

Science education for a research and innovation economy

Foreword (Professor Ulrike Tillmann FRS, Chair of Royal Society Education Committee)

The UK's strength and global reputation in science, research and innovation is a valuable economic and cultural asset. The UK's scientists, engineers and entrepreneurs helped to shape the ideas and technologies that created the modern world – and their combined contribution continues to pay a handsome dividend, contributing billions to the UK economy every year.¹ The Royal Society supports the Government's ambition to cement the UK's status as a science superpower, investing 2.4% of GDP on R&D by 2027.

The Royal Society welcomes the Government's plans to invest in people as well as infrastructure to achieve this goal. Investment in science education is essential, increasing the absorptive capacity of the UK economy and enabling employers to access the talent of all our young people - an important part of the innovation supply chain. Great science education ensures that young people have the skills and confidence to engage with research and innovation as citizens and consumers, as well as workers and researchers.

Yet too many of our young people are currently denied the opportunities that derive from an excellent science education, with shortages of specialist subject teachers in secondary schools and colleges – and diminishing time spent on science in primary schools. Ensuring that all young people, in every part of the UK, can access the benefits deriving from great science education would make an important contribution to levelling up.

The Royal Society is calling on the Government to continue and accelerate its investment in science teaching, the foundation of the world-leading science education our young people deserve. Great teaching encourages young people to study science further. Even better - as you will see in this report – investment in continuing professional development (CPD) for those teaching science more than pays for itself, by reducing the need to recruit and train new teachers.²

We recommend that the Government invests to renew and improve the CPD infrastructure for science teachers, to ensure that all our young people can receive a great science education and contribute to a research and innovation driven economy.

¹ Engineering accounts for 23% of the entire economy (ONS, 2020) and it has been predicted that science and technology industries will add £14 billion a year to the economy by 2025 (ABPI, 2019).

² See sections 5 and 6 of this report, plus <https://epi.org.uk/publications-and-research/the-effects-of-high-quality-professional-development-on-teachers-and-students/>

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1. Executive summary

1.1. The Royal Society is the national academy of science for the UK.

Its Fellows include many of the world's most distinguished scientists working across a broad range of disciplines in academia, industry, third and public sector organisations. The Society draws on the expertise of the Fellowship to provide independent and authoritative advice to UK, Commonwealth and international decision makers.

1.2. Schools and colleges are essential contributors to driving forward economic success.

The UK's future economic growth and recovery will rely on ensuring that all young people experience the best education possible. Technological advance, the power of data and global challenges dictate that this educational experience will require a significant step-up in the quality and uptake of school and college science, if we are to unleash the creativity and talent of the innovators and researchers of the future, who will drive the economy and address the challenges we face.

1.3. Shortages of qualified specialist science teachers is detrimental to STEM education.

The Royal Society considers school science as foundational for the skills required to generate future research and development, and other high value economic activity. Yet the current shortage of suitably qualified specialist teachers reduces the UK's capacity to offer high quality STEM education. According to Ofsted, 26.6% of teaching hours in physics in 2019 were taught by teachers with no relevant post-A level qualifications.³ At primary level, just 5% of teachers

³ Ofsted (2021), 'Research review series: science', available from <https://www.gov.uk/government/publications/research-review-series-science/research-review-series-science#fn:34>

are estimated to hold specialised science degrees and teaching qualifications.⁴ A failure to meet teacher recruitment targets in key subjects such as chemistry, mathematics and physics remains a persistent problem.⁵ Physics also suffers from a higher graduate attrition rate than other areas of teaching.⁶

1.4. A modest additional investment in science teacher CPD will help to improve teacher retention and pupil outcomes.

The Royal Society is seeking from Government an uplift in spending to £87 million for science teacher professional development in the forthcoming spending review, to be deployed over the three-year period 2022-2025. We propose a [new body](#) is created which, alongside CPD delivery, uses the funding to support governance, improve quality oversight and coordination of science teacher subject CPD ensuring future sustainability. This uplift would improve the educational experience and attainment of school pupils and college students, increase retention of teachers, and provide the skills to meet the Government's research and development target of 2.4% of GDP. The sum being sought equates to £29 million per year for three years, representing an estimated 1.1% of the total sum invested by government in salary and training costs of the science teaching community in England.

1.5. Investment in professional development saves money.

The Royal Society has calculated the investment made in the professional capital of science teachers over a 40-year career span through salaries and initial teacher training, as £105bn. An increase of 1.5% in the retention rate would mean that 8,800 teachers from each annual cohort would remain in the profession until retirement and the reduced need for additional recruitment and initial teacher training costs would save at least £126 million per year (see section 6, particularly 6.2 for details).

⁴ Royal Society (2014), 'Vision for science and mathematics education', available from <https://royalsociety.org/topics-policy/projects/vision/>

⁵ Department for Education (2019), 'Initial Teacher Training (ITT) Census for 2019 to 2020, England' available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/848851/ITT_Census_201920_Main_Text_final.pdf

⁶ Institute for Fiscal Studies (2018), 'The characteristics of and earnings and outcomes for physics teachers', available from <https://www.ifs.org.uk/publications/12885>

2. Recommendations

- 2.1. *The Government should support the science education teaching workforce by committing £87 million over the next three-year spending period to science continuing professional development (CPD).*** We are seeking this level of support to address the priority status of science skills in meeting its ambitions to make the UK a ‘science superpower’, to aid economic recovery following the unprecedented disruption of the Covid-19 pandemic, and to ensure that STEM career opportunities in England are no longer determined by where young people are born and go to school.
- 2.2. *The Government should support the establishment of an independent expert body, chaired by a respected scientist and educationalist, responsible for the oversight, dispersal and coordination of funding of science education teacher CPD.*** This body would ensure high quality subject professional learning for an increasing number of science teachers and would be responsible for gathering evidence that demonstrated the value of this investment in teachers to pupils, schools and colleges, the STEM community and the economy. Drawing on research and evidence this body would bring about a steady increase in the uptake of CPD by signalling to school and college senior leaders of its value, including higher pupil attainment and teacher motivation. The Royal Society has set out a proposed a model for an independent [Office for Science Education Professional Development](#), in section 9 of this report.
- 2.3. *We recommend that the [Office for Science Education Professional Development](#) should also be a ‘subject pathfinder’*** – piloting plans for systematic lifelong professional development for teachers of all subjects, as advocated by the Institute of Physics.⁷
- 2.4. *As part of its continued investment in support of science subject specific CPD for teachers of science, the Government should also make available the additional funding to match that lost by the withdrawal of the Wellcome Trust from its support for education.*** This commitment will ensure continuity for the duration of the spending period, while consideration is given to future arrangements for a sustained plan to meet the UK’s future STEM skills needs.

⁷ <https://www.iop.org/about/publications/subjects-matter#gref>

3. Investing in UK's future as science superpower

- 3.1.** In 2019, the Government set out a vision to secure the UK's position as a scientific superpower. This included new policies on research and innovation, changes to visa arrangements for specialist researchers and accelerating the paths to settlement for those coming to work in UK research and science. However, to ensure the UK remains a leading scientific nation, Government investment in science needs to be accompanied by financial and structural support in the development of home-grown scientific skills. In June 2021, in a reply to a letter from the Science Minister, seeking advice on gaps in the UK's offer to research talent, the Royal Society President highlighted a need for the Government to acknowledge and support the essential role played by schools and colleges in providing the future scientific skills to drive our future economy – citing a need for increased Government investment in the professional expertise of science teachers and college lecturers through subject CPD.
- 3.2.** Earlier in 2021, the Government announced its commitment to 'levelling up' across the whole of the UK, designed to ensure that as Covid-19 recovery progresses, no community is left behind. In education, this included a pledge for more support to improve teaching in disadvantaged areas in England such as Plymouth, North Durham and City, Ashfield and Mansfield and South Sefton and North Liverpool. The pursuit of a fairer education is not only seen as being consistent with the Royal Society's education policy activity but is considered as an essential element in meeting the increased demand for the STEM professionals who will generate economic recovery and growth.
- 3.3.** The Royal Society's strategic aims for UK education include ensuring it contributes to growing the UK's status as a world-leading scientific nation, whilst ensuring that the UK has a more equitable education system that advances academic achievement and technical expertise for all future citizens. On this basis we welcome the provision of the additional investment in teaching to aid post-pandemic education catch-up. However, it is the belief of the science education community that to secure the UK's future as a world leading scientific nation, greater support is needed to secure and grow the confidence of the science teaching workforce post-Covid across the country.
- 3.4.** It is therefore the view of the Royal Society that not only is there a need to secure financial support for science teacher CPD, but also to ensure a planned system is put in place that will increase CPD uptake, match provision to need, and present robust evidence of impact in the three areas of teacher satisfaction, pupil attainment and economic cost-effectiveness. The proposed planned system would aim to quantify and then reduce the uneven geographical spread of specialist science teachers to ensure all pupils have access to specialist teachers. It

is timely now to consider the science education CPD system for the following reasons. First, as schools and colleges aim to compensate for lost learning during the pandemic. Second, consideration should be given to the role of subject CPD in contributing to retention of the rising number of science graduates applying for initial teacher training because of changing perceptions around teaching as a career, prompted by Covid-19. Third, the withdrawal of the Wellcome Trust as longstanding charitable funder of science teacher CPD infrastructure.

- 3.5.** Investment in science teacher CPD will not only address long-term challenges but also support education recovery. School and college education in the UK have been through a period of unprecedented upheaval since the beginning of the Covid-19 pandemic. Teachers, pupils and parents have had to navigate a challenging and rapidly changing education system, experiencing school closures, develop digital and other methods of remote teaching and learning, and facing unsettling changes to exams and assessment often at incredibly short notice. Despite these difficulties, teachers have remained committed and creative in providing the best possible education for young people even during these challenging times.
- 3.6.** The education system is faced with a range of further challenges as we navigate the post-pandemic world. These include students who have missed two years of external assessments; newly qualified teachers with limited or different experiences of classroom and remote learning, including reduced training in practical science in laboratory settings.
- 3.7.** Despite the recent rise in applications for science teacher training, the system is still under pressure from historic inability to meet recruitment and retention targets year-on-year, particular in the sciences. In 2018/19 the number of graduates entering initial teacher training failed to meet the DfE's required target in several subjects, including physics, chemistry and computing. Evidence suggests that high quality subject specific CPD is one method that teachers cite as having a positive influence over their decision to stay in the profession, through improving their confidence in what they teach.⁸
- 3.8.** The detrimental effect of the Covid pandemic on education and the resulting focus on recovery have been a distraction from the longstanding debate around preparation of young people to thrive in a technology dominated future. Equally how best to prepare future citizens to have the skills and knowledge that will contribute to meeting the global challenges, such as climate change, biodiversity loss, the data and artificial intelligence.

⁸ <https://www.iop.org/sites/default/files/2020-12/Subjects-Matter-IOP-December-2020.pdf>

4. The current context of continuing professional development

- 4.1.** In 2018, the Department for Education published its reactions to responses from its public consultation on 'Strengthening qualified teacher status (QTS) and improving career progression for teachers'.⁹ The consultation set out a range of intended commitments, including plans to improve access to high quality CPD, and convening an expert group to explore options for improving awareness of standards for teachers' professional development. DfE also committed to undertake further work with the teaching profession to understand the 'feasibility and desirability of developing a badging scheme or framework for CPD provision'. The report clearly suggests how DfE acknowledges the value that CPD plays in cultivating professionalisation from early career onwards.
- 4.2.** In April 2021, Ofsted published a research review focusing on science education, in which it stated that CPD 'needs to be focused on the content and how to teach it, as opposed to generic pedagogies...CPD should also aim to improve science teachers' disciplinary knowledge in relation to the nature of science.'¹⁰ The report went on to state that: 'it is paramount that science teachers and technicians [have] access to regular, high-quality subject-specific continuing professional development'. They further noted that 'this is especially important in science given that many teachers are teaching outside of their subject specialism'. As noted elsewhere in this report, the unique challenges that science teaching present mean that the issue of science subject specific CPD warrant further examination and a practical and actionable solution.¹¹
- 4.3.** The current CPD landscape across England is inconsistent, with large variations existing between individual schools and amongst local authorities. A 2019 analysis showing that some local authorities committed four times the level of funding for professional development in their budget compared to others, with Hampshire spending £1010 per full-time teacher per year while Bury Council committed just £267 per full-time teacher per year.¹² Other studies show that CPD expenditure varies greatly between schools, with the highest expenditure-per-student in England being nearly ten times greater than the lowest (£97 compared with £10)¹³.

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https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/704942/Government_consultation_response_-_QTS_and_career_progression.pdf

¹⁰ <https://www.gov.uk/government/publications/research-review-series-science/research-review-series-science>

¹¹ <https://www.gov.uk/government/publications/research-review-series-science/research-review-series-science>

¹² <https://tdtrust.org/2018/01/18/post-code-lottery-teachers/>

¹³ 2019 Department for Education data via SchoolDash <https://www.schooldash.com>

- 4.4.** In international comparisons, teachers in the UK have access to less CPD than in top performing PISA countries according to the Teaching and Learning International Survey (TALIS). Fewer than 50% of teachers in England had experienced subject related CPD in the 12 months before the TALIS study, compared to nearly 90% in Shanghai and 80% in Singapore.¹⁴ Teachers are also less likely to engage in subject specific CPD than in most other high performing countries.¹⁵
- 4.5.** The need for subject specific CPD is even more critical at primary level. In 2014 the Royal Society recommended that every primary school should have in-house or have access to at least one subject specialist teacher in both science and mathematics. At the time, it was estimated that 5% of primary school teachers in England held a science degree, and just 3% held a mathematics degree.
- 4.6.** In addition to the unique challenges faced by science teachers that subject CPD can address, it also plays an important role in ensuring that science teachers can keep abreast of scientific discovery, especially at secondary and post-16. The vibrancy of scientific research and the increasing pace at which research outcomes are translated into applications mean that science teachers should have a working knowledge of developments in genetic technology, data science, artificial intelligence and the remediation of climate change and biodiversity loss, amongst others. Teachers would then be better placed too, to advise students on study, training and career paths into these growing areas of research and employment.

5. Teacher retention: Raising teachers' professional status through systematic subject CPD

- 5.1.** Teachers are the foundations of the education system. The Royal Society's 2014 report Vision for science, mathematics and computing education, stated that UK teachers should have a high professional status, recognised by government, the education sector and the public, and that government prioritises a strong supply of specialist science and mathematics teachers as a matter of urgency.
- 5.2.** Analysis carried out in 2017 showed that science teachers are more likely than their non-science peers to leave the profession, and this is especially true for those in their early career. The likelihood of science teachers resigning their post within five years is 26% higher than for their non-science counterparts.¹⁶ Ofsted has stated that these statistics highlight what it

¹⁴ <https://www.iop.org/sites/default/files/2020-12/Subjects-Matter-IOP-December-2020.pdf>

¹⁵ <https://wellcome.org/sites/default/files/developing-great-subject-teaching.pdf>

¹⁶ <https://cms.wellcome.org/sites/default/files/science-teacher-retention.pdf>

described as ‘an imperative need’ to ensure schools not only improve recruitment but also ensure they do everything they can to improve retention for science teachers.

- 5.3.** Provision of CPD has been found to have a significant impact on retention across teachers of the sciences. Research commissioned by the Wellcome Trust and carried out by Education Datalab found that science teachers who participate in CPD courses through the major provider were 160% more likely to remain in teaching.¹⁷ The current shortage of suitably qualified specialist teachers reduces the UK’s capacity to offer high quality STEM education and therefore initiatives which offer teachers the chance to develop their knowledge, skills and career paths, and which also have such a positive impact on the overall retention rates of teachers, should therefore be seen as a priority for government.
- 5.4.** Science is identified as a ‘shortage subject’ by the Department for Education, and its 2019 Teacher Recruitment and Retention Strategy¹⁸ listed investment in professional development as a key priority in signalling that teachers’ career development is valued.
- 5.5.** In secondary schools in England, teachers across all subjects are more likely to leave the profession during the early years of their career, with 20% exiting teaching after their first two years. These numbers are greater when looking at ‘shortage subjects’ such as science and maths. Some 50% of maths and physics teachers remain in post five years after their training.¹⁹
- 5.6.** The challenge in retaining shortage subject teachers is more pronounced in areas of greater disadvantage where supply issues are even more acute. Half of physics teachers in London and in affluent areas outside of London have a degree in physics, compared with less-than 20% of physics teachers in areas of high disadvantage outside of London. Not only does this deficit of teacher subject expertise place limits on the quality of students’ education it can also have a negative effect on teachers’ ability to enthuse and inspire pupils whose self-belief and persistence are already reduced in comparison to peers in more affluent and better-served communities.
- 5.7.** In 2019, the school workforce census showed that 27% of teaching hours in physics were taught by teachers who hold no relevant post-A level qualifications. At primary level, just 5% of teachers are estimated to hold specialised science degrees and teaching qualifications. A

¹⁷ <https://cms.wellcome.org/sites/default/files/science-teacher-retention.pdf>

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https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/786856/DFE_Teacher_Retention_Strategy_Report.pdf

¹⁹ https://epi.org.uk/wp-content/uploads/2020/02/Teacher-shortages-and-pay_2020_EPI.pdf

failure to meet teacher recruitment targets in key subjects such as chemistry, mathematics and physics remains a persistent problem. Physics also suffers from a higher graduate attrition rate than other areas of teaching.

- 5.8.** Current estimates indicate that some 40,000 teachers leave the teaching profession in England each year. A recent EPI report commissioned by the Wellcome Trust suggests that if schools increased spending on professional development by £500 per teacher per year, up to 12,000 teachers could be prevented from leaving teaching every year.²⁰
- 5.9.** A significant argument therefore in favour of systematic science CPD is that it would increase the number of science teachers in early career wishing to remain in the profession. A planned and structured path would allow science graduates to develop the craft of teaching alongside continuing engagement with the subject area that impassions many to wish to become teachers in the first place. The greatest value derived from the meeting of subject knowledge with the craft of the classroom.
- 5.10.** The chronic issues in teacher recruitment have been detailed elsewhere in this report, and current estimates show that the DfE falls short of its recruitment targets by approximately 3000 teachers per year across all subjects. In the sciences, recruitment of physics teachers fell particularly short, with only 43% of the target recruitment achieved in 2019.²¹ Additionally, maths, chemistry and computer science are all also shown to have the highest failure rates in recruitment in England.
- 5.11.** This report does note that at the time of writing, the Covid-19 pandemic appears to have had a positive impact on teacher recruitment figures across most subjects. However, this is expected to be a temporary effect of the current circumstances and not a sustained change to recruitment figures beyond the next year or two. The opportunity presented by this very welcome surge of applicants serves to reinforce the need to provide a robust programme of subject CPD that will ensure these new entrants are encouraged and supported to remain in the profession.

²⁰ <https://epi.org.uk/publications-and-research/the-effects-of-high-quality-professional-development-on-teachers-and-students/>

²¹ <https://www.theguardian.com/education/2019/nov/28/government-falls-short-on-secondary-teacher-recruitment-targets>

6. Cost efficiencies for teacher training and retention

- 6.1.** As mentioned elsewhere in this report, the recruitment, retention and development of the teaching workforce is a significant expense. Currently, CPD costs are low. In reviewing CPD provision across the country, the Royal Society has been able to identify opportunities to make the recruitment and training of teachers more cost-efficient.
- 6.2.** In England, for example, around 23,500 new teachers are recruited every year.²² This high level of recruitment is driven, in part, by wastage – around 40% of teachers leave the profession within the first five years²³ and it can be expected that just 6,000 of the original 23,500 will remain in the profession until retirement. Estimating the minimum cost of initial teacher training to be £23,000²⁴ per teacher, according to 2016 figures, results in a total annual ITT cost of over £137million across primary, secondary and FE science teachers. This figure is likely to be significantly higher in reality since training costs have increased since 2016, particularly when considering additional bursaries for trainees in shortage subjects such as physics.
- 6.3.** The effect of a modest improvement in teacher retention on the cost of recruitment can therefore be quantified. A 1.5% increase in the retention rate as calculated above would mean that 8,800 teachers from each annual cohort would stay in the profession until retirement and the reduced need for additional recruitment and initial teacher training costs would save at least £126 million per year.
- 6.4.** Based on available data the Royal Society has calculated the investment made by UK Governments in the ‘professional capital’ of science teachers over a 40-year career span through salaries and initial teacher training as £105 billion (this figure does not include on-costs such as employers’ pension or national insurance contributions).²⁵
- 6.5.** Taking £105bn over a 40-year career gives an annual figure of £2.625 billion which includes investment in the entire secondary science, FE science and primary teaching workforce (for

²² Department for Education. School workforce in England: reporting year 2019 <https://explore-education-statistics.service.gov.uk/find-statistics/school-workforce-in-england>

²³ House of Commons Library (2019). Teacher recruitment and retention in England <https://commonslibrary.parliament.uk/research-briefings/cbp-7222/>

²⁴ Institute for Fiscal Studies (2016). The longer-term costs and benefits of different initial teacher training routes <https://www.ifs.org.uk/publications/8368>

²⁵ Using data from: <https://explore-education-statistics.service.gov.uk/find-statistics/school-workforce-in-england>; <https://epi.org.uk/publications-and-research/the-cost-of-high-quality-professional-development-for-teachers/>; <https://epi.org.uk/wp-content/uploads/2021/04/EPI-CPD-entitlement-cost-benefit-analysis.2021.pdf>; <https://www.nfer.ac.uk/teacher-workforce-dynamics-in-england/>

primary, an adjustment was made to reflect that an estimated 10% of teachers' time dedicated to science). The total also incorporates the cost of initial teacher training, which is estimated at £6 billion.

- 6.6. The proposed costs being sought in this paper to support science CPD to improve the educational experience and attainment of pupils and students, improve retention of teachers and provide the skills to meet the Government's research and development target of 2.4% of GDP is £29 million per year for three years, representing 1.1% of the total salary and training costs of the science teaching community.

7. Economic value of science education

- 7.1. Science is a substantial driver for innovation and therefore economic growth and prosperity. The global health crisis caused by the Covid-19 pandemic, and the impressive collective effort of the STEM workforce to address this at speed, has highlighted the importance of scientists and engineers to address the world's challenges.
- 7.2. The Government's stated target aims for 2.4% of Gross Domestic Product to be spent on R&D by 2027 and its Covid-19 pandemic recovery plan includes a commitment to 'investing massively' in science and technology with a view to the UK 'cement[ing] its position as a global science superpower'.²⁶
- 7.3. Within the context of research and innovation, similar regional disparities in performance exist. The Government's 'levelling up' agenda is both an acknowledgement of this problem and an initiative to help resolve it, by investing in 'green' skills to support its Net Zero and wider environmental economic ambitions, as it has set out in *Build back better: our plan for growth*.²⁷
- 7.4. It is, therefore, important to recognise the value of science education to the economy, and to enhance this value further. However, understanding the contribution science education makes to the economy is not straightforward. As Walker & Zhu (2013) observed, 'there is surprisingly little quantitative research about the causal effects of specific high school courses on educational attainment and labour market outcomes'.

²⁶ See [Build Back Better: our plan for growth \(HTML\) - GOV.UK \(www.gov.uk\)](#)

²⁷ HM Treasury. 2021. Build back better: Our plan for growth. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/968403/PfG_Final_Web_Accessible_Version.pdf

- 7.5.** Unsurprisingly, the various attempts that have been made over recent years to quantify the value of 'science' education to the economy have focused on calculating/estimating the economic returns of tertiary STEM education (including science, technology, engineering and mathematics) in respect of qualifications at level 4 and above.²⁸
- 7.6.** Research by London Economics, published by the Gatsby Foundation in 2017 attempted to quantify economic returns to STEM education in the UK.²⁹ The study provided estimates of the net benefit to the Exchequer associated with degree and sub-degree qualifications for STEM (and non-STEM) subjects. Based on reviewing returns data for 2016/17, its analysis shows that full-time students undertaking specific STEM-based qualifications at Level 4/5 deliver substantial benefits to the public purse (and that these returns are generally larger than the returns associated with full-time students studying non-STEM-based subjects). The analysis also shows that while the returns to undergraduate degrees (level 6) are considerably greater than the returns to sub-degree qualifications, the returns to level 4/5 vocational qualifications are significant; in general, the net benefits to the public purse from men taking sub-degree and first-degree courses are greater than those accruing from women.
- 7.7.** There is, of course, a difference between evaluating the benefits to the economy of STEM-trained individuals and the supply of STEM talent. There is a significant mismatch between the projected employment requirement in the STEM industries and the supply of home-domiciled individuals with STEM qualifications in the UK^{30,31} and the UK compares poorly internationally.³²
- 7.8.** A key contributing factor to the UK's STEM skills deficit is the stubbornly low progression from GCSE to A level, which has not been helped by the narrow choice of A levels students are able to take.³³ Of those with good science GCSEs, only a small fraction progress to take science A levels two years later,³⁴ and further evidence published by the Department for Education shows

²⁸ Level 4 qualifications are Higher National Certificate (HNC) or equivalent. For more on qualification levels, see [Qualifications can cross boundaries: Guide to comparing qualifications in the UK and Ireland \(qaa.ac.uk\)](http://qaa.ac.uk)

²⁹ See le-gatsby-assessing-the-economic-returns-to-level-4-and-5-stem-based-qualifications-final-07-06-2017.pdf

³⁰ See [uk-stem-education-landscape \(raeng.org.uk\)](http://raeng.org.uk)

³¹ See [New report shows STEM workers twice as likely to miss job opportunities due to lack of skills - GOV.UK \(www.gov.uk\)](http://www.gov.uk)

³² See [f8d7880d-en.pdf \(oecd-ilibrary.org\)](http://oecd-ilibrary.org), eg figure B3.3. Also [dp1443.pdf \(lse.ac.uk\)](http://lse.ac.uk).

³³ See [Full article: Stratifying science: a Bourdieusian analysis of student views and experiences of school selective practices in relation to 'Triple Science' at KS4 in England \(tandfonline.com\)](http://tandfonline.com) and [Jobs are changing, so should education \(royalsociety.org\)](http://royalsociety.org)

³⁴ This is based on comparing 2016/17 GCSE performance data with 2018/19 A level data. In 2016/17, 587,640 students completed Key Stage 4, and 85.6% (503,020) took GCSE sciences (including double award science, biology, chemistry, physics and computing; see [Revised GCSE and equivalent results in England: 2016 to 2017 - GOV.UK \(www.gov.uk\)](http://www.gov.uk)). In 2018/19, there were just 35,540 entrants to A level Physics (the least popular science A level subject; see [A level and other 16 to 18 results: \(www.gov.uk\)](http://www.gov.uk)

that, fewer than one-third of all students who obtained GCSE grades A*–C (equivalent to grades 9 to 4) in biology and chemistry (and fewer than one in five for physics) continue to take A levels in these subjects.³⁵ It is, therefore, unsurprising that the OECD’s research into young people’s aspirations has shown that the UK has one of the lowest shares of 15-year olds intending to pursue a STEM-related career . More recent UK research has shown that ‘while 73 per cent of young people at age 10 and 11 and 86 per cent of those aged 17 and 18 agreed that they learned interesting things in science, only 16 per cent of 10 to 11-year-olds (and 12 per cent of 17 to 18-year-olds) aspired to a career in a related field’.³⁶

7.9. A recent study has established that taking more science in secondary school increases the probability of enrolling in a STEM degree by 1.5 percentage points and the probability of graduating in a STEM subject by 3 percentage points.³⁷ These results do however, mask substantial gender heterogeneity: while girls are as willing as boys to take advanced science in secondary school – when offered – the effect on STEM degrees is entirely driven by boys. Girls are encouraged to choose more academically challenging subjects, but still the most female-dominated ones.

7.10. Nonetheless, time-series data from HESA show that the number of UK-domiciled STEM graduates (all undergraduate qualifications) rose 7.4% between 2014/15 and 2018/19.³⁸ The UK, however, produces fewer STEM graduates than many other countries - for example, in the UK 26.3% of all graduates are in STEM subjects, while in Germany this is 35.6% and in Tunisia 43.3% - and most UK STEM graduates are male.³⁹

7.11. Studying science at school has recently been shown to increase future earnings. A study by Simetrica Jacobs for, STEM Learning indicates a wage premium attached to various science education outcomes at school. For example, taking at least one STEM A level has a lifetime wage premium of over £31,000, while achieving two good science GCSEs carries a premium of £8,474. Simply taking Triple Science at GCSE offers a wage premium of £6,845⁴⁰

[2018 to 2019 \(revised\) - GOV.UK \(www.gov.uk\)](#)). While, for various reasons, not every individual counted in the GCSE statistics would be represented in A level statistics two years later, these data suggest that only about 7% of the GCSE cohort progresses to take A level sciences.

³⁵ See [Subject progression from GCSE to AS Level and continuation to A Level \(publishing.service.gov.uk\)](#), table 3.1.

³⁶ See [Why do students value science but not want to be scientists? \(schoolsweek.co.uk\)](#).

³⁷ See [dp1443.pdf \(lse.ac.uk\)](#)

³⁸ Analysis based on HESA data (see [Table 25 - HE qualifiers by subject of study and domicile 2014/15 to 2018/19 | HESA](#)) concerning numbers of undergraduate qualifications obtained by UK domiciled students in the Biological Sciences, Physical Sciences, Mathematical Sciences, Computer Science and Engineering and technology.

³⁹ See [Core STEM Graduates 2019 - Welcome to the WISE Campaign](#)

⁴⁰ <https://www.stem.org.uk/sites/default/files/pages/downloads/Valuing%20Impact%20of%20Science%20CPD.pdf>

8. Impact of CPD on pupil outcomes

- 8.1.** High-quality CPD for teachers has been shown to have a significant impact on pupils' educational outcomes, as well as having the potential to close the gap in attainment between being taught by early career and more experienced teachers.⁴¹ CPD also has similar attainment effects to those generated by large, structural reforms to the school system⁴². Whilst there are other interventions with a larger impact on pupil attainment, such as one-to-one tutoring, these programmes are typically far more costly. Evidence suggests that high quality CPD has a greater effect on pupil attainment than other interventions schools might consider, such as performance related pay or changes to the timing of school day.⁴³
- 8.2.** Regular, high quality CPD therefore has a profound effect on the students who benefit from more confident and knowledgeable teachers. Analysis of the major national provider, STEM Learning, through their CPD programmes shows that participant secondary schools have doubled the rate of progress in science GCSEs, and schools who engaged in this programme in 2018/19 reported 16,000 more young people achieving grade 4 or above in at least two science GCSEs.⁴⁴ The benefits are also observable at primary level, with participating schools showing an improvement to science results 50% faster than before the programme.⁴⁵ Over the last three years, entries into STEM A level subjects have increased 8.5%, with 80% of these entries coming from schools who have engaged with STEM Learning CPD.⁴⁶
- 8.3.** Recently published Wellcome Trust commissioned research from the Education Policy Institute suggests that adhering to a 35-hour teacher CPD entitlement per year could increase student outcomes by two thirds of a GCSE grade, equating to a £6000 boost to lifetime earnings per student.⁴⁷
- 8.4.** Additionally, the same Wellcome/EPI report suggested that allowing teachers access to this entitlement would cost £210m per year across all subjects – representing less than 1% of the total schools' budget in England. In this report, the Royal Society's requests Government to provide £87m in funding over three years to provide science subject CPD and a body to oversee the commissioning of science professional development, delivery of grants, and to undertake policy and research work. This relatively small increase in spending in comparison

⁴¹ <https://epi.org.uk/publications-and-research/effects-high-quality-professional-development/>

⁴² Ibid.

⁴³ Ibid.

⁴⁴ https://www.stem.org.uk/sites/default/files/pages/downloads/teacher_engagement_SL_science_GCSEs_1p_040520.pdf

⁴⁵ https://www.stem.org.uk/sites/default/files/pages/downloads/attainment_in_primary_science_1p_040520_0.pdf

⁴⁶ https://www.stem.org.uk/sites/default/files/pages/downloads/KS5%20Uptake_Exec%20Summary_PUBLISHED.pdf

⁴⁷ <https://epi.org.uk/publications-and-research/the-cost-of-high-quality-professional-development-for-teachers/>

to the overall budget would ensure not only an improvement in CPD provision, but also a streamlining of delivery, separate from government and encouraging of a wide range of providers.

9. Model of delivery - An Office for Science Education Professional Development - *Evolving science teacher CPD*

9.1. *“CPD enables teachers to be better informed about developments in their subject area, to improve their teaching skills and to have greater confidence in the classroom. Good teachers matter more than good courses in inspiring children and stimulating their enthusiasm. CPD is important in all subjects to maintain the knowledge, skills and understanding of teachers and to improve standards in teaching.*

“Science teaching is particularly vital, given that developments in science and technology increasingly influence the whole of society. A healthy democracy needs a public with a broad understanding of major scientific ideas, one that can engage critically with issues and arguments -which involve both scientific knowledge and the limitations of science. Children need to be excited by science at a young age if they are to acquire the "scientific literacy" which we consider to be an essential, but often neglected, part of their education.”

Science in Schools: House of Lords Science and Technology Select Committee (March 2001)⁴⁸

9.2. Following the publication of The House of Lords Science and Technology Committee First Report on Science in Schools in March 2001, the past two decades have derived support from government, independent charities, STEM companies, professional bodies and learned societies for subject specific science teacher and technician CPD.

9.3. The decision of the Wellcome Trust to focus its resources on renewed global strategic priorities and cease its work on science teachers, presents a funding gap to fill, but also offers an opportunity to take stock of the current provision, governance, and coordination of science education continuing professional development. It is vital that there is a continuation of the

⁴⁸ <https://publications.parliament.uk/pa/ld200001/ldselect/ldscitech/49/4902.html>

progress made to date, placing science teacher lifelong learning at the heart of the workforce's professional growth.

- 9.4.** The Royal Society believes it is appropriate two decades on from the commitment made by the DfE and the Wellcome Trust, for Government to establish an Office for Science Education Professional Development to build on the positive achievements thus far. This body will be tasked with ensuring a mixed proposition of science CPD provision that will meet government priorities, address the dynamic nature of scientific and technological advance and in turn, provide the skills to meet these. The Office should also address the knowledge deficit of most science teachers around technical and vocational training and apprenticeships, and to contribute to the Government's policy agenda around raising the status of technical routes and levelling up, and support delivery on what is considered the most challenging of the Gatsby Good Career Guidance benchmarks - to embed wider knowledge of career opportunities in subject teaching.

9.5. Growth in capability, expertise and impact for science teacher CPD

The Royal Society advocates that this body acts as steward and guardian for science teacher CPD through the following functions:

- Oversight and coordination of science CPD, meeting the needs of government, of schools and colleges and the STEM community
- Developing a dedicated research programme around science CPD that informs future strategy and funding decisions – including gathering robust independent evidence on the pupil attainment, motivational and other cost benefits of science specific teacher CPD
- Develop expertise in policy and grant-making that will ensure that CPD provision remains innovative and refreshed.

- 9.6.** Investment in the right type of teacher professional development is a cost-effective way of bringing about improvement in education. Through research intended to characterise best practice in the UK and around the world, the Teacher Development Trust identified two conditions under which CPD is most effective:

- Professional development opportunities that are carefully designed and have a strong focus on pupil outcomes have a significant impact on student achievement.
- Professional development programmes must consider both subject knowledge and subject-specific pedagogy to achieve their full potential.

- 9.7.** An example of a CPD initiative fulfilling these criteria is the National Centre for Computing Education (NCCE), which was established in 2018 following the publication of the government report *Digital Skills for the UK Economy*. The NCCE's arrival was part precipitated by the

case presented by The Royal Society through its two reports⁴⁹ on the need to move from a basic skills ICT curriculum to the introduction and widescale delivery of courses at GCSE in computer studies, and the consequent need to upskill the existing teacher workforce to deliver.

9.8. Computer studies and science in schools have challenges in common, especially in relation to the recruiting pupils, post-16 despite the subjects' vital role in providing the technical skills that will drive the economy and a tendency for 'STEM devotees' to lack diversity. Key differences, however, centre on the different communities they serve, with science education existing in well-established ecosystem of curriculum experts, professional development providers, dedicated research expertise and professional associations. By contrast computing is in a rapid growth phase and the NCCE provides the foundations for the developing infrastructure that we hope will continue to expand.

9.9. We propose separating the delivery function from the governance and coordination of science teacher CPD since it does not best serve the community for a single institution to fulfil both these roles. The model acknowledges the pivotal contribution that STEM Learning as a deliverer should continue to offer, while developing and enabling a range of providers to flourish and meet the needs of schools and their teachers and promoting innovation within the system that will encourage competition.

9.10. What will the Office for Science Education CPD do?

Bring key stakeholders together: representatives from government departments, UKRI, key public and private science CPD funders, educational researchers, education practitioners, relevant teacher associations, learned societies and subject organisations, employers and skills bodies, e.g. to:

- Consider CPD priorities, and to co-develop programmes for addressing these priorities.
- Develop grant giving expertise to target emerging areas of need and nurture innovation
- Gather intelligence about the (science) CPD ecosystem to identify and seek to address mismatches in supply and demand
- Carry out reviews of the distribution of science CPD provision in England
- Facilitate regional and thematic collaborations that enable researchers, practitioners, policymakers, and other stakeholders to work together and address regional and local need
- Identify areas requiring research evidence and robust data and support their production and practical application in policy and practice.
- Respond to (but not being constrained by) the policy needs of government and others
- Act as a pathfinder for other school subject areas

⁴⁹ Shut down or restart? The way forward for computing in UK schools and After the reboot: computing education in UK schools.

- Coordinate with other education system actors and reforms to ensure that science CPD is joined up with the Government's wider agenda for professional development and school improvement.

9.11. What will be within scope?

Oversight, governance, quality control and effectiveness of:

- Science subject specific CPD for secondary school science teachers and lecturers in Further Education
- Science subject CPD for all primary teachers
- Science subject CPD for science technicians and support teachers working in a science context (e.g. working with pupils who are not neurotypical)
- Potential to cover post-18 vocational and technical education and adult education once established.
- Provide funding grants or awards.
- Commissioning of research to help improve science CPD

9.12. What will be outside scope?

- Delivery of CPD
- Training of CPD tutors

9.13. How it will be governed?

- Independent Chair (e.g. Senior Fellow of the Royal Society)
- Programme board representing government, industry, academia, primary, secondary and FE education, UKRI, Ofsted
- Sub-groups of experts who can engage directly with the major scientific disciplines – typically comprising learned societies, professional bodies, researchers Secretariat (hosted by a scientific or educational organisation (e.g. UKRI Higher Education Institution or charity)

9.14. How an Office for Science Education Professional Development could oversee funding for delivery of existing and future CPD (75% of total spend), maintain quality, gather evidence of impact and increase uptake of subject professional development (25% of total spend).

Office for Science Education Professional Development

- Governance and coordination of science education subject CPD
- Fully self-supporting and operational body.
- Lead on commissioning CPD, deliver a grant-giving programme to respond to emerging themes and promote innovative practice, oversee a programme of policy, research and evaluation, that would both secure the current provision of and future development of science CPD.
- Strong executive board with high profile presence. Likely to be extensive public scrutiny (e.g. by Parliamentary Committees).

Key features

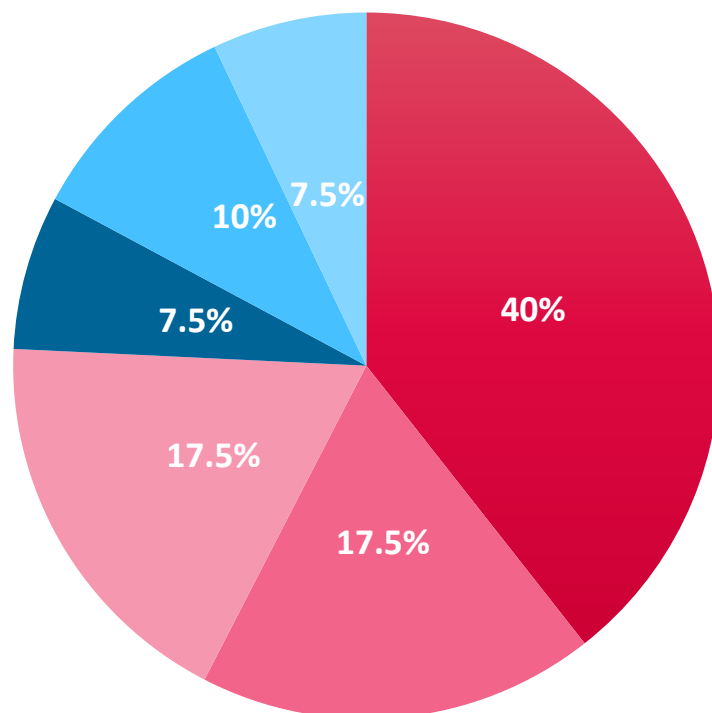
- Support for existing core delivery (eg STEM Learning, other DfE science initiatives) to include teacher bursaries
- Commissioning of CPD to meet emerging policy needs
- Innovation Grant Funding - responsive mode CPD development grant funding (open calls); themed calls for proposals (eg practical science)
- Advocacy, research, industry liaison/development and policy development for science teacher professional learning, future sustainability/legacy
- Coordinating, commissioning and reporting independent research and evaluation into the impact of subject professional development
- Executive salaries, grants administration, secretariat support/ committee expenses, administration, office rental and other overheads

Costs

- Total cost annually £29million
- Total cost over three years **£87million**

9.15 The chart below presents a proposed breakdown of how the sum requested would be assigned to CPD delivery (red shades) and support, including research and advocacy (blue shades). Some 75% of the funding sought would be used for delivery of CPD, including bursaries. The remaining 25% would fund greater uptake and future sustainability, generating more robust impact evidence, policy and administrative support.

Proposed Funding Allocation



- Core delivery includes teacher bursaries
- Commissioning CPD to meet emerging policy needs
- Innovation grant funding
- Advocacy with school senior leads, future planning
- Research and evaluation of impact
- Governance & Administration