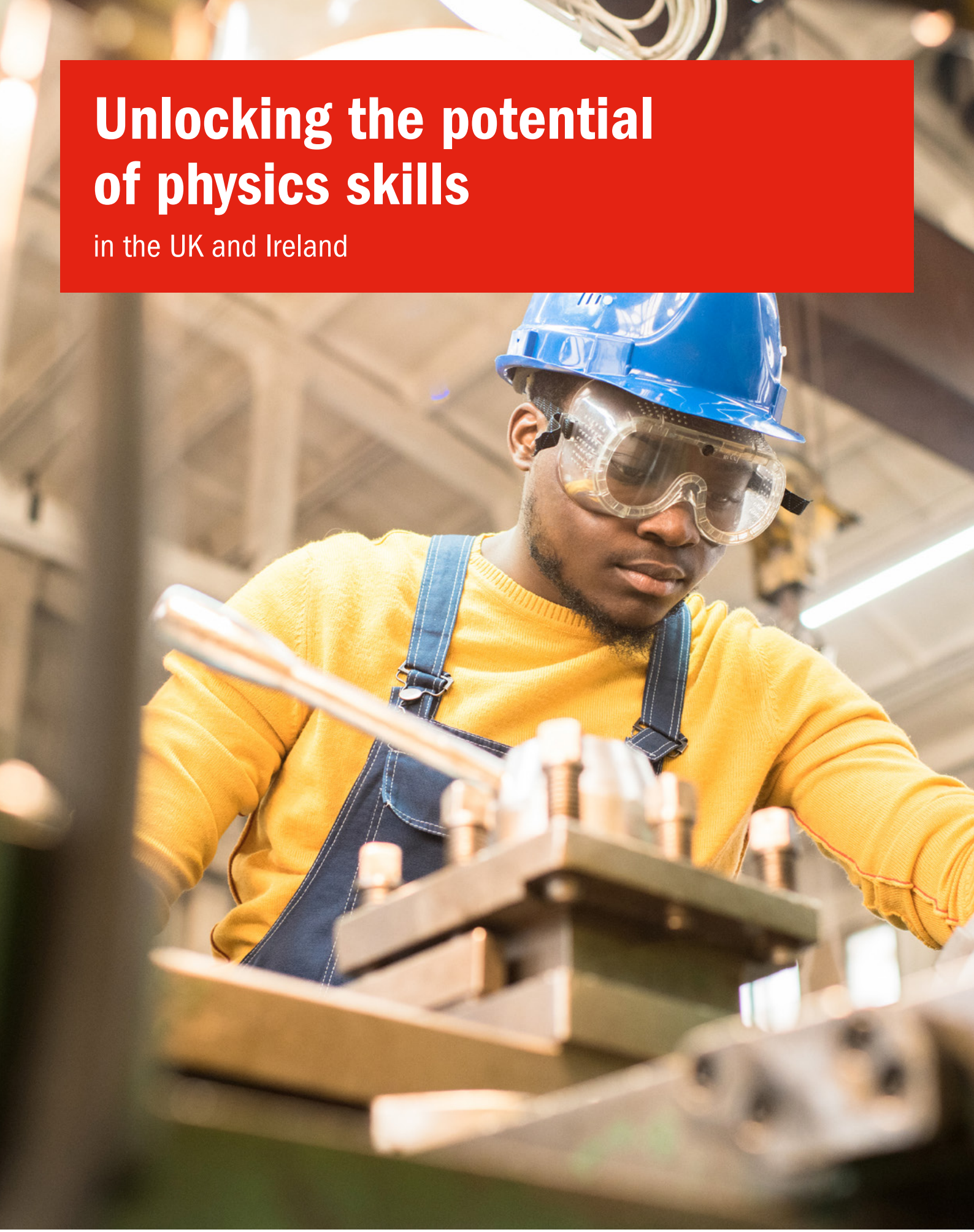
Unlocking the potential of physics skills

in the UK and Ireland



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Summary

New research commissioned by the IOP finds that:

- **Physics skills[1] support nearly 2 million jobs and underpin productive industries in every part of the UK and Ireland**, with the highest concentration of jobs in Scotland (with 16% more in Scotland than the UK and Ireland-wide average would suggest) and the fastest growth in jobs in Ireland (45% growth between 2010 and 2020). Strengthening provision of physics skills is therefore central to ambitions to improve economic growth, prosperity and living standards at national and local levels.
- **Demand for physics spans all skills levels:** while high-skill level roles[2] are seeing the fastest growth – with the number of jobs for physical scientists, for example, growing by 40% between 2010 and 2020 – more than half (53%) of physics-demanding jobs do not require a degree, with a sizeable minority (46%) typically requiring intermediate-level qualifications such as A-levels, Highers, Leaving Certificates and apprenticeships.
- **Significant unmet demand for physics skills exists**, with a substantial number of physics-demanding roles at any one time – nearly 9,000 high-duration vacancies in mid-2021, having quickly recovered to pre-pandemic levels – seeming to persist in being hard to fill. This is impacting employers' ability to grow and innovate: separate IOP-commissioned research found that two thirds of physics-based businesses reported suspending or delaying R&D/innovation activities in the past five years due to skills shortages.
- **Strong, sustained growth in demand** for physics skills – particularly outside of the scientific sector, with a significant proportion of hard-to-fill vacancies being for digital, and business and finance roles – reflects their importance, but is **likely to exacerbate existing skills shortages** in the coming years.

1. Developing a definition of 'physics skills' which can be applied in a quantitative way is complex. Broadly speaking, it has been done in two ways: 1) an occupation-based definition based on the O*NET database's 'physics knowledge' descriptor, which can be applied to traditional labour market statistics; and 2) a selection of terms from Emsi Burning Glass's Skills Library with an unequivocal link to physics (examples include medical physics, statistical physics and computational physics), which can be used to analyse online job postings and profiles. Full details of the definitions can be found on pages 2, 7, 8 and 25 of the full research report.
2. High-skill level roles are those which typically require a bachelor's degree or higher qualification.

– Consequently, **action to bolster development of physics skills among the current and future workforce is needed now**, to help governments fully seize the opportunities offered by increased investment in R&D and deliver on ambitions to build more innovative, productive and green economies. This includes:

  - Addressing shortages of specialist physics teachers so that everyone has access to high-quality teaching
  - Challenging misconceptions about physics and the jobs it provides access to, which deter some young people, and supporting informed choices
  - Ensuring availability of a variety of physics education and training pathways, as well as complementary transferable and digital skills development, all informed by close engagement between educators, employers, and researchers and innovators
  - Incentivising employers to invest in employees' upskilling and reskilling
  - Ensuring interventions aimed at strengthening provision of physics skills move beyond the level of 'STEM skills', given the distinct labour market demand for physics observed.

Context

The UK and Ireland's economic growth and future prosperity is dependent upon people in all parts of the countries having the knowledge and skills needed to realise their full potential in productive employment. Education and training in physics open doors to fulfilling careers across a range of critical industries, from engineering and construction, to health and science, to digital and finance. With demand for physics skills growing and now in excess of pre-pandemic levels, targeted action to strengthen the skills of the current and future workforce is needed to drive economic growth and recovery.

In addition to their broad utility across the economy, physics knowledge and skills have a critical role to play in fuelling technological innovation and the green industrial revolution. However, skills shortages threaten to derail plans to increase investment in physics-based R&D and innovation, causing delays to projects and missed business opportunities.[3] For the UK and Ireland to fully seize the opportunities offered by increased investment in R&D, we need an equally dramatic increase in the scale and diversity of the skilled workforce to fuel progress.

Demand for physics skills is set to grow;[4] without change, existing skills shortages will be exacerbated, and will seriously limit physics' potential to deliver long-term economic and societal benefits. Coordinated action and investment in the development of the current and future workforce is needed now if the UK and Ireland are to build more innovative, green economies and secure a more prosperous, sustainable future for everyone.

3. CBI Economics (2021). Paradigm shift: Unlocking the power of physics innovation for a new industrial era
4. See, for example, National Centre for Universities and Business (2018). State of the relationship report 2018: 'Demand for STEM-related occupations is projected to grow at double the rate of other sectors.'

The research

As part of our work to unlock the full potential of physics for society and the economy,[5] the IOP commissioned Emsi Burning Glass to provide new insight on the use of physics-related skills in the UK and Irish economies. The research used traditional labour market intelligence and job postings and profile analytics to evaluate the place of physics in the jobs market, and how it varies across occupations, industries and regions, as well as employers' specific demands for skills and how well they are being met in the current labour market. The full research report is available at iop.org/workforce-skills-project.

A second part of this project will explore future demand for skills in a number of focus areas that make significant use of physics-related technologies, identifying the anticipated changes in technology likely to drive new or greater demand for skills, the associated skills requirements, and existing and potential mechanisms for acquiring these skills.

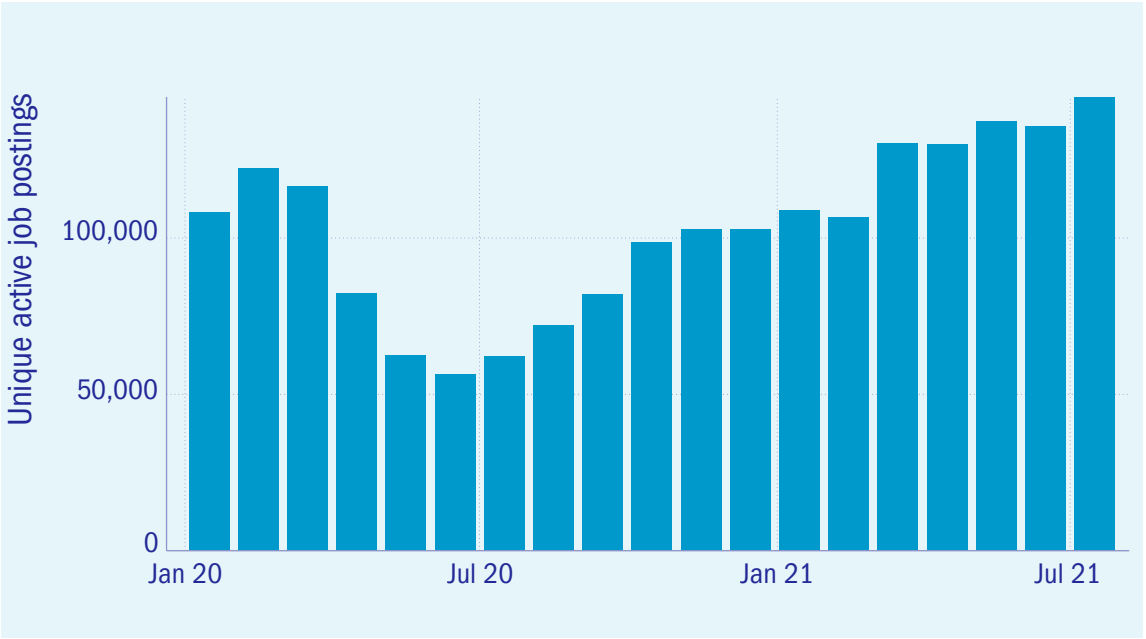
5. More details can be found in the IOP's strategy, 'Unlocking the Future'.

Key findings

Demand for physics skills is high, widespread and growing

- 1 in 20 (or 1.85 million) jobs[6] across the UK and Ireland make use of physics skills and knowledge
- Demand for physics is widespread across critical industries, in engineering, construction, manufacturing, energy and transport, as well as in business and finance, digital, teaching, health, and the public and regulatory sector
- Demand is growing faster than the wider labour market: demand for medical physics skills[7] has grown strongly in the last two years, likely driven by the Covid-19 pandemic, but so has demand for scientific physics skills in the public and regulatory, business and finance, and construction sectors.

Recruitment trend in physics-demanding occupations since January 2020



Job postings fell by 54% between February and June 2020, but have now more than recovered

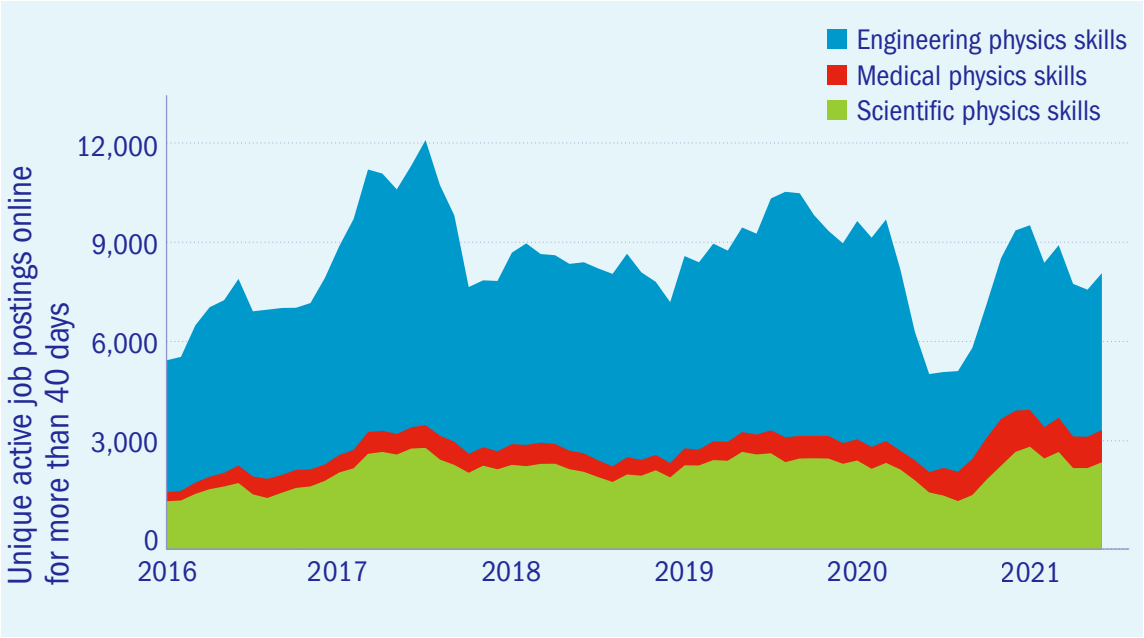
6. This figure is based on a relatively strict, occupation-based measure of physics-demanding jobs and accordingly could be considered to be a conservative estimate.
7. 'Physics skills' are defined in three groups. Scientific physics skills are those with an unequivocal connection to physics as a scientific subject. Reflecting physics' role as an underpinning science for many practical activities, there are two further groups where physics is applied in practice: medical and engineering physics skills. Full details of the definition can be found on page 25 of the full research report.

Physics' diverse application in the workforce sees it playing a critical role in the UK and Irish economies, supporting a growing number and variety of jobs and industries. Accordingly, strengthening provision of physics skills is central to ambitions to improve economic growth, prosperity and living standards in all nations and regions of the UK and Ireland, and this should be reflected in relevant economic strategies. Given the scale and diversity of demand for physics observed in the labour market, it is essential that interventions aimed at strengthening provision of physics skills move beyond the level of 'STEM skills' and enable targeted response to employers' distinct demand for physics skills and knowledge.

Significant unmet demand for physics skills exists, particularly outside of the scientific sector

- High demand sees employers advertising physics-demanding roles for longer as they struggle to find the right talent
- A substantial number of physics-demanding roles at any one time (nearly 9,000 in June 2021) seem to persist in being hard-to-fill, suggesting a significant level of unmet demand among employers
- Postings specifically seeking scientific physics skills are more likely to be advertised for longer and show signs of high and rising pay, but few of these are for scientific roles. Instead, they are for roles in the digital, business and finance, and engineering sectors: job postings seeking scientific physics skills for digital, and business and finance roles increased by 45% and 36%, respectively, between 2016 and 2019.

High-duration postings seeking physics skills by skill type, 2016-2021



The number of high-duration postings is now close to pre-pandemic levels, with those seeking scientific and medical physics skills growing particularly strongly

As governments increase investment in science and innovation to fuel economic growth, demand for physics skills within the research and innovation sector is growing. But wider labour market demand for physics appears to be growing even more quickly and is now in excess of pre-pandemic levels. As a result, employers are struggling to access the skills they need and seeing negative impacts on their ability to take on new business and stay competitive – in separate research commissioned by the IOP, 66% of physics-based businesses reported suspending or delaying R&D/innovation activities in the past five years because of skills shortages.

Without mitigation, physics skills shortages will limit commercial and technological development, and governments' ambitions to build more innovative, equal economies. The UK and Ireland will be unable to fully benefit from increases in R&D investment while there are not enough people with the right skills in the workforce. Governments must act now to ensure that high-quality physics teaching and training is available everywhere and for everyone.

Building the workforce of the future begins at school. To increase the supply of students leaving school with well-developed physics knowledge and skills, and pursuing further work and study, shortages of teachers with the capability and training to teach science well in primary schools and of specialist physics teachers in secondary and further education must be addressed – and addressed with urgency, to prevent existing skills shortages from worsening.[8]

It is particularly important that we increase the diversity of those participating in physics-related education and training beyond the age of 16, to ensure everyone can benefit from the opportunities physics opens up in the workplace, and to build a thriving, innovative workforce. As an example of the scale of the current problem, only 10% of STEM apprenticeships were started by women in 2018/19. Such underrepresentation contributes to an engineering workforce (which our evidence shows relies heavily on physics skills and knowledge) in which only 15% of workers are female, 1.7% are Black, African, Caribbean or Black British, and 11% have a disability – a significant loss of talent.[9]

8. The importance of this is reflected in the aspiration of the IOP's strategy which aims to ensure that 'every secondary school pupil in the UK and Ireland will have access to a specialist physics teacher'
9. EngineeringUK (2021). EngineeringUK response to the inquiry Equity in the STEM workforce

The teaching workforce

Every year, too few teachers of physics start in the profession and too many leave it. Ongoing professional development for teachers is inconsistent and inadequate. As a result of these and other challenges in our education systems, there are major regional disparities in access to specialist physics teachers and the quality of physics teaching. The IOP is working to address this problem and ensure that every secondary school pupil in the UK and Ireland has access to a specialist physics teacher.

It is difficult to accurately determine the number of specialist physics teachers from the data sources considered in this research. Separate IOP work to better understand the numbers of specialist physics teachers currently working in the UK and Ireland is ongoing.

At the same time, around 80% of the 2030 workforce is already in work today.[10] Action to increase the supply of physics skills in the long-term must be complemented with action to reskill and upskill those already in the workforce throughout their working lives. Greater incentives are needed to encourage employers to invest in their employees' training. This is particularly critical for SMEs, which face additional barriers due to scale and capacity – evidence from the CBI found that 43% of micro and small businesses did not provide any training in 2018, compared to 4% of organisations with 250 or more employees.[11] Potential mechanisms at governments' disposal include more flexible use of the apprenticeship levy in the UK – for example, so that it can be used to fund a wider range of training – or the introduction of skills tax credits. The latter could be used in a similar way to existing R&D tax credit schemes and could be targeted specifically at SMEs or priority national skills gaps.

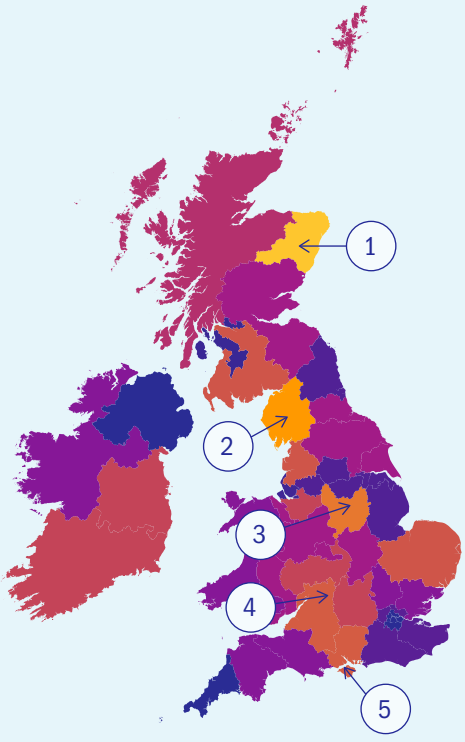
10. Industrial Strategy Council (2019). UK Skills Mismatch 2030 – research paper
11. CBI (2020). Learning for life: Funding a world-class adult education system

Physics skills underpin productive employment and industries in every part of the UK and Ireland

- Demand for physics skills is large enough to be significant in every part of the UK and Ireland, with the highest concentration of jobs in Scotland (16% more than the UK and Ireland-wide average) and the fastest growth in jobs in Ireland (45% growth between 2010 and 2020 compared to 15% across the UK and Ireland)
- Different industries depend on physics skills in different parts of the UK and Ireland: the oil and gas and associated industries in Scotland, scientific R&D in the East of England, transport manufacturing in the East Midlands, and air transport in Ireland and London
- Physics-demanding jobs are well paid: all groups of physics-demanding roles see significantly higher average earnings than jobs within the wider economy.

Physics' diverse applicability sees it used in different ways in different parts of the UK and Ireland. But in every region and nation, in and outside of urban centres, physics skills create value and are in demand, providing access to well-paid jobs and powering productive industries. Physics skills therefore offer an effective tool to national and regional skills strategies seeking to target local economic growth and improved living standards. Given the geographic diversity of physics needs, it is essential that strategies to strengthen local skills provision are driven by, and involve close collaboration between, local education and training providers and employers.

Concentration of physics-demanding jobs by NUTS 2 region



Location Quotient 2020
(UK & Ireland=1)

2.0
1.5
1.0

1. **North Eastern Scotland**
   LQ: 2.07; jobs: 29,800
2. **Cumbria**
   LQ: 1.34; jobs: 17,500
3. **Derbyshire and Nottinghamshire**
   LQ: 1.21; jobs: 60,800
4. **Gloucestershire, Wiltshire and Bristol-Bath area**
   LQ: 1.18; jobs: 78,100
5. **Hampshire and Isle of Wight**
   LQ: 1.17; jobs: 55,300

The Location Quotient (LQ) is a metric used in economic geography to understand relative specialisation, where an LQ of 1 represents the number of jobs which would be predicted given the overall trend, and values over 1 demonstrate concentration and specialisation

Physics skills are valuable to a wide variety of careers, at all skill levels

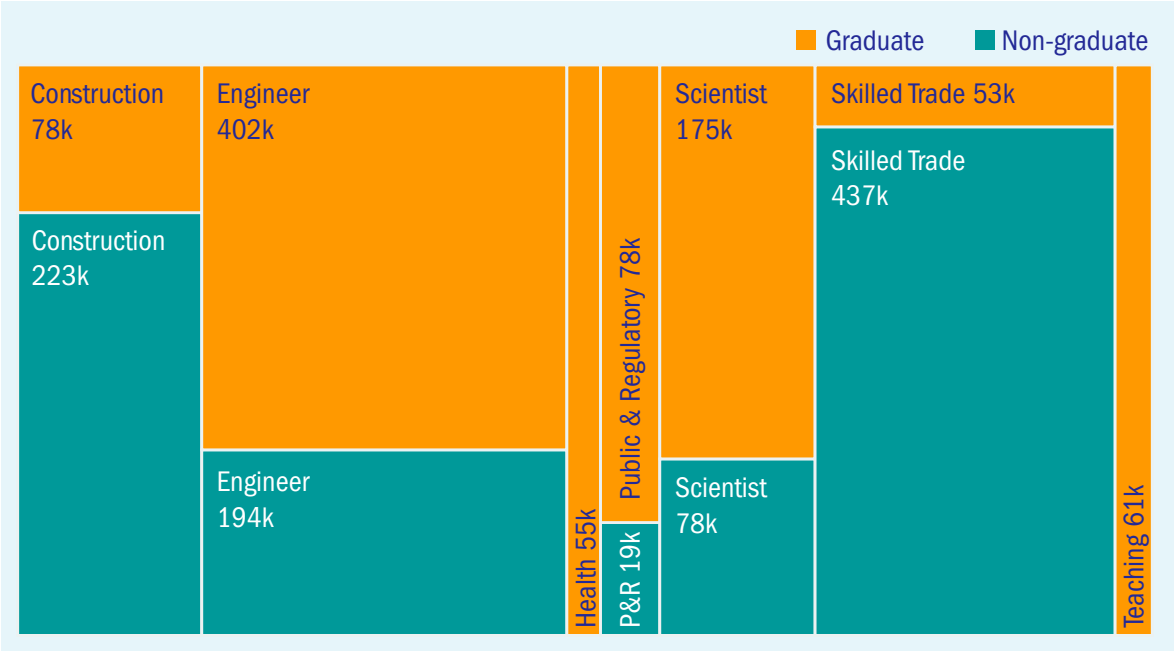
- Many employers value the broad applicability of physics skills, which equip workers to succeed in different roles within an organization or sector and in different careers across their working life
- Demand for physics spans all skills levels: in fact, more than than half (53%) of physics-demanding jobs do not typically require a degree, with a sizeable minority (46%) typically requiring intermediate-level qualifications such as A-levels, Highers, Leaving Certificates and apprenticeships
- High-skill level roles are seeing the fastest growth (with the number of physical scientists, for example, growing by 40% between 2010 and 2020), but many opportunities will remain at all skill levels for the foreseeable future, with a significant number emerging at middle-skill level[12] in particular.

Physics is often viewed as the preserve of university graduates. But our evidence shows this isn't the case – significant numbers of opportunities exist at all qualification levels. In addition, the very nature of careers is evolving, from a linear progression through a single occupation, into a more complex network in which workers apply and adapt their skills within a variety of roles and industries throughout their working life. As a result, it is the types of skills workers have that matters to many employers, rather than just their level or the route through which they were acquired.

Policymakers must ensure availability of a variety of physics education and training pathways – at all skill levels, of all qualification types (encompassing academic and technical), and in all parts of the UK and Ireland – to support employers' access to the skills they need and to open up opportunities for productive careers to all. This must be complemented with guidance to help employers understand how new qualifications are relevant to their businesses, to ensure recruitment practices reflect changes in the education and training system. Skills policy must also better reflect the changing nature of careers, for example, by ensuring that those with existing higher-level qualifications are supported to expand their skillsets at lower qualification levels, and by supporting uptake of more flexible short courses and micro-credentials that can be completed while in work, in addition to more traditional qualifications.

12. Middle-skill level jobs are those which require intermediate-level qualifications, such as A levels, Highers, Leaving Certificates and many types of apprenticeship.

Physics-demanding jobs by occupational group and typical qualification level



More than half of physics-demanding jobs are open to non-graduates

Misconceptions about what physics is and the jobs it provides access to, which deter some young people from pursuing physics, must be challenged. Careers guidance must reflect the variety of careers that physics education and training can lead to, and encourage all students considering pursuing physics beyond age 16 – especially those from underrepresented groups – to understand that there is an option that is right for them. Through the Limit Less campaign, the IOP is working to dismantle stereotypes that influence choices from an early age and bring physics-related careers to life for all young people, including through the development of resources for schools and community groups, as well as an ambassador scheme for employers. The IOP is also seeking to establish and fund consortia to provide access to innovative careers information, opportunities for skills development and training that is grounded in the future needs of the UK and Irish economies through its Challenge Fund. In addition, industrial placements and professional development opportunities for teachers, such as those supported through STEM Learning's ENTHUSE Partnerships, can help them to promote appreciation of physics' application in the workplace and support informed career choices.

Complementary skills development is essential to unlocking the full potential of physics skills

- Transferable skills – such as teamworking, communication and problem solving – complement and strengthen more domain-specific skills, and are essential to the successful application of physics skills in all work settings
- New technologies are driving employer needs, with demand for digital skills – such as those relating to computer science, data science and machine learning – in combination with physics skills growing particularly strongly in recent years
- Professional registration and development schemes are valued by employers for their role in supporting employees to continually strengthen, update and expand their skills.

Physics skills and knowledge are powerful drivers of productivity and innovation, but offer their greatest value in the workplace in concert with other skills. This is particularly evident as increasing numbers of employers seek workers with physics skills to help them exploit digital technologies, in light of their strong analytical capabilities.

The skills clusters (which identify combinations of skills sought by employers) identified by the research provide useful evidence of in-demand complementary skills to inform individuals' education and training choices, as well as the development of education and training courses and curricula – in particular, developments to strengthen provision of emerging digital skills within physics education and training. Many larger employers have developed apprenticeship programmes which enable them to develop employees with the exact skillsets required of their workforce.

Transferable skills provision must be embedded within physics education and training at all levels, and continually built upon throughout their duration, to boost individuals' employability and productivity in the workplace. Students should be encouraged to take part in work experience and placements, and employers should be supported (including by relevant funders) to offer more such opportunities, in particular to underrepresented groups, which are currently less likely to participate.[13] Such placements offer the dual advantage of equipping students with workplace-ready skills and building appreciation of the career options physics provides access to.

Placements for workers in other organizations within an industry or sector (or within other departments or sites of larger businesses) are also used in many businesses as an effective way of expanding the skills of their existing workforce and fostering innovation across supply chains, while also improving retention of more senior level employees, which can be a particular challenge in some sectors.

13. APPG on Diversity and Inclusion in STEM (2020) Inquiry on Equity in STEM education: Final report

Employers' ability to benefit from technological transformation depends upon strong links with research and education institutes

- Digitalisation and the drive for decarbonization are transforming industries; physics skills are valued by employers for their diverse and nimble applicability in a rapidly changing economy
- Research programmes and facilities, as well as specialist course provision, in academic institutions play a significant role in meeting employer demand for high-level skills in high-tech industries.

Many of the industries in which high concentrations of physics-demanding roles are found – such as manufacturing, energy supply and transport – have the most significant roles to play in reaching net zero greenhouse gas emissions by 2050. Employers value the creative approach to problem-solving which is at the heart of physics, and stress the importance of physics skills to their efforts to develop and implement more sustainable practices. Physics-based technologies – for example, innovations in clean energy generation, and sensing, monitoring and control – also have a vital role to play in decarbonization and mitigating the impacts of climate change. Strengthening physics skills among the workforce should be recognised as an essential part of governments' net zero strategies.

Strong links which support the sharing of knowledge, skills and expertise between businesses, academia and innovators are essential to enabling employers to fully benefit from the latest technological developments offered by the fourth industrial revolution and the drive for decarbonization. Such links can be cultivated through expert networks, strategic alliances with universities including industry-funded studentships and knowledge transfer partnerships, and placements or secondments across supply chains and between academia and industry. However, OECD data suggests that only 20% of innovative firms in Ireland and 30% in the UK collaborate with higher education or government institutions,[14] indicating significant untapped potential to strengthen links (though it should be noted that separate IOP-commissioned research suggests this proportion is higher among physics innovators than the general business population).

Employers in the high-tech industries which are most critical to governments' ambitions to drive growth through R&D investment are particularly dependent on the training, research and facilities provided by academic institutions. Public funders must consider these dependencies when deciding where to target R&D and infrastructure funding and when rebalancing portfolios, so as not to disrupt access to critical skills.

14. OECD (2021). Science, Technology and Innovation Scoreboard

Unlocking the full potential of physics

This research is one part of a broader programme of work at the IOP to unlock the full potential of physics for society and the economy.

The second part of the current project will explore future demand for skills in a number of focus areas that make significant use of physics-related technologies, identifying the anticipated changes in technology likely to drive new or greater demand for skills, the associated skills requirements, and existing and potential mechanisms for acquiring these skills.

The IOP commissioned CBI Economics to undertake a survey of physics-based businesses, to find out more about companies that use physics innovation in their work. The analysis found that physics-based businesses make a substantial contribution to the economies of both the UK and Ireland: enhancing productivity, boosting economic growth and increasing prosperity. However, they also face a number of challenges, which are inhibiting them to reach their full potential. Read the full report at: iop.org/strategy/productivity-programme/innovation-survey

The IOP has also commissioned Cebr to generate economic insights on the physics sectors in the UK and Ireland, providing a measure of their performance and health now and across the past decade. Read more about the research at: iop.org/strategy/productivity-programme/physics-and-economy

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The Institute of Physics (IOP) is the professional body and learned society for physics in the UK and Ireland. It seeks to raise public awareness and understanding of physics, inspire people to develop their knowledge, understanding and enjoyment of physics and support the development of a diverse and inclusive physics community. As a charity, it has a mission to ensure that physics delivers on its exceptional potential to benefit society.