Enhancing physics graduate employability through curriculum development: enablers, barriers and opportunities

Veronica Benson, SEPnet Employer Liaison Director; Olga Fernholz, Industrial Placements Officer, School of Physics and Astronomy, University of Nottingham; Andrew Hirst, WRIPA Operational Manager, Department of Physics, University of York

Background

A 'Physics Graduate Employability' workshop was held on 18th July 2018 organised by the South East Physics Network (SEPnet) and the White Rose Industrial Physics Academy (WRIPA), supported by the Institute of Physics and chaired by Professor Sir William Wakeham. It aimed to develop a collective future vision for physics departments in the UK and set out ways to achieve this by overcoming current challenges and identifying opportunities. Delegates considered the wider context of the Government's Industrial Strategy, proposed changes to the degree accreditation process and listened to innovative approaches to curriculum design and skills training.

'Key recommendations'

- **A physics degree programme should move from one that emphasises factual knowledge to one of application of knowledge**
- **Industry partners should provide input into curriculum-based learning experiences**
- **Universities need to align graduate skills and knowledge with regional innovation and opportunities.**

Introduction

Physics-based businesses directly contribute 8.5% of the UK's economic output, more than £77bn per year. Including indirect spending, the total impact of physics-based businesses on the UK economy was more than £220 bn in 2012 (Deloitte, 2012), and is arguably greater than this today. Despite such impressive statistics, physics-based technical industries find it difficult to recruit sufficient numbers of suitably qualified graduates. Destinations of Leavers from Higher Education (DLHE) data typically shows that only a third of physics graduates that go into employment pursue technical careers. Unlike other disciplines, such as chemistry or engineering, there is no obvious "Physics Industry", so many physics undergraduates find it difficult to identify technical career paths. In parallel, employers look for graduates with a range of 'high performance behaviours' e.g. complex problem solvers, creative and cognitive flexibility.

Equally important, individuals and society now expect a different return on their investment in a university degree because of the tripling of fees to £9,000 in 2012 – currently £9,250. In this new HE environment, with its emphasis on league tables, students (and parents) are increasingly selecting courses based on employability rates and the expectation that degree courses prepare graduates for the jobs market. Physics departments need to consider how they will attract the best students in an increasingly competitive market.

Physics graduates can help address STEM skills shortages

Now, for the first time for nearly 40 years the UK has an industrial strategy. The government's Strategy focuses on improving national productivity by addressing several underlying problems. These problems include pronounced regional differences in economic performance, a highly centralised economy, low investment in R&D compared with other highly industrialised nations (e.g. South Korea, Japan, France and Germany) and uneven skills distribution. In short, since the financial crash, productivity is low and there is a serious STEM skills shortages. This has led to the economy stagnating (Industrial Strategy Commission, 2017).

The Industrial Strategy highlights the need for more STEM students with the right skillset to support the growth of the economy. Physics graduates are recognised as technical problem-solvers based on their deep knowledge of fundamental principles. Indeed, physics is arguably the most fundamental and adaptable of the science disciplines and, in today's globally changing world, the relevance of a physics degree is even more important in relation to a wide range of sectors e.g. the food industry, automotive, space, digital, energy and computing. It is timely to consider in what ways physics degree programmes can be re-imagined and designed for the 21st century.

Physics degree programmes need to adapt

Physics degree programmes need to equip our students with the skills that current industry needs at the same time as providing them with the means to re-invent and upskill themselves across a working lifetime. Indeed, if predictions prove correct about the impact on the labour market of technological innovations, then smart algorithms will replace many high-skilled work processes carried out by professionals. Therefore, the physics degree should focus not only on academic knowledge but also on developing the graduate attributes that can respond to a rapidly evolving employment landscape. Key skills include complex problem solving, critical thinking, negotiation, judgement and decision-making. Innovative approaches to teaching and learning (e.g. threshold concepts, games-based learning, 'wicked issues') that embed these key skills and simulate real-world working with employer input are vital. We need to move from degree programmes that teach facts and use a "Learn, Assess & Forget" approach to one that emphasises the application of knowledge, reflective learning and formative assessment. The Institute of Physics recognises the need to embed cognitive, practical and transferable skills and is reviewing its accreditation process to ensure courses are designed to equip students with the graduate attributes that students and businesses need.

Simulating real-world learning to develop employability

Real-world learning (eg, year in industry placements and summer internships) are some ways that physics students develop key learning skills and through this learning experience they apply their academic knowledge to problem solve. Several university physics departments have taken this a step further and employer engagement, working with regional employers, occurs within curriculum development. Salford run a first year module called: 'Frontiers of Physics and Entrepreneurial Skills'. This employer seminar series is integrated into the curriculum and introduces students to the roles that physicists do and the sectors that they work in. The employer seminar series provides context to problem-based laboratory exercises where students develop skills in computer interfacing and CAD design. The School of Computing, Science and Engineering at Salford has recently opened a new manufacturing hub called the 'Morson Maker-Space'. Morson Maker-Space is billed as a 'factory-floor' space where businesses, researchers and students work together on industrial techniques and processes. The key aim of the Maker-Space is to teach students about digital fabrication technologies (e.g. 3D printing, laser cutting and rapid prototyping) and support them to learn about 'design thinking'.

Sheffield Physics as part of the White Rose Industrial Physics Academy has introduced a number of "real-world" project-based learning activities. One example is the final year undergraduate "Group Industrial Projects". These projects are characterised by "authentic" physics problems set by local employers. The students work in teams to solve an open-ended problem and prepare both a presentation and report for the business. In addition, the premise of project-based learning has been extended to modules focused towards 'Physics Education and Outreach' and 'Physics in an Enterprise Culture'. These modules are underpinned by portfolio-based assessment, reflective learning, ideation and communication. These activities are part of a wider strategy that embeds and connects career development training and collaborative problem-solving with the development of professional skills and connections via local networking events (e.g. physics-focused recruitment events, employer visits and webinars).

We need to retain students' interest and motivation while also developing their confidence and ability to cope with real-world situations. In the physics department at Cardiff, projects simulate the real world of scientists. Students design their own experiments and have to defend their ideas. They learn to deal with uncertainty. Conceptual understanding is developed in round table discussions and students and staff learn together. Active learning encourages creativity and innovation, enthusiasm and self-confidence.

If we view the physics curriculum through the lens of students' career development this helps us to design both co- and extra curricular activities to enhance students' abilities in relation to self-awareness, opportunity awareness, making good choices and acting on those choices. Students need to develop these abilities if they are to succeed in a rapidly changing work environment.

The key to the future economic success of the UK is to find a formula that increases productivity and grows economies outside London. Developing the capability of physics students and graduates and retaining these regional talent pools by

connecting them with local industries, through projects, placements and networking opportunities while at university is key.

Conclusion

There is increasing evidence of effective active learning taking place within physics departments based on reflective and formative assessment to develop students' employability. We are also seeing greater emphasis placed on professional training and industry input into curriculum development. Linear career paths will become less common and future graduates will need to be resilient and committed to lifelong learning. This places a responsibility on physics departments to decide how and in what ways the curriculum will be delivered.

A key driver to future growth and prosperity is innovation. Innovation requires graduates to have both the specialist subject knowledge and experience to apply their physics to the real world. Physics departments will need to collaborate more effectively with local employers and their supply chains to improve the diffusion of knowledge and skills that currently hampers regional innovation. Linking regional physics clusters such as WRIPA and SEPnet enables us to address these challenges by drawing on a wider range of expertise and knowledge whilst also developing a stronger business network.

The South East Physics Network (SEPnet) is a consortium of 9 university physics departments at Hertfordshire, Kent, Portsmouth, Queen Mary, Royal Holloway, Southampton, Surrey, Sussex and Open University. SEPnet was set up in 2008, funded by HEFCE, to advance and sustain physics as a strategically important subject for the UK economy and it science base in the South East of England. SEPnet is now in its third phase and is fully funded by its partner physics departments.

The White Rose Industrial Physics Academy (WRIPA): In 2014, the universities of Sheffield and York were awarded HEFCE (now Office for Students) Catalyst funding to set up the White Rose Industrial Physics Academy (WRIPA). The Academy has now grown into a consortium of five university physics departments with Hull, Leeds and Nottingham joining the Academy in 2016. WRIPA's priority objective is to build the capability of undergraduate students so that they are better equipped to apply their knowledge and skills to graduate-level technical work.