterate, since the SWC only observes teachers in state-sector schools in England, any teacher who moves to a private school or to a school outside of England will be considered to have left the profession.

the project at baseline, even for the relatively few teachers that were in a ‘good’ or ‘outstanding’ school (see Table 27). This is because the school had been deemed challenging enough to be targeted by the FPL project, despite having been rated favourably by Ofsted in its last inspection.

Retention in a challenging school was defined at the teacher-level. That is, an FPL participant teacher was considered as having been retained in a ‘challenging school’ if they either stayed in the same school they were in at baseline, or had moved to a different school which was rated ‘requires improvement’ or ‘inadequate’ in the year they moved. It should be noted that this same definition also applies to comparison teachers (including those in ‘good’ or ‘outstanding’ schools not targeted by the FPL project), but the results of the statistical matching (see Table 27) ensure that the observed characteristics of the ‘good’ and ‘outstanding’ schools in the comparison group are similar to the observed characteristics of the ‘good’ and ‘outstanding’ schools within the treatment group.

As a concrete example, an FPL teacher in a ‘good’ school who stayed in the same school, or a non-FPL teacher in a ‘requires improvement’ school who moved to an ‘inadequate’ school would both be considered to have been ‘retained in a challenging school’. Similarly, any teachers who moved to another school with a ‘good’ or ‘oustanding’ rating were considered to have moved to a ‘non-challenging’ school, regardless of the rating of the school they were in at baseline.

Progression was defined according to three broad role categories – classroom teachers, middle leaders, and senior leaders. Middle leaders were defined as teachers in a “Leading Practitioner”, “Excellent Teacher”, “Advanced Skills Teacher”, or “Advisory Teacher” post, or who received a Teacher Leadership Responsibility (TLR) payment of £100 or more in a given year.[27] Senior leaders were defined by those in an “Executive Head Teacher”, “Head Teacher”, “Deputy Head Teacher” or “Assistant Head Teacher” role in a given year.

A teacher was considered to have ‘progressed’ if they moved from a classroom teacher role to either a middle or senior leadership role, or a middle leadership role to a senior leadership role one, two or three years after baseline. Progression within a school/LA/challenging school is defined as those teachers who remain within the same school/LA/a challenging school and progressed from classroom teacher to middle leadership or middle leadership to senior leadership. Teachers not retained in the profession were not included in the progression analysis.

[27] This is a definition of middle leader that has been used by DfE in the past. See Footnote 14 in https://www.gov.uk/government/statistics/teachers-analysis-compendium-2017

Eight different regression models were estimated, one each for retention and progression within the same school/the same LA/challenging schools/the profession. As independent variables, all of the variables from the propensity score matching were included – in order to control for any remaining imbalances in the matching variables between the treatment and comparison groups after matching – as well as the treatment indicator and year dummy variables to account for specific time period effects (e.g. the impact of Covid-19 on the 2020 data). Senior leaders were excluded from the sample estimating the effect on progression as, based on the definition above, they are not able to progress any further and therefore progression outcomes are 'did not progress further' by definition.

To compare the differences between the two groups, the probability of 'retention' or 'progression' was estimated if every teacher had been involved in the project, and then again if every teacher had not been involved in the project. The average of these predicted probabilities is the average estimated retention/progression rate for treatment and comparison teachers, respectively. The difference between treatment and comparison teachers is the estimated 'marginal effect', which is presented in the tables in section 4.4.3, with the accompanying odds ratio estimates in Appendix D. Standard errors for the marginal effect estimates are calculated using the delta method and statistical significance is assessed at the five per cent level.

Statistical Matching

Table 27 below highlights the sample characteristics for the full treatment and comparison groups. Some characteristics, such as gender and full-time status, were fairly closely aligned even in the unmatched sample. However, other characteristics, like teacher age, experience, school deprivation and attainment, were not.

Teachers in the potential comparison group tended to be fairly evenly spread over attainment and FSM quintiles, and the majority were teaching in non-priority schools (AEA categories 1-4). FPL participant teachers, however, were much more likely than potential comparison teachers to be younger, less experienced, and teaching in more deprived and lower-attaining schools. Unlike comparison teachers, nearly all treatment teachers were teaching in AEA category 5 or 6 schools, most of which were outside of London, as these were the schools targeted by the project.

After matching, the proportions of comparison teachers in each of the key matching characteristics were much more closely aligned with treatment teachers. The propensity score matching ensured that teachers in the matched comparison group were drawn primarily from AEA category 5 and 6, more-deprived and lower-attaining schools. While some small differences between treatment and comparison teachers still existed after matching, including the matching variables in the logistic regression modelling ensured that the final estimates controlled for any of these outstanding differences.

Focussing on the subset of potential comparison teachers who were the most similar to treatment teachers necessarily involved discarding some potential comparison teachers from the matched sample, when there were no sufficiently similar treatment teachers with which to match. Of the 75,729 potential comparison teachers, only 4,828 were matched to a treatment teacher, highlighting how most comparison teachers were fairly dissimilar to teachers recruited to the FPL project (at least in observed teacher and school characteristics).

Four potential treatment teachers were also discarded from the matched sample, as these teachers have no sufficiently similar counterpart in the potential comparison teacher sample.

Table 27 Characteristics of treatment and comparison teachers before and after matching in the full sample

Characteristic	Treatment teachers (%)	Potential comparison teachers (%)	Matched treatment teachers (%)	Matched comparison teachers (%)
Male	44.7	43.2	44.6	46.0
Female	55.3	56.8	55.4	54.0
Aged under 30	32.8	21.8	32.7	33.5
Aged 30-49	56.5	61.2	56.6	56.7
Aged 50 or older	10.7	17.1	10.7	9.8
Within 5 years of qualifying	40.4	25.8	40.0	39.5
Between 5 and 9 years since qualifying	18.8	20.6	19.0	19.8
Between 10 and 19 since qualifying	24.6	31.8	24.8	25.8
20 years or more since qualifying	12.7	18.9	12.7	11.4

Characteristic	Treatment teachers (%)	Potential comparison teachers (%)	Matched treatment teachers (%)	Matched comparison teachers (%)
Unknown years since qualifying	3.5	2.9	3.5	3.4
Classroom teacher	66.1	54.3	65.9	64.7
Middle leader	30.5	37.4	30.7	32.7
Senior leader	3.4	8.3	3.4	2.6
Full-time	89.0	83.5	89.1	90.1
Part-time	11.0	16.5	10.9	9.9
AEA category 1-4	5.6	71.3	5.7	5.5
AEA category 5-6	94.4	28.7	94.3	94.5
Ofsted outstanding	9.3	26.1	9.3	9.7
Ofsted good	36.7	53.8	36.9	38.6
Oftsted requires improvement	36.4	13.0	36.5	36.3
Ofsted inadequate	10.3	4.5	10.2	9.4
Ofsted rating unknown	7.3	2.7	7.1	6.1
FSM highest 20%	30.2	15.8	30.3	30.7
FSM middle-highest 20%	31.5	18.0	31.4	31.3
FSM middle 20%	18.7	20.0	18.7	17.3
FSM middle-lowest 20%	12.4	21.3	12.4	12.5
FSM lowest 20%	7.2	25.0	7.2	8.2
Attainment highest 20%	9.1	26.9	9.2	9.3
Attainment middle-highest 20%	15.8	27.5	15.8	18.4
Attainment middle 20%	28.0	25.3	28.1	25.6

Characteristic	Treatment teachers (%)	Potential comparison teachers (%)	Matched treatment teachers (%)	Matched comparison teachers (%)
Attainment middle-lowest 20%	40.8	17.2	40.6	41.2
Attainment lowest 20%	2.1	0.7	2.1	1.9
Attainment unknown	4.2	2.4	4.1	3.6
Non-London	> 98.0*	83.6	> 98.0*	99.9
London	< 2.0*	16.4	< 2.0*	0.1
Baseline year 2017	60.6	31.9	60.4	61.5
Baseline year 2018	32.9	33.5	33.1	32.3
Baseline year 2019	6.5	34.6	6.5	6.2
Number of teachers	**711**	**75,729**	**707**	**4,828**

Note: * indicates proportion has been rounded due to small sample sizes.

In addition to the full matched sample, a second matched sample was derived, with which to estimate the differences in career progression and retention within the same school/same LA/a challenging school. This sample was only used for the teacher level analysis and not the school level analysis. Given that career progression or retention within the same school/same LA/a challenging school for teachers who left the profession is not observed for teachers who leave the profession, this additional matched sample consisted of a subset of teachers in the full sample who did not leave the profession in the three years after baseline. Characteristics of teachers in the matched sample of non-leavers were very similar to the full matched sample.

Appendix D: Outcomes of SWC impact analysis

Table 28 Odds ratios from the retention and progression outcome analysis

	1 year after baseline	2 years after baseline	3 years after baseline
Retention in state-sector teaching	2.0 (1.5 – 2.8)	1.3 (1.0 – 1.7)	1.2 (0.9 – 1.5)
Retention in the same school	1.0 (0.8 – 1.3)	0.8 (0.7 – 1.0)	0.7 (0.5 – 0.9)
Retention in the same LA	1.1 (0.8 – 1.5)	0.9 (0.7 – 1.2)	0.8 (0.6 – 1.1)
Retention in a challenging school	1.3 (0.9 – 1.9)	0.8 (0.6 – 1.1)	0.7 (0.5 – 0.9)
Progression in state-sector teaching	1.1 (0.8 – 1.4)	0.9 (0.7 – 1.2)	1.1 (0.8 – 1.5)
Progression in the same school	1.1 (0.8 – 1.6)	0.9 (0.7 – 1.3)	1.1 (0.7 – 1.7)
Progression in the same LA	1.1 (0.8 – 1.5)	0.9 (0.6 – 1.2)	1.0 (0.7 – 1.4)
Progression in a challenging school	1.1 (0.8 – 1.5)	0.8 (0.6 – 1.1)	0.9 (0.6 – 1.3)

Note: Figures in brackets represent the 95 per cent confidence interval of the odds ratio estimate.

Appendix E: Survey sample characteristics

Table 29 Selected characteristics of achieved survey samples at baseline, endpoint and in the matched analysis - Role

Role	Baseline[28] N	Baseline[28] %	Endpoint[29] N	Endpoint[29] %	Matched[30] analysis N	Matched analysis[30] %
Classroom teacher	227	61.2	69	56	47	56.6
Middle leader	120	32.3	38	31	28	33.7
Senior leader	19	5.1	11	9	8	9.6
Missing	5	1.4	6	5	0	0

Table 30 Selected characteristics of achieved survey samples at baseline, endpoint and in the matched analysis – FPL participant type

FPL participant type	Baseline N	Baseline %	Endpoint N	Endpoint %	Matched analysis N	Matched analysis %
Newly Qualified Teacher/Early Career Teacher (NQT/ECT)	15	4	6	5	5	6
School-based development coach (SBDC)	38	10.2	17	14	13	15.7
Physics Non-specialist	220	59.3	65	52	32	38.6

[28] A total of 371 responses were received at baseline.
[29] A total of 124 responses were received at endpoint.
[30] A total of 83 responses were matched at baseline and endpoint.

Physics specialist	98	26.4	36	29	33	39.8

Table 31 Selected characteristics of achieved survey samples at baseline, endpoint and in the matched analysis – Years in teaching

Years in teaching[31]	Baseline N	Baseline %	Endpoint N	Endpoint %	Matched analysis N	Matched analysis %
30 years or more	5	1.3	4	3	3	3.6
20-29 years	33	8.9	18	15	14	16.9
10-19 years	97	26.1	31	25	23	27.7
5-9 years	78	21	17	14	13	15.7
1-4 years	90	24.3	34	27	26	31.3
First year of teaching (NQT)	60	16.2	7	6	4	4.8

Table 32 Selected characteristics of achieved survey samples at baseline, endpoint and in the matched analysis – Participation in the project

Participation in the project[32]	Baseline	Baseline	Endpoint N	Endpoint %	Matched analysis N	Matched analysis %
Joined from the start and completed*	n/a	n/a	67	54	52	62.7
Joined after the start but completed*	n/a	n/a	36	29	24	28.9
Dropped out early; did not complete	n/a	n/a	8	7	7	8.4

[31] A total of 8 participants at baseline and 13 participants at endpoint were missing from the responses to this question as they were routed out from the survey as their role in school did not fall into any of the relevant teaching role categories of class teacher, middle leader or senior leader.

[32] A total of 13 participants at endpoint responded that they had not participated in the FPL project at all and were subsequently routed out from the survey.

*These responses include respondents who completed FPL prior to completing the endpoint survey, as well as those who were still participating in FPL at the time they completed the endpoint survey.

Table 33 Selected characteristics of achieved survey samples at baseline, endpoint and in the matched analysis – FSM quintiles

FSM quintiles	Baseline N	Baseline %	Endpoint N	Endpoint %	Matched analysis N	Matched analysis %
Lowest 20%	16	4.3	11	9	10	12
2nd lowest 20%	41	11.1	14	11	9	10.8
Middle 20%	64	17.3	8	7	7	8.4
2nd highest 20%	104	28	32	26	27	32.5
Highest 20%	78	21	18	15	15	18.1
Missing	68	18.3	41	33	15	18.1

Table 34 Selected characteristics of achieved survey samples at baseline, endpoint and in the matched analysis – Ofsted rating

Ofsted rating	Baseline N	Baseline %	Endpoint N	Endpoint %	Matched analysis N	Matched analysis %
Outstanding	38	10.2	17	14	12	14.5
Good	135	36.4	33	27	30	36.1
Requires improvement	147	39.6	35	28	29	34.9
Inadequate	41	11.1	11	9	9	10.8
Missing	10	2.7	28	23	3	3.6

Appendix F: Fund-level (core questions) factor analysis

Approach to fund-level factor analysis

The TLIF project evaluations included surveys of participants at baseline and endpoint. The surveys included ‘core questions’ – common questions and items included in all the TLIF surveys - with the aim of providing data that could be combined across all projects to analyse fund-level outcomes. Surveys also included, to differing extents, ‘bespoke questions’ – questions that were specific to the project focus and outcomes. This section explains the approach taken to factor analysis of the survey ‘core questions’. Appendix G outlines the approach taken to factor analysis of bespoke questions.

Factor analysis is a statistical technique that summarises information from a number of survey items into a smaller set of reliable outcome measures. It combines survey items that are correlated and assess the same underlying latent construct by grouping together question items that have similar patterns of responses. This enables more robust and straightforward analysis than reporting single items. We used the factors derived through this analysis as our outcome measures to report the survey findings in this report.

Factor analysis was conducted in two stages. First, it was conducted on the core question items that were asked of *all* respondents in exactly the same way. This resulted in Factors 1 to 4 for all respondents. Second, it was conducted on core question items that covered consistent themes, but where the wording, or the inclusion, of items varied slightly depending on the *role of the respondent* (class teachers, middle leaders, or senior leaders). This resulted in Factors 5 to 8 for class teachers, Factors 9 to 12 for middle leaders, and Factors 13 and 14 for senior leaders. The Future Physics Leaders project evaluation included questions for class teachers, middle leaders, and senior leaders. However, the overall sample is very small to be broken down by sub-groups so analysis should be interpreted with caution.

Each survey question was designed to measure a specific construct – for example ‘leadership quality’ – through a series of items related to that construct. In our analysis, the items that loaded onto each individual factor were, in most cases, derived from a single survey question. This indicates that our survey was successful in measuring the constructs that it intended to. Most survey questions were answered on a Likert scale (e.g. an 8-point agree-disagree scale). The response on the scale was converted to a score for each item, then combined to produce a mean score and score range for each of the factors. Any teacher, middle or senior leader that answered a third or less of the items entered in to the factor analysis were removed from the analysis for the purpose of constructing the factors on a consistent set of responses.

Factors were selected that met the following criteria:

- strong internal consistency of each factor which indicates reliability (indicated by a high Cronbach's Alpha statistic on a range from 0 to 1)
- loadings above 0.3 which indicate an association between items and the underlying factors. The relationship of each item to a factor is expressed by a factor loading. Factor loadings are similar to correlation coefficients – a higher value on a range from -1 to 1 indicates a stronger correlation with the factor
- Eigenvalues greater than 1 which indicate strong validity of the factors (the additional variance explained by bringing items together into a single factor)
- low levels of correlation between factors, indicating that each factor is measuring something slightly different.

Several factors were only comprised of two items. However, we deemed this to be acceptable as a two-item factor provides a more robust measure of a concept than two separate items.

Some questions and items that were entered into factor analysis did not load onto factors, or form reliable factors. These are analysed separately in the report, as applicable to the project.

Factors for all respondents

Table 35 Factor 1 - Effectiveness of school leadership (all)

Effectiveness of school leadership (all): Item statements	Loading
My school leadership team: sets a clear vision	0.769
My school leadership team: is effective	0.768
My school leadership team: creates an ethos within which all staff are motivated and supported to develop their own skills and subject knowledge	0.734
My school leadership team: sets high expectations for all pupils	0.721
My school leadership team: challenges assumptions about low capabilities of disadvantaged pupils	0.694
My school leadership team: uses data to monitor the quality of teaching and learning and to initiate improvements where required	0.683
My school leadership team: identifies professional development as a priority for all teachers	0.673
My school leadership team: values experimentation and the introduction of new ideas for teaching and learning	0.660
My school leadership team: trusts staff to adapt teaching practices to meet the needs of pupils	0.650

My school leadership team: sets the conditions for effective behaviour management	0.649
My school leadership team: supports teachers to develop their careers (either via a teaching or leadership route, depending on their interest)	0.646
My school leadership team: identifies professional development as a priority for all support staff	0.597
My school leadership team: facilitates collaborative work with other schools	0.569

Reliability of measure: Alpha = 0.941

Table 36 Factor 2 - Effectiveness of professional development (all)

Effectiveness of professional development (all): Item statements	Loading
The facilitation of the professional development I have received is effective	0.806
The content of the professional development I have received is relevant to my needs	0.796
The professional development I have undertaken has been effective	0.755
There is support to implement learning from professional development	0.709
I have access to high-quality professional development	0.687
I am encouraged to undertake professional development	0.589
I receive support to undertake follow-up activities when engaging in professional development	0.584

Reliability of measure: Alpha = 0.917

Table 37 Factor 3 - Effectiveness of school culture (all)

Effectiveness of school culture (all): Item statements	Loading
I enjoy working at my school	0.679
Most pupils achieve the goals that are set for them in my school	0.588
My school has a collaborative culture characterised by mutual support	0.558
All in all, I am satisfied with my job	0.529
The atmosphere throughout my school encourages pupils to learn	0.524
My workload is manageable	0.507

Reliability of measure: Alpha = 0.818

Table 38 Factor 4 - Motivation for professional development (all)

Motivation for professional development (all): Item statements	Loading
I am keen to engage in professional development	0.807
Professional development plays a major role in helping me to improve the quality of my teaching / leadership	0.772

Reliability of measure: Alpha = 0.831

Factors for classroom teachers (CT)

Table 39 Factor 5 - Personal knowledge for effective teaching (CT)

Personal knowledge for effective teaching (CT): Item statements	Loading
I have the required subject pedagogical knowledge to effectively teach my subject(s) / key stage	0.920
I have the required generic pedagogical knowledge to effectively teach my subject(s) / key stage	0.794
I have the required subject knowledge to effectively teach my subject(s) / key stage	0.733

Reliability of measure: Alpha = 0.877

Table 40 Factor 6 - School teaching quality (CT)

School teaching quality (CT): Item statements	Loading
Teachers in this school manage behaviour effectively to ensure a safe learning environment	0.723
Teachers set high expectations for all pupils' achievement	0.708
Teaching in my subject(s) / key stage is generally very good	0.348

Reliability of measure: Alpha = 0.665

Table 41 Factor 7 - Motivation for teaching-focused professional development (CT)

Motivation for teaching-focused professional development (CT): Item statements	Loading
I use professional development both to maintain and to extent my knowledge of my subject area(s) / key stage	0.889
I use professional development both to maintain and to extend my critical understanding of a range of subject- or key stage-specific pedagogical approaches	0.843

Reliability of measure: Alpha = 0.878

Table 42 Factor 8 - Opportunities for career progression (CT)

Opportunities for career progression: Item statements	Loading
I have the opportunity to progress as a classroom teacher within my school if I want to (e.g. as a specialist subject leader)	0.897
I have the opportunity to progress into a middle/senior leadership position within my school if I want to	0.786

Reliability of measure: Alpha = 0.84

Factors for middle leaders (ML)

Table 43 Factor 9 - Personal knowledge for effective teaching (ML)

Personal knowledge for effective teaching (ML): Item statements	Loading
I have the required subject pedagogical knowledge to effectively teach my subject(s) / key stage	0.892
I have the required generic pedagogical knowledge to effectively teach my subject(s) / key stage	0.856
I have the required subject knowledge to effectively teach my subject(s) / key stage	0.730

Reliability of measure: Alpha = 0.906

Table 44 Factor 10 - School teaching quality (ML)

School teaching quality (ML): Item statements	Loading
Teachers in my subject/key stage have the required subject pedagogical knowledge to effectively teach their subject(s) / key stage	0.934
Teachers in my school have the required generic pedagogical knowledge to effectively teach their subject(s) / key stage	0.845
Teachers in my subject/key stage have the required subject knowledge to effectively teach their subject(s) / key stage	0.747
Teachers in my subject/key stage use research findings to make changes to their teaching practice	0.589
Teachers set high expectations for all pupils' achievement	0.523
Teachers in this school manage behaviour effectively to ensure a safe learning environment	0.412

Reliability of measure: Alpha = 0.859

Table 45 Factor 11 - Motivation for teaching-focused professional development (ML)

Motivation for teaching-focused professional development (ML): Item statements	Loading
I use professional development both to maintain and to extend my critical understanding of a range of subject- or key stage-specific pedagogical approaches	0.898
I use professional development both to maintain and to extend my knowledge of my subject area(s) / key stage	0.865

Reliability of measure: Alpha = 0.9

Table 46 Factor 12 - Opportunities for career progression (ML)

Opportunities for career progression (ML): Item statements	Loading
I have the opportunity to progress into a system leadership position if I want to (e.g. a specialist leader of education (SLE))	0.787
I have the opportunity to progress into a middle/senior leadership position within my school if I want to	0.742

Reliability of measure: Alpha = 0.765

Factors for senior leaders (SL)

Table 47 Factor 13 - School teaching quality (SL)

School teaching quality (SL): Item statements	Loading
Teachers in my school have the required subject pedagogical knowledge to effectively teach their subject(s) / key stage	0.914
Teachers in my school have the required generic pedagogical knowledge to effectively teach their subject(s) / key stage	0.901
Teaching across different subject(s) / key stages is generally very good	0.867
Teachers in my school set high expectations for all pupils' achievement	0.828
Teachers in my school have the required subject knowledge to effectively teach their subject(s) / key stage	0.803
Teachers in my school manage behaviour effectively to ensure a safe learning environment	0.709
Teachers in my school use research findings to make changes to their teaching practice	0.678

Reliability of measure: Alpha = 0.931

Table 48 Factor 14 - Opportunities for career progression (SL)

Opportunities for career progression (SL): Item statements	Loading
I have the opportunity to progress into a senior system leadership position if I want to (e.g. (NLE), Multi-Academy Trust Chief Executive, Teaching School Alliance Director)	0.853
I have the opportunity to progress into a system leadership position if I want to (e.g. a specialist leader of education (SLE))	0.815

Reliability of measure: Alpha = 0.821

Appendix G: Bespoke project-level factor analysis

Survey questions that were bespoke to measuring the Future Physics Leaders project outcomes were also analysed using factor analysis – the same statistical procedure as outlined in Appendix F. The analysis resulted in four bespoke project-level factors as outlined below. The remaining bespoke project-level survey items did not form factors or load into these factors, and are, therefore, reported as separate, individual questions/items.

Table 49 Factor 15 - Physics pedagogy

Physics pedagogy: Item statements	Loading
Rectify pupils' physics misconceptions	0.822
Use a variety of materials and resources in my physics lessons	0.787
Pitch the content of my physics lessons appropriately to pupils' needs to scaffold their learning	0.746
Draw on relevant and real-world physics examples	0.740
Teach physics in an enjoyable and engaging way	0.776
Teach a variety of practical physics lessons	0.681
Manage pupil behaviour in practical physics lessons to ensure pupils work safely	0.594

Reliability of measure: Alpha = 0.907

Table 50 Factor 16 - Physics leadership

Physics leadership: Item statements	Loading
Deliver high-quality professional development sessions on physics	0.853
Mentor/coach colleagues on teaching physics	0.821
Exemplify evidence-based physics teaching practice	0.802
Support non-specialist physics teachers to teach practical physics lessons	0.79
Be observed modelling effective physics teaching	0.768
Work with other departments to ensure cross-curricular links are made between physics and other relevant subjects (e.g. sciences, technology, engineering and maths)	0.748
Carry out observations of others' physics teaching practice	0.71

Support the development of physics teachers (e.g. Newly Qualified Teachers (NQTs)/Early Career Teachers (ECTs)/non-specialist physics teachers) in other schools in my area	0.705
Lead the development of physics curriculum	0.7
Share physics teaching resources with colleagues	0.632
Develop my own physics expertise by engaging with a physics network beyond my school (e.g. engaging with/contributing to academic publications; presenting at conferences; peer-reviewing articles)	0.598

Reliability of measure: Alpha = 0.941

Table 51 Factor 17 - Access to physics professional development

Access to physics professional development: Item statements	Loading
I have access to high-quality physics teaching professional development (internal and/or external to your school)	0.84
I have access to high-quality physics leadership professional development (internal and/or external to your school)	0.801
I have access to physics subject networks/community (e.g. to share good practice)	0.776

Reliability of measure: Alpha = 0.851

Table 52 Factor 18 - Pupil behaviour, progress and attainment in physics

Pupil behaviour, progress and attainment in physics: Item statements	Loading
My pupils enjoy learning physics	0.852
My pupils are making good progress in physics	0.769
My pupils are motivated to study physics post-16	0.715
My pupils are well behaved during physics lessons	0.666
My pupils understand the sorts of careers that physics study could lead to	0.654

Reliability of measure: Alpha = 0.843

Appendix H: Extent to which participants were involved in each of the main elements of the Future Physics Leaders project

Participants answering the endpoint survey were presented with a list of the main elements associated with each of the strands of FPL and asked which elements they had engaged with.

Participants were then asked a follow-up question in relation to each strand of FPL they said they were engaged with and were asked to rate their level of involvement on a scale of 1 to 8 where 1 was ‘Not at all’ and 8 was ‘fully’. The scale has subsequently been collapsed into four categories as follows: 1-2 (‘Not at all’); 3-4 (‘Somewhat’); 5-6 (‘Moderately’); 7-8 (‘Fully’).

Finally participants were asked to rate the extent to which each of the FPL elements they were involved with had met their needs on a scale of 1 to 8 where 1 was ‘Not at all’ and 8 was ‘fully’. The scale has subsequently been collapsed into four categories as follows: 1-2 (‘Not at all’); 3-4 (‘Somewhat’); 5-6 (‘Moderately’); 7-8 (‘Fully’).

The responses are presented below in relation to each of the four participant types: School-based development coaches; specialists; non-specialists; and NQTs.

School-based development coaches (SBDCs)

Table 53 School-based development coaches - elements engaged with

	Yes N	No N
National CPD sessions on becoming a SBDC	11	5
Supporting the delivery of hub CPD for specialist/non-specialist physics teachers	11	5
Receiving coaching support from an IOP development coach	11	5
Providing coaching support to FPL NQTs/RQTs	5	11
N=16		

Table 54 School-based development coaches - extent of engagement

	Not at all (1-2) N	Somewhat (3-4) N	Moderately (5-6) N	Fully (7-8) N	N
National CPD sessions on becoming a SBDC	0	0	4	7	11
Supporting the delivery of hub CPD for specialist/non-specialist physics teachers	0	3	1	7	11
Receiving coaching support from an IOP development coach	0	4	2	5	11
Providing coaching support to FPL NQTs/RQTs	0	1	2	2	5

Table 55 School-based development coaches - extent met needs

	Not at all (1-2) N	Somewhat (3-4) N	Moderately (5-6) N	Fully (7-8) N	N
National CPD sessions on becoming a SBDC	0	2	2	7	11
Supporting the delivery of hub CPD for specialist/non-specialist physics teachers	0	2	3	6	11
Receiving coaching support from an IOP development coach	0	5	1	5	11
Providing coaching support to FPL NQTs/RQTs	0	0	2	3	5

Physics specialists

Table 56 Physics specialists - elements engaged with

	Yes N	No N
Hub CPD sessions for physics specialists	29	7
Providing coaching support to FPL NQTs/RQTs	12	24
N=36		

Table 57 Physics specialists - extent of engagement

	Not at all (1-2) N	Somewhat (3-4) N	Moderately (5-6) N	Fully (7-8) N	N
Hub CPD sessions for physics specialists	2	3	8	16	29
Providing coaching support to FPL NQTs/RQTs	1	3	2	6	12

Table 58 Physics specialists - extent met needs

	Not at all (1-2) N	Somewhat (3-4) N	Moderately (5-6) N	Fully (7-8) N	N
Hub CPD sessions for physics specialists	0	3	9	17	29
Providing coaching support to FPL NQTs/RQTs	0	3	3	6	12

Physics non-specialists

Table 59 Physics non-specialists - elements engaged with

	Yes N	No N
Hub or school-based CPD sessions for non-specialist teachers of physics	46	7
N=53		

Table 60 Physics non-specialists - extent of engagement

	Not at all (1-2) N	Somewhat (3-4) N	Moderately (5-6) N	Fully (7-8) N	N
Hub or school-based CPD sessions for non-specialist teachers of physics	2	8	15	21	46

Table 61 Physics non-specialists - extent met needs

	Not at all (1-2) N	Somewhat (3-4) N	Moderately (5-6) N	Fully (7-8) N	N
Hub or school-based CPD sessions for non-specialist teachers of physics	0	3	14	29	46

Physics NQTs

Table 62 Physics NQTs - elements engaged with

	Yes N	No N
Hub CPD sessions for physics specialists	4	2
Mentoring from an IOP development coach	5	1
Mentoring from a school-based mentor	2	4
Matched physics-focused teaching timetable	5	1
N=6		

Table 63 Physics NQTs - extent of engagement

	Not at all (1-2) N	Somewhat (3-4) N	Moderately (5-6) N	Fully (7-8) N	N
Hub CPD sessions for physics specialists	0	2	2	0	4
Mentoring from an IOP development coach	1	0	1	3	5
Mentoring from a school-based mentor	1	0	0	1	2
Matched physics-focused teaching timetable	1	0	0	4	5

Table 64 Physics NQTs - extent met needs

	Not at all (1-2) N	Somewhat (3-4) N	Moderately (5-6) N	Fully (7-8) N	N
Hub CPD sessions for physics specialists	0	2	0	2	4
Mentoring from an IOP development coach	1	0	1	3	5
Mentoring from a school-based mentor	0	1	1	0	2
Matched physics-focused teaching timetable	1	0	0	4	5

Appendix I: Analysis of Management Information for the Teaching and Leadership Innovation Fund: Institute of Physics

Introduction

The Teaching and Leadership Innovation Fund (TLIF) was a DfE fund through which 10 providers offered support to schools in a variety of areas from behaviour management to phonics and STEM teaching. The aim of the fund was to create and develop a sustainable market for high-quality Continuous Professional Development (CPD). This is a summary of Management Information (MI) data submitted by all ten providers receiving TLIF funding and **does not** assess project impact. The data was submitted in February 2020 and covers the schools and participants recruited, as indicated by the providers.

Comparable national figures in this report are based on the 2018 School Workforce Census covering teaching staff in state-funded schools, and Ofsted as at the most recent inspection. The 2018 School Workforce Census was chosen in order to align with the most schools across programme cohorts between 2017 and 2020. The school level analysis refers to all schools that were recruited by providers to participate in the project, including those that withdrew. Schools may have been recruited by more than one provider and participants may have been registered for more than one project.

Targets: Background

Each provider had a number of Key Performance Indicators (KPIs). These were broken down into three different categories:

- **geography**: whether specific areas were targeted by providers (e.g. regional targets, Opportunity Areas, priority areas) and whether particular schools should be targeted by providers (e.g. based on Ofsted rating);
- **schools**: the target number of schools;
- **participants**: the target number of participants.

All providers had a geography target and either a participant or a school target, but not necessarily both.

In the context of the TLIF evaluation, a priority area is defined as Achieving Excellence Areas (AEAs) 5 or 6 (Opportunity Areas fall within this category), and a priority school is defined as a school with an Ofsted rating of Requires improvement (Ofsted grade 3) Or Inadequate (Ofsted grade 4).

Note: there are some discrepancies between the overall numbers from providers and those in the data set sent to us. The provider numbers cannot be broken down in school/area type etc. so analysis will not be conducted on this data, however headline figures will be presented where available.

Targets: Breakdown

The Institute of Physics (IoP) delivered the Future Physics Leaders Programme, which aimed to improve the recruitment, retention and quality of Physics teachers. IoP had the following KPI targets:

Geography Level:
- 100% of the schools were to be recruited from priority areas.
- A minimum of 70% of participants were to be recruited from priority schools.
- The programme was intended to have national coverage.

School Level:
- A minimum of 168 schools were to be recruited to the programme.
- The programme was aimed at both Primary and Secondary schools.

Participant Level:
- A minimum of 924 participants were to be recruited during the programme.
- The programme was aimed at: specialist and non-specialist teachers of Physics.

Note: The role/leadership data held isn't detailed enough to determine the breakdown between specialist/non-specialist teaching roles reliably, so analysis has not been conducted on this target.

Total school numbers

A total of 172 schools were recruited by IoP. However, removing schools where all participants withdrew reduces this to 163 schools.

The initial target was 168 schools. 99% of schools recruited were from priority areas which slightly below the target of 100%.

Note: IoP's own data puts the number of schools at 168, however, not all of these schools are present in DfE's Management Information data set.

Total participant numbers

The total number of teachers that participated in the course was 826. Removing those that withdrew gives a total of 649. The target number of participants was 924.

Note: IoP's own data puts the number of participants at 838, however, not all of these participants are in our participant data set.

58% of all recruited participants were from priority schools. Of those that completed the course, 57% were from priority schools. The target was 70%.

Note: 9 schools have no Ofsted rating data and have not been included in the priority schools analysis.

Schools by Phase

IoP recruited entirely from Secondary schools. This aligns with the focus on Physics teachers, though they could recruit primary schools according to their contract.

Schools by Region

IoP recruited from schools in all 8 RSC Regions. The region with the highest proportion of schools recruited by IoP (including withdrawals) was Lancashire and West Yorkshire where 27% of participating schools were based.

Of the remaining schools:

- 18% were based in the West Midlands,
- 16% in East Midlands and the Humber,
- 12% in the East of England and North East London,
- 10% in South East and South London,
- 8% in South Central and North West London,
- 4% in the South West
- 3% in the North of England

Schools by AEA Category

AEA categories are DfE classifications of Local Authority Districts (LADs) by educational performance and capacity to improve, introduced in 2016. It splits areas into six categories from "Strong" Category 1 areas to "Weak" Category 6 areas.

Of all the schools recruited by IoP (including withdrawals) 99% were in Categories 5 and 6 with around 1% in category 2.

Schools by Index of Multiple Deprivation Decile

The Index of Multiple Deprivation (IMD) is a "neighbourhood" measure of deprivation produced by the Ministry of Housing, Communities and Local Government. Each neighbourhood is placed into a decile with decile 1 containing the most deprived areas and decile 10 containing the least deprived.

IoP recruited across all of the areas, but this was weighted towards more deprived areas with 33% of schools recruited (including withdrawals) located in deciles 1 and 2.

Participants by role

Roles were provided in TLIF Management Information as free text and matched to a standardised leadership level. Below these have been compared to national figures taken from the 2018 School Workforce Census Publication. IoP recruited participants from all teaching and leadership levels except Headteacher:

- 71% of participants (including withdrawals) were classroom teachers (compared to 57% nationally)
- 21% of participants were middle leaders (compared to 28% nationally),
- 3% were senior leaders (compared to 10% nationally).
- 4% of participants were non-teaching staff.

The level of the data does not allow the split between specialist and non-specialist teacher to be explored reliably, so this analysis has not been conducted.

Appendix J: Practical summary of the evidence about effective CPD (Coe, 2020)

CPD that aims to support the kinds of changes in teachers' classroom practice that are likely to lead to substantive gains in pupil learning should:

1) Focus on promoting the teacher skills, knowledge and behaviours that are best evidenced as determining pupil learning. Such content should be appropriately sequenced and differentiated to match the needs of participants.

2) Have sufficient duration (two terms) and frequency (fortnightly) to enable changes to be embedded.

3) Give participants opportunities to:

a) be presented with new ideas, knowledge, research evidence and practices

b) reflect on and discuss that input in ways that surface and challenge their existing beliefs, theories and practices

c) see examples of new practices/materials/ideas modelled by experts

d) experiment with guided changes in their practice that are consistent with these challenging new ideas and their own context

e) receive feedback and coaching from experts in those practices, on an ongoing basis

f) evaluate, review and regulate their own learning

4) Create/require an environment where:

a) participants can collaborate with their peers to support, challenge and explore

b) school leadership promotes a culture of trust and continuous professional learning

c) teachers believe they can and need to be better than they are

d) the process and aims of the CPD are aligned with the wider context (e.g. accountability)

Source: Coe, R. (2020). 'The case for subject-specific CPD.' Paper presented at the Subject CPD Roundtable, Institute of Physics, London, 22 January.

Appendix K: Results of Fund-level change-over-time analysis

Analysis was conducted to explore change over time (between baseline and endpoint) in survey responses to core-questions. Respondents were asked to rate a series of items on a scale of one to eight, where one was 'Strongly Disagree' and eight was 'Strongly Agree'. The responses were then converted into a point score, with 'Strongly Disagree' being worth -4.0 points, and 'Strongly Agree' +4.0 points. A mean score was then calculated based on all the items making up a factor (the minimum and maximum score for each factor is displayed in the tables below), and compared between baseline and endpoint. The results of the analysis of the fund-level composite outcome measures are displayed in the tables below.

Table 65 Fund-level outcomes - school leadership

Factor	Range Min	Range Max	Mean score Baseline	Mean score Endpoint	Mean score Change	N	Statistically significant change (p = <0.05)
Effectiveness of school leadership (all)	-52	52	23.14	23.73	0.59	83	No

Table 66 Fund-level outcomes - teaching quality

Factor	Range Min	Range Max	Mean score Baseline	Mean score Endpoint	Mean score Change	N	Statistically significant change (p = <0.05)
Personal knowledge for effective teaching (CT)	-12	12	6.64	7.83	1.19	47	No
Personal knowledge for effective teaching (ML)	-12	12	9.82	9.96	0.14	28	No
School teaching quality (CT)	-12	12	5.51	5.28	-0.23	47	No
School teaching quality (ML)	-24	24	12.61	12.82	0.21	28	No

Factor	Range Min	Range Max	Mean score Baseline	Mean score Endpoint	Mean score Change	N	Statistically significant change (p = <0.05)
School teaching quality (SL)	-28	28	24.60	19.20	-5.40	5	No

Table 67 Fund-level outcomes - access to and engagement with CPD

Factor	Range Min	Range Max	Mean score Baseline	Mean score Endpoint	Mean score Change	N	Statistically significant change (p = <0.05)
Effectiveness of professional development (all)	-28	28	9.46	9.94	0.48	83	No
Motivation for professional development (all)	-8	8	6.19	5.93	-0.27	83	No
Motivation for teaching-focused professional development (CT)	-8	8	5.32	4.47	-0.85	47	No
Motivation for teaching-focused professional development (ML)	-8	8	5.43	5.68	0.25	28	No

Due to rounding, there may be small differences between the figures presented.

Table 68 Fund-level outcomes - career progression

Factor	Range Min	Range Max	Mean score Baseline	Mean score Endpoint	Mean score Change	N	Statistically significant change (p = <0.05)
Opportunities for career progression (CT)	-8	8	0.13	-1.36	-1.49	47	Yes (negative)
Opportunities for career progression (ML)	-8	8	1.11	1.32	0.21	28	No
Opportunities for career progression (SL)	-8	8	1.50	2.50	1.00	8	No

Table 69 Fund-level outcomes - school culture

Factor	Range Min	Range Max	Mean score Baseline	Mean score Endpoint	Mean score Change	N	Statistically significant change (p = <0.05)
Effectiveness of school culture (all)	-24	24	6.88	8.05	1.17	83	No

Appendix L: Regression outputs for physics only – analysis of teacher progression and retention outcomes in the SWC

Tables 70 and 71 contain outputs from regression modelling of retention and progression outcomes following the same methodology and specification as outlined in Appendix C. These estimates pertain only to physics teachers (rather than physics and general science teachers as in section 4.4.3).

Retention rate in teaching

Table 70 Difference in the estimated rate of retention in teaching with and without the treatment – physics only

	Treatment teachers	Comparison teachers	Difference	Statistically significant?
Estimated retention rate in state-funded teaching 1 year after baseline (%)	94.1	89.8	4.3	Yes
Number of teachers	**686**	**2583**		
Estimated retention rate in state-funded teaching 2 years after baseline (%)	85.7	84.1	1.5	No
Number of teachers	**640**	**2239**		
Estimated retention rate in state-funded teaching 3 years after baseline (%)	80.1	78.7	2.2	No
Number of teachers	**411**	**1324**		

Note: Estimated retention rates are the average predicted retention rates from a logistic regression model for treatment and comparison teachers, controlling for observed characteristics. The difference in average predicted retention rates is the marginal effect. Statistical significance of this difference is assessed at the five per cent level. Due to rounding, some estimated marginal effects may not exactly equal the difference between treatment and control teachers.

Progression rate in the profession

Table 71 Difference in the estimated rate of progression in the profession with and without the treatment – physics only

	Treatment teachers	Comparison teachers	Difference	Statistically significant?
Estimated progression rate in state-funded teaching 1 year after baseline (%)	9.7	9.2	0.4	No
Number of teachers	**518**	**1976**		
Estimated progression rate in state-funded teaching 2 years after baseline (%)	14.3	16.0	-1.7	No
Number of teachers	**477**	**1678**		
Estimated progression rate in state-funded teaching 3 years after baseline (%)	20.3	21.3	-1.0	No
Number of teachers	**305**	**908**		

Note: Estimated progression rates are the average predicted progression rates from a logistic regression model for treatment and comparison teachers, controlling for observed characteristics.The difference in average predicted retention rates is the marginal effect. Statistical significance of this difference is assessed at the five per cent level. Due to rounding, some estimated marginal effects may not exactly equal the difference between treatment and control teachers.

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