IOP Institute of Physics Scotland

Scotland's Skills Delivery Landscape

Response to the call for evidence, December 2022

To Mr James Withers, Independent Advisor To The Scottish Government

To be submitted via email to skillsdeliveryreview@gov.scot by 23 December 2022

A. About us

The Institute of Physics is the learned society for physics and professional body for physicists across the UK and in Ireland. We seek 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. Our mission as a charity is to ensure that physics delivers on its exceptional potential to benefit society. We are registered as a distinct charity in Scotland.

B. General observations

IOP Scotland welcomes this call for evidence and the opportunity to respond. As the professional body for physicists, our members are at the forefront of developing physics knowledge and skills in both educational settings and workplaces. Physics undergraduates are able to join the Institute as Associate members from day one of their degree studies, and we support them throughout their careers as either full members or even becoming chartered physicists. We also co-ordinate coaching support for teachers, provide and refer members to financial support through grants and awards, and administer annual prizes for notable achievements in physics. Since its founding in 2012, we have been full members of the Learned Societies Group for STEM Education in Scotland, and have contributed to public discussion on both the need for physics knowledge and skills and the best ways to enhance these. We also participate in the Scottish Parliament's Cross Party Groups on Skills and Science and Technology.

The study of physics teaches knowledge about the nature of the universe and the particles which comprise it, as well as forces and motion, matter, energy and electricity, light and sound, thermodynamics, magnetism, and advanced issues such as relativity, quantum, and nuclear properties such as radioactivity. However, it also requires and develops several key skills including a grounding in mathematics and numeracy, understanding how we acquire and demonstrate knowledge, observation and analysis, including recording data, problem-solving and creativity, ability to use digital devices but also to communicate and collaborate. It rewards habits like logic, curiosity, open-mindedness, perseverance, and concentration. These skills are also of wide, general application in other contexts: some of the implications of this appear in this response.

Studying physics opens doors: not only in research and academia, but also in astronomy and space, climate science and meteorology, engineering, lasers and photonics, medical physics and digital healthcare, renewable energy, robotics and AI, VFX and gaming, and of course teaching.

Physics also contributes to nearly 2 million jobs across the UK, and the equivalent of 220,000 in Scotland alone.[1] Scotland has the highest proportion of physics-based employment of any part of the UK. Demand for physics skills reaches across all skill levels, and is growing at a faster rate than employment more generally.

However, there is **significant unmet need in the provision of physics skills**, and this is adversely impacting employers' ability to grow and innovate. Research commissioned by the IOP[2] 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. Strengthening the provision of physics skills is therefore central to achieving Scotland's and the UK's shared ambitions to improve economic growth, prosperity and living standards. This investment does not need to be weighted towards the tertiary sector: over half of all physics-based jobs do not require a degree, including 89% of roles in skilled trades, 74% of roles in construction, and over 30% of scientist and engineering roles.[3]

Achieving this requires a multi-layered approach, encompassing the quality of physics teaching; addressing stereotypes which dissuade people unnecessarily from physics study and careers; widening the availability of education and training options; incentivising employers to invest in physics skills among their workforce; and developing interventions specific to physics rather than science or STEM more generally. The good news is that these measures are achievable and the benefits would be real, enhancing Scotland's position as a world leader in key technologies and securing more sustainable economic growth and employment opportunities.

Developing physics knowledge and skills begins at the earliest age. To this end, we have designed and deliver a public engagement package called Small Stories across Scotland. This is specifically aimed at Early Years children and their parents and carers, which seeks to present physics concepts such as gravity and sound in participative, accessible and fun ways to a junior audience. Only a very small proportion of primary school teachers have a science background (certainly compared with some other countries), and that many such teachers lack

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1 *The Contribution of Physics to the Scottish Economy – Executive Summary*: Institute of Physics (2022). See https://www.iop.org/sites/default/files/2022-12/IOP-Contribution-of-Physics-to-the-Scottish-Economy-summary.pdf

2 *Paradigm Shift*: Institute of Physics (2021). See https://www.iop.org/strategy/productivity-programme/innovation-survey.

3 *Physics in Demand*: Institute of Physics (2022). See https://www.iop.org/sites/default/files/2022-01/Physics-in-demand-labour-market-skills-uk-and-ireland.pdf

confidence in teaching science issues, and this has knock-on effects on science learning and enthusiasm among pupils throughout schooling and beyond.

C. Responses to questions

Question 1: If there was one thing you would like to see change in how our skills landscape is structured and delivering, what would it be?

The IOP supports the development of **a physics graduate apprenticeship**. Since graduate apprenticeships were launched in 2017, they have proved a valuable addition to the skills development landscape in Scotland. By being developed collaboratively with employers, they are designed with the needs of specific industry sectors in mind, giving greater confidence that tertiary learning will be relevant to the skills needed in the workplace. They also promote recognition, development and retention of talent; improved productivity, and better fit with the practices of the employing organisation and its approach to personal and professional development. For the apprentices themselves, it improves their own hiring prospects and attractiveness to the employer, equips them with more practical outcomes of their learning, and promotes work-based learning which puts learning in a relevant context. For our society and economy as a whole, the collaborative process should help to identify physics-based opportunities, and generate more productive employees. It also offers another avenue to promote physics in a more structured way to currently underrepresented social groups.

Graduate apprenticeships are valued by employers, especially in a post-COVID environment where learning and recruitment have been interrupted, and a good deal of practical, hands-on learning and assessment were stripped out of key stages of school education.

The IOP would be happy to work with SDS and the Scottish Apprenticeships Advisory Board to develop this proposal. But it is already clear that there are significant needs to be filled in the workplace, and that there are practical barriers to filling those gaps which a graduate apprenticeship could help to solve.

A physics graduate apprenticeship would benefit from intended reforms to the GA system which have been identified in relation to existing apprenticeships, namely a flexible delivery system (given the wide range of industries where physics knowledge and skills are relevant); agile funding (given the different development and supply cycles of physics-dependent products and services); and enhanced awareness of the programme and the opportunities it provides (given the comparative lack of awareness of the types of careers which physics knowledge and skills open up).

Question 4: Thinking about how our economy and society is changing and the Scottish Government's ambitions for a skilled workforce as set out in NSET, do you have any

evidence on where the current skills and education landscape needs to adapt or change and how it could be improved? Please provide evidence to support your answer.

Yes.

The NSET's aim on skills is that "people have the skills they need at every stage of life to have rewarding careers and **meet the demands of an ever-changing economy and society** and that employers invest in the skilled employees they need to grow their businesses." (emphasis added)

The economy and society are changing in large part because of technological developments inspired by physics. This trend was clear even two decades ago:

> "*More than any other discipline, physics has transformed the face of civilization, particularly during the last century. It has developed techniques and insights that have propelled chemistry, biology and medicine to new heights. It has led to the genesis of modern engineering and has created vast industries, such as energy, communications, computing and the broadcast media. It has been the winner of wars and preserver of peace. It has played a seminal role in the emergence and development of the Internet, one of the most significant new communication media in history. As we stand at the threshold of the 21st century, its potential for economic and social innovation is greater than ever*."
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> John McInerney, Head of Physics, National University of Ireland, University College Cork, Ireland in *Physics World*, 2000

When this paragraph was written, the extent to which modern life would be dominated by online communications and digital devices was barely perceptible. Despite this astounding digital transformation, there are no signs that this will slow down or narrow focus. Indeed, the opposite is true. Most of the transformative, life-changing innovations which will drive our world during the next generation will also be physics-based: enhanced digitalisation and automation, quantum computing, the Internet of Things, Big Data, artificial intelligence and machine learning, robotics, advanced manufacturing, nanomaterials such as graphene, food technology, biomedical tech, zero carbon and renewable energy generation (including hydrogen and fusion technologies) and use, and energy storage.

This in turn will mean jobs will be created and career options forged which require physics knowledge and skills on an unprecedented scale, and the pace of change in demand will also be entirely novel to us. Yet our skills system is not equipped or appropriately focused to meet this.

A specific example from the energy sector makes this point more directly. Heating accounts for 50% of energy demand in Scotland, with transport and electricity accounting for most of the

remainder. Although generation from renewables has increased significantly, it still accounts for less than 28% of gross energy consumption, and less than 4% of consumption on heating and less than 1.5% on transport. To meet our climate change targets and contribute to both UK and international obligations, over the next two decades, the vast majority of natural gas-based domestic heating systems in our 2.67 million homes across the nation will need to be replaced with sustainable alternatives (such as heat pumps, hydrogen fuel, or from local heat networks). Transformation on this scale has never been attempted before. One million homes and 50,000 non-domestic properties are due to be emission-free by 2030: this is estimated to generate 28,000 jobs alone. The vast majority of these will require some knowledge of the physics of heating systems, but will not require a degree education. This is consistent with Phase 1 of the IOP's Workforce Skills study, which identified that 53% of physics-based roles did not require a degree. But today there are little or no options for those young people who do not choose to study physics at S3 or S4 in schools to seek a National 5 or Higher qualification later, even if they only become aware of and interested in career options relating to energy transition and decarbonisation, such as domestic heating refitting, at age 16 or older. The lack of physics knowledge and skills by itself could be a significant barrier to achieving Government policy targets, some of which are specified in legislation.

Upskilling to achieve the required level of physics knowledge and skills to fill these gaps will require significant progress on two broad fronts:

- more young people should proactively be encouraged to see physics as fundamental to understanding the world and human progress, and appreciate its potential value for their own minds, their careers, and for the benefit of society; and
- No child or young person should be dissuaded from studying physics or pursing physics-based careers because of outdated stereotypes.

Perceptions of physics matter. Although school pupils' attitudes towards physics are more positive in Scotland than elsewhere in the UK, there are marked declines in positivity towards it as pupils mature (notably between primary and secondary, and between National 5 and Higher). These declines, especially the latter one, are more marked among girls.[4] This has been characterised as a perception that physics is especially complex and abstract among the sciences, that working in related fields demands long hours unsuited to typical family and social lives, and thus appeals to people who are socially awkward. When asked to characterise a physicist visually, most young people imagine an older white man in a lab coat with unkempt hair. Such perceptions often derive from historic pioneers of physics, and bears little relationship to the study or practice of physics today. In reality, physics is useful in a wide range of occupations and makes significant contributions to the UK and Scottish economies. Although important, pure research is a small and unrepresentative proportion of

4 "Attitudes towards Physics" (2002) by N Reid & E Skryabina, in *Research in Science and Technological Education*, issue 20 pp 67-81. DOI: 10.1080/02635140220130939.

physics-based occupations. Even in that context, such research is almost always collaborative, and often international, meaning that physicists typify good communication and planning skills, and habitually embrace other cultures. The dislocation between widespread perception and reality is longstanding, cultural and deep-seated.

On the latter bullet point, there is no robust evidence that physics is especially suited to one sex/gender or another, and a good deal of evidence that such beliefs are predominantly based upon stereotypes,[5] which have a dissuasive effect on school pupils (and potential pupils and students), especially as they become more aware of and respondent to other people's perceptions of them as they mature. Girls and young women have been underrepresented within physics, and progress on this front has been slow and sporadic. We have recently seen evidence, though this is less well-documented, that similar underrepresentation issues arise among some ethnic minority groups, those with disabilities, LGBT+ identities, and who derive from poorer socio-economic backgrounds. Interventions such as Education Scotland's Improving Gender Balance and Equalities (IGBE) programme, piloted by the Institute of Physics Scotland, show positive results in addressing these stereotypes and unconscious biases in educational practice. However, it is clear that these interventions must be scaled up and embedded in policy and practice if they are to have positive effects on the scale needed. To this end, the IOP is running a Limit Less campaign to address such stereotypes, especially among those who support and work with children and young people and who can challenge rather than reinforce these stereotypes.

In Scotland, key interventions which would support such an ambition include:

- better data about the equality and social characteristics of young people studying physics, so that progress can be tracked and the effectiveness of specific interventions measured;
- more opportunities for extracurricular STEM and science clubs to instil enthusiasm and passion for physics and awareness of the possibilities it opens up; and
- proactive whole-school approaches to embedding equalities and equities practices across schools. These should be reinforced by professional teaching standards, career-long professional learning opportunities, and school inspections.
- a need for provision of courses such as HNC/HND physics in a greater number of Further Education colleges across Scotland.

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5 See, for example, the ASPIRES 2 project summary report (2020), L Archer, University College London Faculty of Education and Society. Available here: https://discovery.ucl.ac.uk/id/eprint/10092041/6/Moote_9538%20UCL%20Aspires%202%20report%20online%20version.pdf

- a need for improved career guidance in schools on opportunities and career pathways using skills and knowledge gained through physics
- a need to raise the awareness of teachers of local career opportunities.

School management, clusters, regional improvement collaboratives, local authorities and national agencies can all support these ambitions by prioritising this work and ensuring individuals have specific responsibilities to make progress.

Question 5: Can you provide any evidence of skills structures in other places that are delivering outcomes in line with Scotland's ambitions which Scottish Government should look to in achieving its ambitions?

We would sound a note of caution about cherry-picking aspects of solutions from other nations and states around the world, where actions might be dependent in whole or part on other aspects of their culture, education systems

Part 2 – Apprenticeships

Question 7: The Terms of Reference sets out an ambition for apprenticeship programmes to be an embedded part of the wider education system to ensure that there are a range of different pathways available to learners. Do you have any views or evidence on how changes to the operation of apprenticeship programmes could support this ambition?

As a science, the idea of physics in the workplace is difficult to detach from the idea of workers with many qualifications solving extremely complex, frontier problems. But an understanding of physics as it is applied in the workplace means around half of physics-demanding roles are in occupations which require intermediate level qualifications. The importance of physics in construction, manufacturing and infrastructure means there are many roles where the bulk of the work relies on applied understandings of physics knowledge, but the typical qualification level is in the low or middle-range of skills.

Therefore, there is a need for institutions at all levels to recognise that physics is valuable for many different types of careers. At school age, providing a good education in physics will be useful to far more than those who will go on to study the subject at university – it prepares pupils for practical work with valuable job opportunities, regardless of whether further study is right for everybody and people should be encouraged to undertake apprenticeships using physics.

Question 8: Apprenticeships are often described as being 'demand-led'. Do you have any evidence about how process for developing and approving apprenticeship frameworks responds to skills priorities? Please include suggestions of how the

development process could be enhanced.A purely demand-led approach may have limitations, since individual employers may (wholly reasonably) not be focused on the knowledge and skills which would allow apprentices to work in related but slightly different environments but which nonetheless utilise similar skills, nor would they be expected necessarily to be focused on skills needs ten to fifteen years later. A good example of an additional consideration is the "just transition" priority identified in the Climate Emergency Skills Action Plan: an employer may not believe that it is in their interests or predominantly their responsibility to achieve a broader balance or greater diversity among the full suite of apprentices. The IOP believes that there are benefits to having a more diverse physics community and workforce, and that individual employers should be encouraged to consider this, but demand alone would not be enough to change the dynamic of apprentice recruitment – this would have to involve the national agency, the apprenticeship advisory board and indeed schools and higher and further education institutions.

Part 3 – National Occupational Standards (NOS)

Question 10: Do you have any evidence on how the current arrangements for NOS are delivering against the intended ambitions of the NOS Strategy?

Physics is specifically cited in NOSs related to: operating and decommissioning nuclear power stations, medical treatments (esp. radiotherapy, imaging (MRIs and X-rays), dentistry), animation, visual effects and interactive media, construction, and food technology. However, there are a wider range of other physics-based occupations which have been identified in IOP research, including software design, electronic engineering, plumbing and air conditioning installation and maintenance, aircraft maintenance, quality control, environmental health, conservation and health and safety. The absence of reference to physics in NOSs relating to these occupations may be inadvertently contributing to a lack of awareness of the value of physics. We would welcome the opportunity to work with the devolved administrations who now maintain the NOS system to identify opportunities to recalibrate the standards to make them more relevant.

Part 4 – Upskilling and Reskilling

Question 14: Thinking about the government's ambition to optimise the existing system for upskilling and reskilling throughout life, do you have any evidence to support how changes to the delivery landscape could help to achieve this ambition?

Yes. More options for learning more about physics post-16 could promote upskilling and reskilling for life.

Part 5 – Sector and regional skills planning

Question 15: Thinking about the overall ambition to ensure that the skills and education system is aligned to local, regional and national skills priorities, what aspects of the current delivery landscape are working well to support this ambition?

There seems to be a lack of follow-through from national economic, science, innovation and energy strategies and priorities to specific action plans to achieve the specified outcomes – Climate Emergency Skills Action plan notwithstanding. Actions which reach into school-level education and post-16 have long lead-in times which mean results are not immediate. There needs to be political consensus around these reforms which mean they are not tinkered with through electoral cycles.

Question 17: The NSET sets out a vision for a system which is agile and responsive to future needs, where labour market insights can inform strategic provision planning. Do you have any evidence to indicate how changes to the delivery landscape could better deliver this vision?

Technology develops faster than education and training regimes can catch up, which is why a core grounding in principles of energy, electronics, mechanics and quantum/digital offer the flexibility to be able to respond to opportunities as they develop. Although the North East of Scotland will see an unprecedented upheaval in jobs from the oil and gas sectors, demand for energy production is unlikely to decline significantly even given advances in energy efficiency and conservation.

Connections with employers through a physics apprenticeship would offer the opportunity to respond to market research, knowledge and economic conditions. The Scottish Apprenticeships Advisory Board and SDS could review the extent to which they have access to integrated advice on science and technology developments expected over the next 15–30 years, to allow time for responding to anticipated demand in ways which can realistically create training packages and the skilled workforce needed.

Question 19: One of the major challenges and opportunities facing the economy is the just transition to net zero. Thinking about the current delivery landscape, how well is it structured to deliver this ambition?

Yes. Refer to climate change issues mentioned in response to question 15.

Part 6 – Careers and Young People

Question 20: Do you have any evidence to inform how the new Careers by Design Collaborative could be embedded within the wider education and skills system and delivery landscape to enable the recommendations of the Careers Review to be taken forward to ensure people can access the advice, information and guidance that they need?

Careers guidance and information should have access to the same future-scoping recommended in relation to SDS and the SAAB (see answer to question 17 above).

Question 21: Alongside Careers information, advice and guidance, do you have any evidence to demonstrate what additional support young people, including those from marginalised groups, might need to develop their skills and experience to prepare them for the world of work? Please include details about who you think should be responsible for providing this support.

Outdated stereotypes of particular careers need to be broken down. The IOP's Limit Less campaign addresses such stereotypes, especially among those who support and work with children and young people and who can challenge rather than reinforce these stereotypes. The Scottish Government, families, communities, schools and public bodies all have responsibilities to improve diversity and support under represented groups into rewarding careers in and using physics.

Part 7 – Employer Support and Engagement

Question 23: Thinking about the different aspects of the system in which employers have an interest, and the existing mechanisms for feeding into policy and delivery, do you have any evidence to support how changes in the delivery landscape could improve the partnership working between Scottish Government, its public bodies and employers?

See answer to question 1