Building the skills portfolio of physics students through sustainability

Andrew Mizumori-Hirst, School of Physics, Engineering and Technology, University of York

Anne Booth, Department of Physics and Astronomy, University of Sheffield

Background context

Recent higher education (HE) policy reforms, such as the condition B3 of the Office for Students' (OfS) regulatory framework, requires HE providers to deliver successful outcomes for all their students (Office for Students, 2023a; OfS, 2023b). At the same time, Physics skills are central to the new industrial landscape (eg computing and health technologies). This means Physics skills are in high demand but graduates increasingly need a combination of broad knowledge of fundamental Physics and graduate attributes to take advantage of these new highly skilled opportunities (Emsi Burning Glass, 2022). This means there is significant unmet demand for Physics skills, impacting employers' ability to innovate and grow (Institute of Physics, 2022a; Industrial Strategy Council, 2019). Part of the answer relies on universities giving students the right balance of knowledge and skills, so students can apply their knowledge in ways they have not been taught. Supporting students to develop graduate attributes (such as problem solving and creative thinking) is also critical to address broader societal challenges, such as decarbonising the economy and dealing with ageing societies. Therefore, development of graduate attributes through the curriculum creates an opportunity to develop a Physics degree that gives undergraduate students the skills, knowledge and experience to contribute to an environmentally and ethically responsible society.

The White Rose Industrial Physics Academy (WRIPA) is a 10-year collaboration between business and the university Physics departments of Hull, Leeds, Nottingham, Sheffield and York. Starting in 2014 and supported by HEFCE Catalyst funding and OfS Challenge Competition funding, WRIPA's mission is to provide undergraduate physicists with the opportunity to gain careers efficacy, work-integrated learning and graduate attributes that better prepares them for managerial or professional employment (OfS, 2022c) in a technical sector. A consortium approach enables the WRIPA universities to develop a broader range of industrial relationships and draw on a wider range of academic expertise than are available at individual universities. Together, the WRIPA universities are able to reach critical mass to catalyse change in Physics in higher education. This change places a strong emphasis on fully embedding graduate attributes within the Physics curriculum.
This approach enables students to relate their learning to societal challenges, such as the importance of sustainability and the environment and the ethical or moral considerations of scientific research. Skills acquisition is also important, as skills have much greater prominence and are compulsory in the Institute of Physics' new degree accreditation framework (IOP, 2022b).

Background

The Department of Physics and Astronomy, University of Sheffield, has embedded skills training, employers and work-integrated learning across the Physics degree from year 1 to year 4. The revised Physics degree is informed by the university's strategic plan for education and its commitment to align curriculum developments with the changing labour markets. This gave rise to the mySkills Portfolio (University of Sheffield mySkills portfolio, nd) and the Sheffield Graduate Attributes (University of Sheffield, the Sheffield Graduate Attributes, nd). The mySkills platform enables students to self-assess and reflect on their skills and employability and align this with the Sheffield Graduate Attributes. The Sheffield Graduate Attributes are 12 skills and characteristics that the university and employers have identified as beneficial for onward career success.

In 2019-20, Sheffield Physics piloted the mySkills platform in a redesigned 70-credit Classical and Quantum Physics module. The aim of this year two core module is to support physicists to further develop graduate attributes by providing opportunities for writing, data analysis, presentation and team work.

The module has run for four years and brings together the taught core Physics, laboratory work and a group-based project. The group-based project forms 10% of the module mark and is aligned to the university's mySkills portfolio and Education for Sustainable Development (ESD) (Advance HE, 2021). ESD enables Physics students to integrate social, economic and environmental dimensions into their project work, contextualised within the Physics subject. Contextualisation is important as it gives students the opportunity to apply their academic knowledge to unfamiliar problems, which lie outside the taught Physics. Reflection on skills developments also supports physicists to align their work to both the University of Sheffield's (UoS) and the United Nations (UN) sustainable development goals.

For the project activity, students work in a group of five. Groups nominate their own project topics based on their interests and how they feel physicists could support a more sustainable world. Nomination requires students to use critical thinking skills to analyse and interpret their findings and synthesise this learning towards a sustainability challenge. For example, students came up with the following project titles: (a) Exploring more sustainable alternatives to rare earth metals in technology; (b) Current and future viability of nuclear energy generation and (c) Can carbon capture technology reduce climate change?

Table 1 highlights how Project C maps across graduate attributes and sustainable development goals.

Table 1. Student Project - Can carbon capture technology reduce climate change? The coloured panels highlight the graduate attributes the students gained and how these map on to sustainable development goals.

UoS graduate attributes	UoS key Sustainable Development Goals	UN's Sustainable Development Goals
My learning	Quality education	No poverty
Academic skills	Affordable and clean energy	Zero hunger
Applying knowledge	Sustainable cities and communities	Good health and wellbeing
Research and critical thinking	Responsible consumption and production	Quality education
Digital capability	Climate action	Gender equality
My impact		Clean water and sanitation
Interpersonal skills		Affordable and clean energy
Working with others		Decent work and economic growth
Equality and inclusion		Industry, innovation and infrastructure
Ethics and sustainability		Reduced inequalities
My self		Sustainable cities and communities
Positive wellbeing		Responsible consumption and production
Purpose		Climate action
Personal development		Life below water
Enterprising		Life on land
		Peace and justice
		Partnerships for the goals

The students' research was disseminated by a live 15-minute presentation. Each group member presented a segment to their peers and received feedback. At the same time, a panel of academic staff assessed the presentation.

Outcomes

Description of the nature and extent of the work's impact. What are the main findings?

From 2019-20 to 2022-23, 293 physics students have completed this module. In 2023-24, a further 100 students will take this module. An alumni survey for the class of 2022 revealed that 86% of students who responded and who took this module are in managerial or professional roles. Module evaluation gave qualitative feedback that highlighted not only that students are learning graduate attributes but that students are aware of the skills they are learning:

> "It made me a better communicator, and helped me develop ways to professionally disagree and give constructive feedback."

> "I think this year I developed skills for effective teamwork – communication, sharing of ideas and adaptability."

> "I have learned how to deal with challenges in a professional way, constructively reflecting on how I deal with them."

Giving students the opportunity to choose their own topic areas was an important feature of the project design. Empowering students in this way maintained motivation as students had inherent interest in the topic and felt part of the decision-making. Students worked with peers they had not worked with before, mirroring team working in industry where skills are brought together to achieve a common goal. Students responded very well to the opportunity to focus on Sustainable Development Goals contextualised within physics. They also wrote a reflective essay about their project experience and the impact of their research topic for physics and future sustainability. The experience gained was ideal content for students' mySkills portfolio. Also, several students who were not on the year in industry programme were more confident to consider applying for roles based on their skills development. This led two students to successfully apply for 12-month placements. One finalist has been inspired to apply for a graduate role at Sellafield. He stated that his project on the future viability of nuclear energy generation "made me think wider and differently about what I can do with my physics skills".

Key messages and transferability

All universities are committed to providing students with personal development opportunities that better prepare them for an ever-changing world. A more inclusive way to do this is by developing innovative pedagogies and curricula. It is envisaged that ESD and the approach to skills learning and assessment can be embedded within any degree discipline, offering an excellent way of 'translating' specific content knowledge to societal challenges. The group-based activity described in this article not only offers students the opportunity to develop graduate attributes but to reflect on their learning. For example, student groups communicate their research topic to inform a non-specialist (though scientifically literate) audience. The groups are required to accurately describe the science involved

and pitch at the audience level while ensuring the audience is aware of the need and impact of the research. Skills development and synoptic learning is of critical importance as graduate employers want to hire students who can solve unfamiliar problems (Hooley, 2021).

Next steps

The next step is to engage employers in the assessment and feedback phases of the group project to replicate an assessment day setting. Currently, students present their project findings to an audience of their module peers and academic staff. The aim here is to help students to reflect and plan to develop their graduate attributes. For example, a small number of students who were not actually presenting but were waiting their turn looked disengaged. Their learning takeaway is the students are constantly being appraised during the presentation stage, similar to the environment of an assessment centre for a graduate programme.

For the 2023-24 cohort of students, taking the same module, groups of students will research an aspect of Physics to solve a 'future-focused' sustainability challenge. These challenges could be energy production, environmental protection or global warming. In addition, the same module will feature two new projects focused on Physics in Modern Society. Students will write an individual report, then produce and present a poster in pairs, reflecting on their skills in working with others and applying knowledge. Again, this new approach aligns with the requirements of the new IOP accreditation framework.

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Acknowledgments

Thanks to Chloe McDaid of the University of Sheffield for the original inspiration for this project.

Contact us

All enquiries

Email: communications@advance-he.ac.uk

Website: www.advance-he.ac.uk

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ISBN: 978-1-7385242-0-4