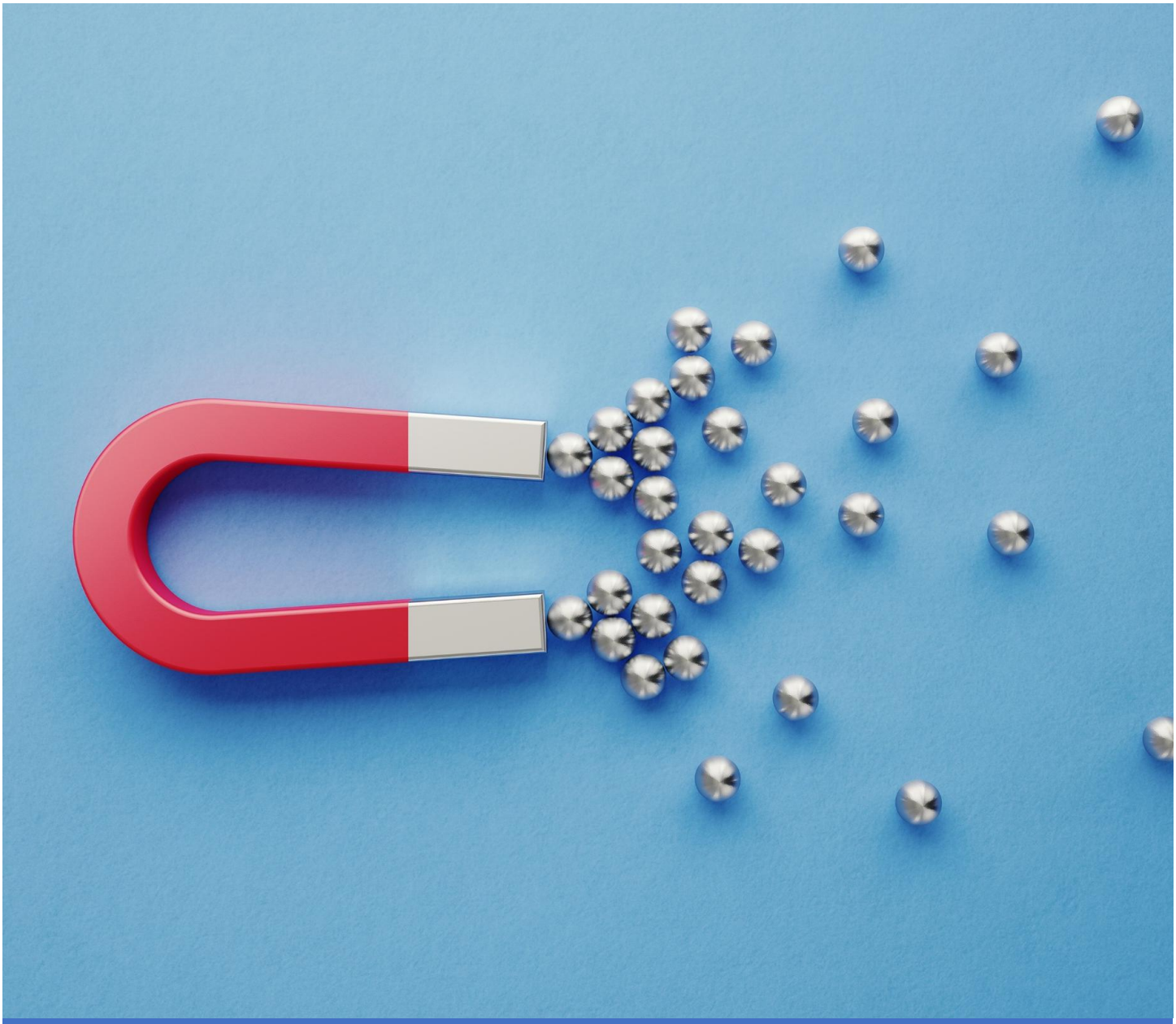

A Vision for Physics Higher Education Research in the United Kingdom and the Republic of Ireland

Nicolas Labrosse, Alison Voice, Helen Heath

21 May 2025

A Vision for Physics Higher Education Research in the United Kingdom and the Republic of Ireland

Contents

Executive summary 2
Context and motivation 4
Methodology 5
Findings 5
Size and Scope of PER community in UK and Ireland 5
Research and Scholarship 6
Visibility of the PER community 7
Recognition, career tracks and promotion 9
Funding 14
Networks 17
Interfaces with other communities 20
Early career development and training 21
Research themes, international relevance and reputation 23
A Vision for the future of PER 23
Recommendations 23
Conclusions 26
Acknowledgements 27
About the authors 27
Glossary 27
Appendix Survey Questions 28

Executive summary

Context and Motivation

This report presents an analysis of the Physics Education Research (PER) landscape in the UK and Ireland, highlighting the importance of this field due to its critical role in enhancing the quality of physics higher education. The study was motivated by the need to recognize and support the growing PER community, particularly in the wake of the Covid-19 pandemic and following the introduction of the new Institute of Physics (IoP) degree accreditation framework. With this report, we aim to underscore the importance of PER in addressing the challenges faced by physics educators and students. The pandemic highlighted the necessity for innovative teaching methods and the rapid adaptation of educational practices, emphasizing the value of evidence-based approaches in physics education.

Methodology

The research was carried out in 2022 and 2023. The study employed a mixed-methods approach, including a desk-based review, an anonymous survey, and two focus groups. This methodology provided a robust framework for gathering insights into the current state of PER, the challenges faced by teaching staff, and the opportunities for growth and development within the physics higher education community.

Findings

This project revealed a vibrant and active PER community. The PER community nevertheless faces significant challenges in terms of visibility, recognition, and funding. The survey and focus group discussions highlighted the need for increased institutional support, better career progression opportunities, and sustainable funding mechanisms. This study also identified the establishment of dedicated PER groups within departments and the promotion of external collaborations as key strategies for enhancing the impact and reach of PER.

A Vision for the Future of PER

In this report we outline a vision for the future of PER arising from the findings of our study. Our recommendations emphasize the need to build on the momentum gained over recent years and to leverage the new IoP degree accreditation framework to drive further advancements in physics education.

Recommendation 1: We strongly encourage the PER community to take any opportunity, via the per-he website or otherwise (e.g. by submitting articles to Physics World or The Conversation) to enhance sharing of information and initiatives relevant to PER.

1.1 Evidence excellence in the PER work being carried out across our nations and further afield.

1.2 Share best practice and solutions to highlight, maintain, support, and develop the research work in progress.

1.3 Use social media to share data, find new contacts, and stay connected with existing ones.

Recommendation 2: The PER community should work together to better evidence the impact of research and practice on others.

2.1 Engage with the IoP and with its Higher Education Group events.

2.2 Network at conferences and via other means, which will naturally lead to identifying colleagues with shared interests.

2.3 Organise PER seminars, leaving time for speakers to discuss with the audience. Inviting PER speakers from other institutions benefits both hosts and speakers alike, and is an excellent way to collectively raise the profile of PER.

2.4 Develop collaborations with other PER research groups and/or other fields such as social sciences, psychology, and science education (e.g. by taking part in webinars, events, and conferences).

2.5 Facilitate more collaboration on big issues such as decolonising, awarding gaps, inclusivity, Generative AI, by increased engagement with existing networks.

2.6 Design and establish a recurring event for the Physics Higher Education Research community to develop ideas for addressing grand challenges in university physics education. This could be done in partnership with the IoP and its Higher Education Group with e.g. an annual 1-day meeting enabling all to reflect on the most important objectives to tackle as a community.

Recommendation 3: The PER community should continue to support each other in career development.

3.1 Ensure that the career development needs of all teaching-focused staff are regularly explained and discussed with Heads of departments, highlighting, for example, the differences in metrics that enable promotion for staff active in PER.

3.2 Raise awareness of the challenges faced by teaching-focused PER staff and how they are perceived in physics departments, to better support physics higher education research activities.

Recommendation 4: Departments and institutions should actively support staff engaged in PER activities regardless of whether they are teaching-focused or on other career paths. Heads of departments, Directors of teaching, and line managers are the people who typically have responsibilities here.

4.1 Safeguard and advertise funding opportunities available for staff (teaching-focused or otherwise) to apply for to continue and strengthen engagement with PER activities.

4.2 Allocate funding to support postgraduate physics education research projects.

4.3 Actively become familiar and engage with the specific promotion criteria that enable staff undertaking PER to develop and apply for promotion. For example, it is essential that all Heads of Physics and line managers are familiar with, and fully understand, how PER-active staff are asked to demonstrate influence in the physics teaching community, locally, nationally, and internationally, as appropriate to grade.

4.4 Provide opportunities for, or support staff to attend, training in educational research methods for those who want to get involved in PER. Some universities offer free Masters in Education, but not all staff have the opportunity to do these. For example, a week of training, or training days interspersed through the year, would upskill staff in qualitative and quantitative PER research. This would then not only strengthen the legitimacy and quality of the research being carried out but also would increase confidence in research methods that are less familiar to physicists – although essential in discipline-based education research.

4.5 Use available fora from professional bodies (e.g. via the IoP's Heads of Physics forum) to share outstanding work being done in learning and teaching in their own departments, but also share concerns, challenges, and possible solutions to common issues such as funding, workload allocation, mentoring, or promotion.

4.6 Support the formation of a PER group if there isn't already one in the department and ensure representation from that group at strategic levels in the department in the same way that other research groups are able to shape strategy.

4.7 Promote impactful work and ensure PER work is clearly present and highlighted on internal- and external-facing dissemination activities (including departmental web pages).

Recommendation 5: The absolute priority strongly expressed in our community survey and across the discussion groups that were held for this project is to secure funding to strengthen research activity and disseminate findings. Thus, we recommend that research councils and funding bodies:

5. 1 Enable sustainable funding and develop spending to support discipline-based education research. The funding would be used to take part in conferences, fund PhD projects, and recruit postdoctoral researchers to undertake high-quality, impactful research.

Our full recommendations are detailed on pages 23-26.

Context and motivation

The concept for this report arose from a discussion at the Institute of Physics (IoP) Higher Education group committee in May 2021. The committee noticed that there was a lot of ongoing research and development in physics education, but it was not funded or officially recognised. It was further noticed that it was not obvious to most observers where physics education research (PER) in higher education settings was carried out, and on what topics. It was suggested that a study compiling a directory of all those involved in PER and scholarship of learning and teaching would shine light on activities taking place and draw funders' attention to ongoing work in key themes. With more Universities creating teaching focussed roles with permanent staff and career progression, it was felt that there should be a recognised critical mass of staff working in PER in the UK and Ireland to push forward projects crucial to the sustainability of high-quality physics education.

As well as a growing community of teaching focussed staff, more physics education groups are emerging within departments. The staff in these groups need education research publications and profile for promotion. However, resources of individuals are limited both in time, as they often have large teaching loads, and limited in funding – and so working together is important.

The Covid-19 pandemic demonstrated that there was appetite for a much deeper understanding of teaching, learning and assessment in physics. In the UK and Ireland, nearly everyone in universities teaches. With the fast pivot to online education due to the Covid pandemic, staff in universities, whether teaching-focused or on more standard pathways, spent time and energy understanding how to create good education resources that supported students in the new environment. It was noted that there were significant variations in students' responses. For example, some students valued the anonymity of online environments and worked well but the loss of personal contact provided challenges for other students and for educators. A lot was learned about education throughout the pandemic and in its aftermath. This project is therefore timely in helping to ensure that we build on the lessons learnt from the pandemic years to improve subject teaching.

Another factor external to departments that is driving change is the updated IoP degree accreditation framework prompting curriculum reviews with an increased emphasis on authentic skills such as group work, communication, critical analysis and problem solving.

The pandemic illustrated that by working together through networks, the Physics community could make big changes rapidly. The sharing of good practice, for example in developing labs at home, is an example. However, even with the covid-19 pandemic behind us, and a newly established degree accreditation framework, the importance and relevance of physics higher education research in our universities is still prevalent. There are always new challenges. At the time of writing, we are considering the impact of generative artificial intelligence on the integrity of our assessments and how we can capitalise on the opportunities it provides.

The Institute of Physics has funded this project to understand the size and strength of the PER community in the UK and Ireland and find ways to enhance the impact of the work that is being done. There is also an appetite to look at the challenges facing us in trying to have impact on the international scene where other countries, in particular Australia and the US already, have major impact. However, whilst we look for wider impact, our PER work primarily needs to focus on the UK and Irish context. This report presents an analysis of the size, scope, and potential of the Physics Higher Education Research community in the UK and Ireland.

The broader motivation for improving the effectiveness of PER research and development is to make our discipline more attractive. We need to support the growing, and very welcome, diversity in the student body. Universities should welcome staff engaging with the subject-specific pedagogic research as it will provide evidence in support of cases demonstrating excellence in teaching activities and enhance responses to student surveys. It will also enhance the student experience and support IoP degree accreditation. A lively PER community in the UK and Ireland will also support all Physics academic teaching staff in delivering the best possible education to our students.

With this report, we have aimed at presenting a snapshot of the PER community in universities in the UK and Ireland. This project also allowed us to engage with our community via surveys and in-person discussions to understand the motivations, drivers, and barriers facing staff at all stages of their careers. In the following, we present the methodology for our study of the Physics Higher Education Research landscape in the UK and Ireland. We then present our results and our interpretations of the findings. We conclude the report with recommendations to all stakeholders to ensure a thriving and sustainable future for the PER community in higher education.

Methodology

To gain as much insight as possible on the status of PER in the UK and Ireland, the following aspects of research were undertaken.

(a) **A desk-based review** of publicly available information (November 2022) on university and department web sites across the 57 IoP accredited institutions. This was to provide a broad level mapping of where PER was being undertaken and showcased, and where university promotion criteria recognised such scholarship as leading to a viable career route.

(b) **An anonymous staff survey** (in December 2022) launched through existing physics networks (e.g. IoP HEG membership, Directors of Learning and Teaching network, Heads of Department network) to obtain more detail about the practices of undertaking PER, such as: access to funding, opportunities for student supervision at undergraduate and postgraduate levels, extent to which PER is recognised as a valuable activity within physics departments, and extent to which it contributes to career progression. The survey questions are given in the appendix.

(c) **Focus groups** to facilitate open discussion, to surface aspects not already raised, and to chart a way forward. Participants were recruited voluntarily through an invitation at the end of the anonymous survey, and through open invitation using the networks mentioned above. Two focus groups were held: one in London at IoP headquarters (on 17th February 2023) and one in Dublin at University College Dublin (on 12th April 2023). These events consisted of a summary presentation of findings so far, short case study talks from participants and break out group discussions followed by plenary reporting.

Findings

Size and Scope of PER community in UK and Ireland

The results of the desk-based review of PER can be used as an indicator of the size of the PER community in the UK and Ireland and of the visibility of the PER community. Table 1 shows that of

the 57 (as of November 2022) IoP accredited departments, 20 (35%) shared sufficient information on their web pages indicating an identifiable PER presence.

In addition, the staff survey revealed that, of the 41 survey respondents (likely a self-selecting interested group since 80% declared that they participated in PER activities), only 46% were aware of a dedicated PER website in their institution. Reasons given for lack of such website ranged from "*lack of support – financial and/or manpower/time*" or "*group has been recently set up so web site is yet to come*" to "*not recognised in a formal activity/group*". Also, related activity by individual academics not associated with a group will often appear on personal webpages only, which were not included in this study. Respondents were not asked about affiliation, and therefore we cannot conclude on how institutions were represented in the responses. However, even the visible material indicates a significant number of academics are actively involved in PER.

Table 1 Data for departments from the desk-based review

Nation	Number of Accredited Physics Departments	Number of Physics departmental websites mentioning a PER group	Number indicating PER work in Education departments	Total number of staff identified as involved in PER
England	39	10	4	93
Ireland	6	2	0	2
Northern Ireland	1	0	0	0
Scotland	8	3	0	17
Wales	3	1	0	5
Totals	57	16	4	117

Research and Scholarship

The survey was launched in the early stage of our project to gather views from the community. The survey attracted 41 respondents, of whom 32 reported themselves as active in PER. Most respondents answered all questions, but where questions were left blank, or respondents selected N/A, their data has not been analysed for that question. Hence percentages quoted in this report are for those who gave a response to a particular question.

To begin with, survey respondents were asked about their definitions of 'Research' and 'Scholarship'. This was done by posing the following question: "Research can be defined as contributing to new knowledge. Scholarship can be defined as the process of updating or maintaining the knowledge, skills and experience of an individual. Do you agree or do you see it differently?" 17 respondents agreed with these definitions, and a further 8 broadly agreed. 4 disagreed and 9 had other views.

The main comments were often to say that the line between research and scholarship is more blurred, or in fact that scholarship encompasses research. Scholarship was also seen not only to benefit an individual, but to include dissemination. One respondent described scholarship as *"practitioner led R&D"* and another as *"the application of research into practice".* Another described it as *"much broader than research and encompasses innovation (which is not necessarily research), learning from best practice, CPD, assisting others to become better teachers"*.

In terms of defining research, one person described it as *"establishing a hypothesis, understanding or developing an evidence base to test that hypothesis and developing a conclusion which is then communicated to the wider community to further test or put into practice"*. While another described it as *"measuring things and reporting"* whereas they defined scholarship as *"reading other peoples' research".* Maybe this can all be summed up by the comment: *"Scholarship of Teaching & Learning is for me the applied end of pedagogy, with the new knowledge end of pedagogy being research"*.

Visibility of the PER community

The findings from the desk-based research and the views from the PER community expressed in the survey and in the focus groups that followed have highlighted the importance of increasing the visibility of our community at all levels: locally within a department and its host institution; nationally; and internationally.

There are multiple reasons for this, but they all revolve around the central concept of recognition. Besides an essential, existential need to be seen for who we are and for what we do, other motivations for recognition include:

1. Being in a position of influence locally to shape learning and teaching practice within one's own institution for the benefit of students and staff
2. Improving perceptions from colleagues and students about scholarship and education research
3. Professional development
4. Career evolution and promotion
5. Opportunities for collaboration locally and across institutions
6. Invitations to speak at seminars and conferences
7. Impact at a national or international level
8. Enhanced reputation to attract funding

Depending on the intrinsic motivations and local contexts, there are several approaches that can be taken to achieve increased visibility:

1. Having an up-to-date personal web page, blog, social media presence
2. Maintaining web pages as a scholarship / research group within the structure of departmental web pages
3. Engaging with Heads of Schools, Deans of Learning and Teaching, and other senior members of university management to highlight the importance of taking an evidence-based approach to supporting students' learning
4. Publishing through journals and conferences presentations
5. Networking – e.g. joining the IoP Higher Education Group, and other relevant scholarship of learning and teaching, or discipline-based education research groups within / outwith the UK and Ireland, subscribing to mailing lists, or contributing to the per-he.org network.

Two case studies (presented at one of the focus groups) outlined how they had set up a successful education group recognised by their departments, and how this had led to enhanced visibility of PER members within and outside their own department.

Case Study: Physics Education Research at Durham – Growth, Impact, and Funding Barriers

The Establishment and Role of PhES

Dr Pippa Petts, University of Durham

I founded the Physics Education and Scholarship (PhES) group at Durham University in October 2021 to establish a dedicated research section for education-focused academics within the Department of Physics. While Durham has well-established research groups in areas such as Astronomy, Quantum Light and Matter, Condensed Matter Physics, the Centre for Advanced Instrumentation, and the Institute for Particle Physics Phenomenology, physics education research (PER) has historically received lower institutional recognition and lacks dedicated funding pathways. PhES was created to address this gap, ensuring that education research is formally embedded within the department's

strategy and contributes to broader discussions on teaching, assessment, and curriculum development.

As the department's sixth research section, PhES provides a structured research environment for education-focused academics and ensures that PER is represented alongside other physics specialisms. While traditional research areas benefit from long-standing funding streams and institutional support, PER continues to face challenges in securing sustained research funding, limiting opportunities for postgraduate and early-career researchers in the field. Since its formation, PhES has grown to include 2 Associate Professors, 6 Assistant Professors, 1 Full-Time Teaching Fellow, 2 Part-Time Teaching Fellows, and 3 Career Development Fellows (CDFs), who receive structured mentoring to support their transition into permanent academic positions.

PhES operates as a full research section within the department but with a heavier teaching load (x1.5 weighting) compared to research-focused colleagues. This reflects the balance required for education-focused academics to engage in both teaching and research.

As Head of Section, I sit on the department's senior management team, contributing to strategic decision-making at the highest level. This role ensures that PER is recognised as an integral part of the department's activities and plays a role in shaping the future direction of physics at Durham.

Mentoring and Career Development

Since its formation, PhES has actively supported the career progression of education-focused academics. The introduction of Career Development Fellows (CDFs) has provided structured mentoring, helping early-career staff gain experience in both teaching and scholarship to strengthen their applications for permanent academic positions.

Durham introduced the Education Track promotion pathway in 2018, providing a dedicated career progression route for academics specialising in teaching and learning. PhES has since seen multiple members successfully promoted through this pathway, reflecting both the strength of mentoring within the group and the growing recognition of education-focused roles within the department.

Research Strengths and Impact

PhES is engaged in a wide range of evidence-based, discipline-specific education research. For example, one of our largest projects involves developing interactive optical tables and augmented reality (AR) and virtual reality (VR) teaching materials using Microsoft Hololens and Meta Oculus. This work has expanded in scope and is now being developed as a Research Excellence Framework (REF) impact case, demonstrating its significance within the department and wider academic community. Other key areas include artificial intelligence in assessment, as well as scholarship and interdisciplinary research to support broader academic inquiry beyond physics pedagogy. These activities enable us to actively contribute to the wider physics education community via national and international dissemination that include hosting and/or presenting at conferences, publishing in high impact PER journals, and running a well-attended education seminar series.

PhES also supports undergraduate student engagement in research, providing opportunities for students to contribute to ongoing projects. One example is an undergraduate research project exploring physics education methodologies over the summer.

Funding Landscape and Future Challenges

One of the most significant challenges for PhES, and for PER nationally, is securing sustainable research funding. Unlike traditional physics research, which benefits from established funding routes through EPSRC and STFC, physics education research does not have a dedicated UKRI funding stream. This lack of clear funding pathways makes it challenging to secure long-term research support, particularly for postdoctoral positions and PhD studentships.

The absence of funded PhD opportunities in this area is particularly concerning, as PhES regularly receives inquiries from students who wish to pursue postgraduate study in PER but have no available funding routes. This stands in contrast to traditional physics research, where EPSRC Doctoral Training Partnerships (DTPs) and STFC studentships provide well-established mechanisms for funding early-career researchers.

Despite these challenges, PhES is actively developing external funding proposals and expanding collaborations with national and international partners to enhance its research capacity. The group remains committed to strengthening its research profile and supporting physics education as a recognised, rigorous, and impactful discipline.

Case study: Establishing a PER presence in a Physics Department

Dr Michael Fox, Imperial College London

The Physics Education group at Imperial College London has evolved from a small number of Teaching Fellows who connected with wider institutional structures to identify and effectively compete for the resources needed to hire people dedicated to conducting educational research in the discipline. One key achievement is garnering support from colleagues within the department by framing educational questions in a Physics context, which has led to peer-reviewed publications and PhD theses. One part of doing this has been to involve people from all parts of the department: academics, administrative staff, technicians, postdoctoral researchers, PhD students, postgraduate Masters, and undergraduate students, and at all levels of engagement, from attending education seminars, training sessions for graduate teaching assistants, taking part in research interviews, focus groups, and surveys, to conducting educational research themselves.

Building the presence in the department is facilitated by the group taking an active role in departmental activities. The group office is physically located on the main thoroughfare through the department, making it easy for students and colleagues to interact with the group. We hold regular seminars and journal clubs, to which anyone interested from the department is welcome to join.

The group would not be where it is today without support from the central university Education Development Unit and the Centre for Higher Education Research and Scholarship, who have provided funding for projects as well as training and a community of practitioners from across the university. This central support is somewhat a unique feature of Imperial College London, in that the university does not have traditional social science or humanities departments. Therefore, the focus of the central units is on STEM education and STEM education research. Beyond the university, the Institute of Physics framework for degree accreditation in recognising physics education research as an aspect of physics has been useful in supporting the group to justify undergraduate thesis projects related to physics education. Additionally, the wider community of Physics Education Researchers both in the UK and internationally has been essential to motivate the work being done. While we have made significant progress using internal funding, the scarcity of a national framework for external funding - and hence recognition - places PER researchers in a weaker position compared to traditional physics researchers and is something that we are keen to push to be addressed.

Recognition, career tracks and promotion

The survey aimed to understand who is involved in PER, and the nature of their contracts. The majority of respondents (63%) reported that most staff in their institution were on permanent contracts, and mostly (58%) on a Teaching Track. 36% reported most PER staff in their institution held

a traditional Teaching and Research lectureship type post. Respondents indicated that PER staff were employed across a range of grades, although only 3 reported that there were Professors. However, one noted “no professors (yet)”. Overall, the data indicates a substantial community involved in research and scholarship in physics education being undertaken by staff at a range of career stages.

For an academic in a Physics department to contribute to Physics Education Research it is essential that this work is accepted as part of that academic’s role and duties and is accepted as evidence for the promotion procedure. Recent years have seen the creation of teaching-focused roles in many institutions in the UK – although not in Ireland. Staff who wish to engage in PER research have few incentives and fewer rewards to do so if these activities are not adequately recognised as part of academic promotion. One survey respondent said:

> *“The set of questions above suggest that most staff engaged in PER research or scholarship are on teaching focused tracks. That's certainly the case for some staff, but not in my case, for example. That also brings challenges - I was explicitly told at my last review that the time I was devoting on education research had taken away from my "research output", so I found myself discouraged to engage in education research.”*

The desk-based review of information regarding academic tracks and pathways on institutional web sites revealed that there is not a uniform approach among universities when it comes to recognising the value of PER. Where the information was publicly available (34 of 57 institutions), there was a separate promotion route for academic staff on a teaching focused pathway in 23 institutions. Of the remaining 11 institutions that do not have a teaching focused pathway, only 7 indicated that PER could be part of research output. In the associated publicly available documentation, promotion is shown to be possible to full professor based on PER. The staff survey indicated that for 68% of respondents, their institutions had separate promotion routes for teaching focused staff.

Delving deeper, respondents were asked to what extent they agreed with the statement “promotion criteria in my institution match the job description for teaching focused staff”. Figure 1 shows the distribution of responses, with 64% agreeing or strongly agreeing.

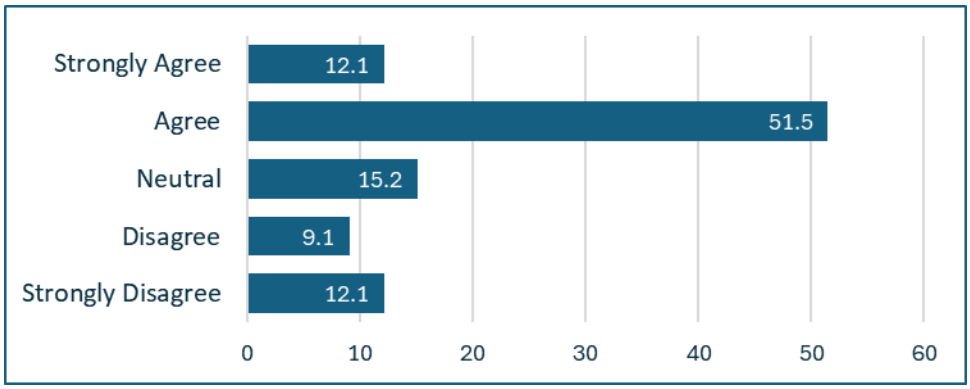

Figure 1 Survey response to statement about alignment of promotion criteria and job description.

Asked if “promotion criteria in my institution are effective for teaching focussed staff”, Figure 2 shows a broader distribution of responses, with only 46% agreeing or strongly agreeing.

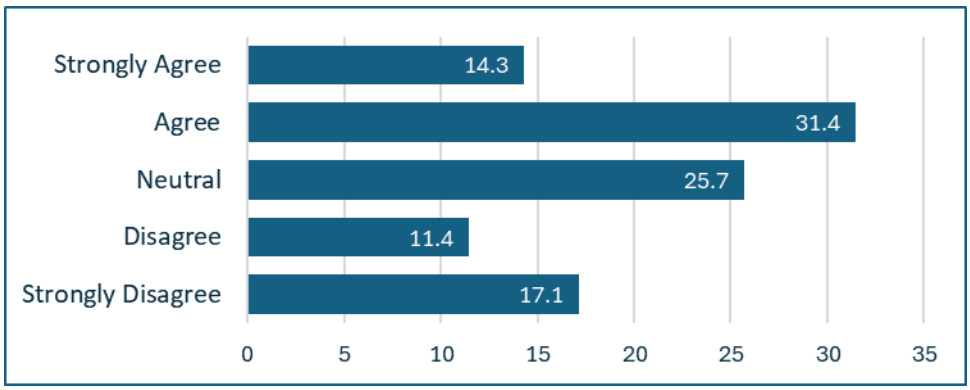

Figure 2 Survey response to statement about effectiveness of promotion criteria for teaching focussed staff

In the desk-based survey it was noticed that although several institutions advertised their recent changes to the promotion procedure as better representing the range of activities undertaken by teaching focussed staff, only 53% of survey respondents felt that recent changes in criteria had supported engagement in PER (Figure 3).

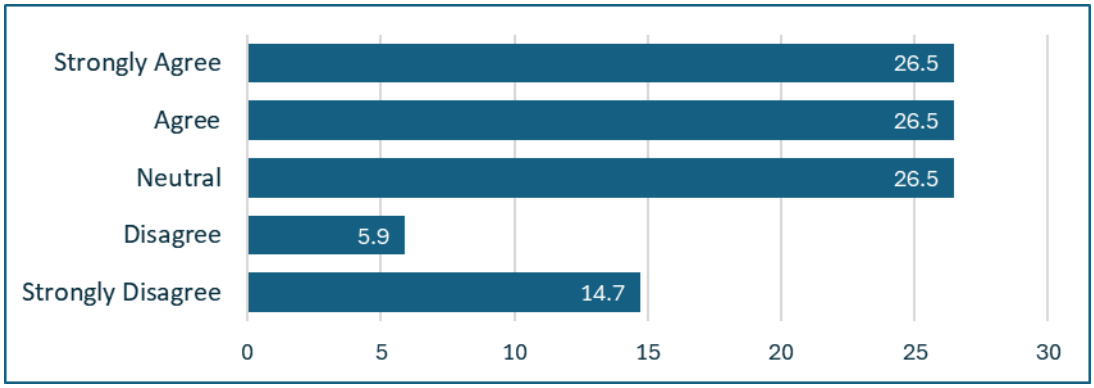

Figure 3 Survey response to statement about changes in promotion criteria better supporting engagement in PER.

The survey asked whether "teaching focussed staff are as likely to be promoted as staff on research and teaching contracts". Figure 4 shows a broad distribution of responses peaking in disagree.

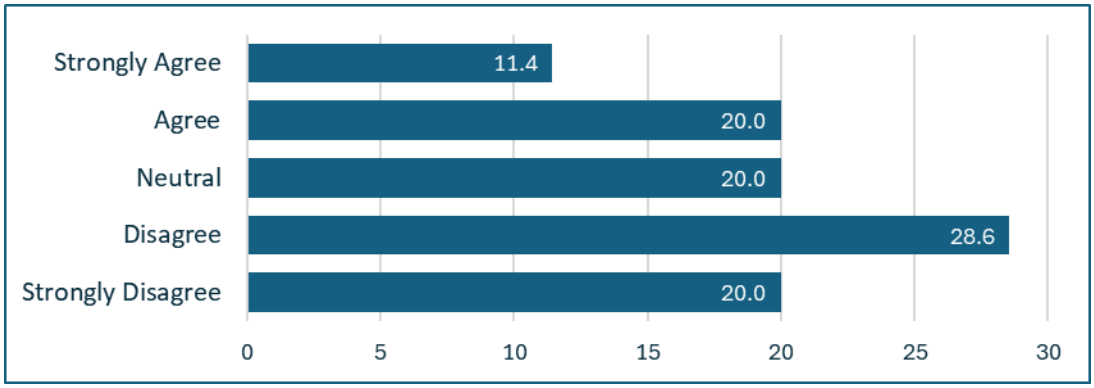

Figure 4 Survey response to statement about whether promotion was as likely for teaching focussed staff

A slightly more positive view is revealed when asked if "for staff on research and teaching contracts, engaging in physics education research/scholarship is valued by the promotions procedure" (Figure 5).

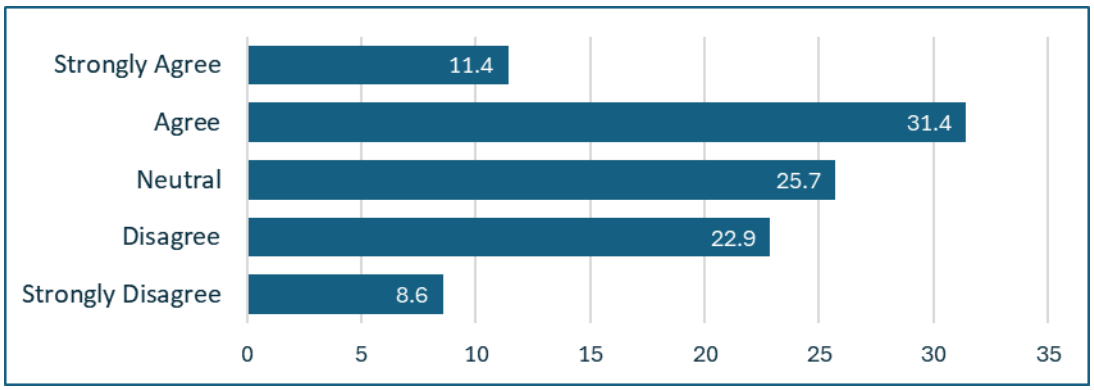

Figure 5 Survey response about the value of PER in the promotion procedure for T&R staff

One survey respondent commented:

> *"Promotion to professorial level is difficult to achieve on "teaching" contracts - criteria are clear but opportunities to meet them are scarce (not enough time to engage in scholarship work; no opportunities to fund PhD or postdocs in educational research; extremely limited external funding; ...)"*

Focus groups also identified barriers such as lack of available funding for postgraduate students. One participant acknowledged that time had been allocated to research in their department's workload allocation but that this time had simply been added to the current workload.

Survey participants were asked to what extent they agree that "engaging in physics education research/scholarship is valued by my department" (Figure 6), "…by my university" (Figure 7) and "…by my colleagues" (Figure 8). The responses suggest that PER is more valued by the institution than in the physics department.

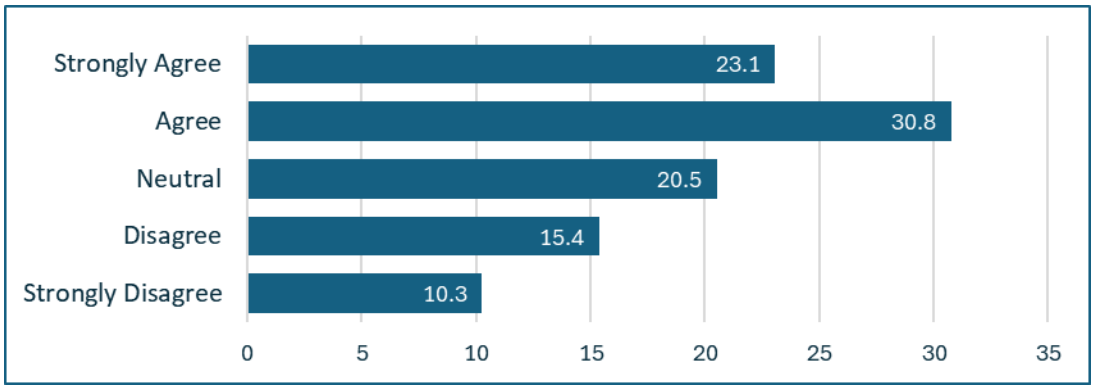

Figure 6 Survey response to "engaging in physics education research/scholarship is valued by my department"

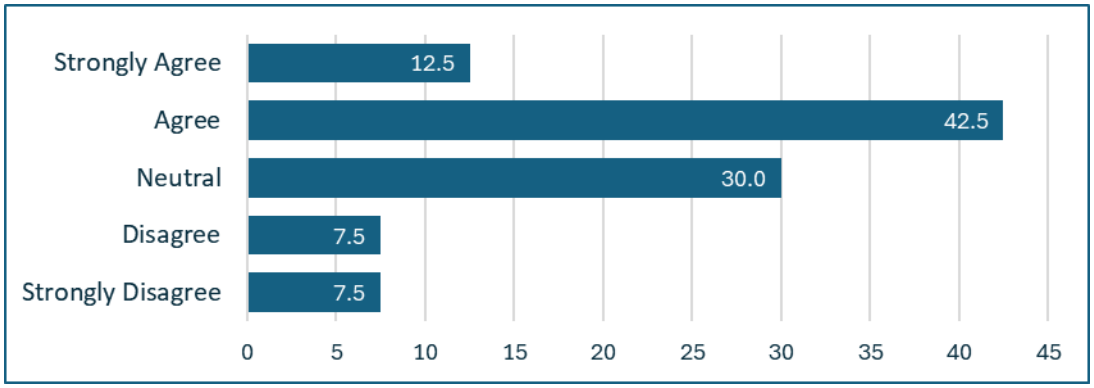

Figure 7 Survey response to "engaging in physics education research/scholarship is valued by my university"

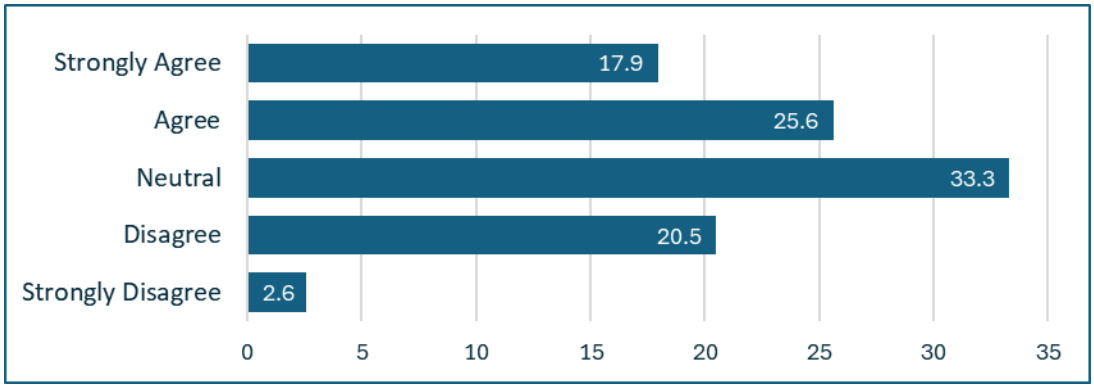

Figure 8 Survey response to "engaging in physics education research/scholarship is valued by my colleagues"

Case study: Review of an academic promotions scheme

Professor Sally Jordan, Open University

Between 2019 and 2021, I led the implementation phase of a review of the Open University's academic promotions criteria and processes. This case study considers the drivers for the review, the changes made and the wider lessons that can be learnt, concentrating on the most relevant for discipline-based education researchers and those on teaching-focused contracts.

The promotions scheme under review had only been introduced in 2015 and, coincidentally, at approximately the same time, a major University restructuring had resulted in a smaller number of larger faculties than previously; it had been agreed that final academic promotions decisions on all cases for promotion up to senior lecturer (associate professor) would be made at faculty not university level.

The promotions criteria supported four separate pathways: research and teaching; research; teaching; and knowledge exchange; with identical criteria for academic leadership forming an integral part of each pathway. Unusually in UK higher education, there was (and remains) no link between an individual's job role and the pathway they choose to use in making a promotion case. I see this feature as an enabler, supporting individuality in career development. Decisions on who is and who isn't included in the REF are made in a different way.

The major driver for the review was a desire to ensure that the scheme was as equitable as possible. Despite the introduction of a "teaching" profile in 2015, staff tutors (the group of academic staff who line-manage our associate lecturers and are closest to the student experience) were less likely than our so-called central academics to be promoted to senior lecturer in some faculties. More generally, staff working part-time were less likely to be promoted than others, and women were less likely than men to be promoted to professor.

It rapidly became apparent that the cause of the disparities was not primarily the promotions criteria themselves, but rather a lack of understanding of the criteria in some quarters, and issues with the academic promotions processes in some faculties. For example, there was a mistaken belief that the requirement on the teaching profile for work to have "impact" was referring to impact in the REF sense of the word, while the requirement that scholarly work should be disseminated outside the candidate's immediate working environment was correlated with high-quality publication, again in the REF sense of the word. These issues were tackled by some small changes in wording (e.g. "influence" replacing "impact") and the introduction of a set of illustrative examples.

A set of "common standards" was introduced to bring greater uniformity of practice across the faculties. This covers membership of promotions groups (with a requirement for membership of promotions committees to reflect the diversity of the academic population, including representation from those promoted on a variety of profiles), required training, guidance on the use and handling of individual circumstances evidence, and the use of personal cases. Candidates with unusual careers can make use of "alternative criteria", allowing criteria from different profiles to be combined, and each case is accompanied by a statement from the candidate's line manager to explain the context in which they work.

Following the revisions, there have been more staff tutor promotions at all levels and better use of individual circumstances, accompanying statements and alternative criteria. There is however more to do. Having been appointed to lead a time-limited piece of work, I effectively remained academic lead for promotions until 2024 when, following recognition that there is an ongoing need for someone in this role, a new academic lead was appointed, who was – at last – able to set up a group to share good practice across faculties. The OU promotions process still relies on written cases. This means that consideration of cases can be less biased in that it relies on what is written rather than knowledge of what a candidate has done, but the approach favours those who write well; alternative mechanisms are something to be considered in the future.

So, what are the wider implications of this piece of work? Firstly, there is a need to take extreme care with language: the word "impact" in the teaching criteria was never intended to be used in the REF sense. That promotions committees had this misunderstanding reflects their previous lack of diversity; if they don't have experience of teaching-focused careers, they are less likely to understand cases brought on the teaching profile. Bias can lead to more bias. Finally, it should be noted that misunderstanding from anyone advising their colleagues, formally and informally, and misunderstandings of candidates and potential candidates themselves can lead to barriers to promotion; thus, widespread information sharing and "myth busting" is important, at the OU and at all universities.

Funding

The lack of sustainable funding in all aspects of physics education research activities is a major issue. Such funding would enable considerable progress for PER to influence practice and policy. In the survey only 57% indicated that staff could access funding to attend education conferences. This leaves many staff unable to engage with the PER community. The survey and focus groups reported that in some cases funding was available through their own institution and indeed this was the main source of funding reported (Figure 9). Other sources of funding named were the Science Foundation

Ireland (SFI) and Irish Research Council (IRC), HEFCE Catalyst and OfS Challenge Fund and Welsh Government. Physics Education Research in the UK appears to fall into a gap between the remits of the major research councils: STFC and EPSRC, which fund scientific research, and ESRC, which funds educational research. Neither council seems to support the intersection of science and education.

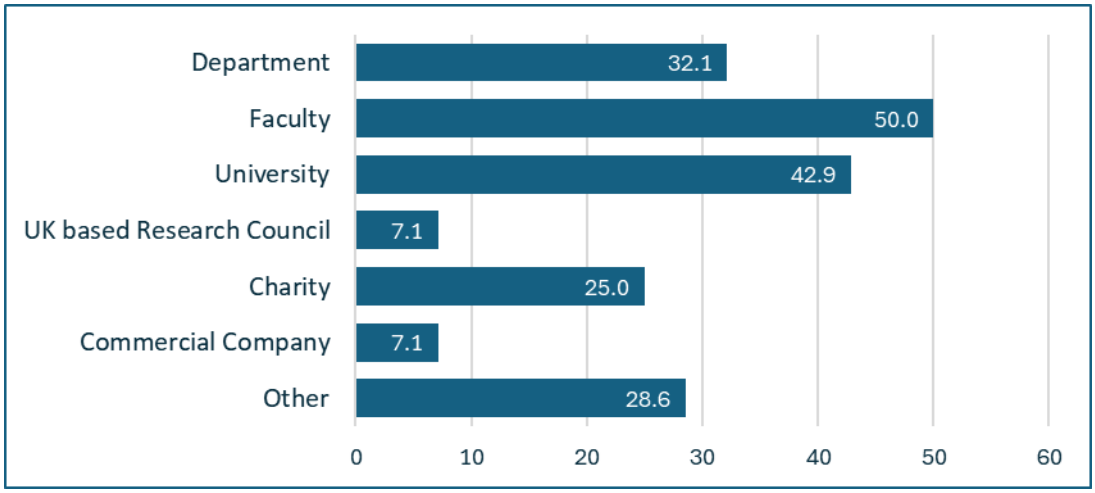

Figure 9 Survey response showing sources of successful funding for PER

71% of survey respondents reported they had opportunities to supervise education projects with undergraduates or PGT students (Figure 10). But only 38% reported the opportunity to supervise PhD students (Figure 11). However, the level of available funding is not usually sufficient to hire PhD students. For example, a respondent said:

> *"In principle staff can supervise PGR education projects, but there is no funding and few high-quality candidates".*

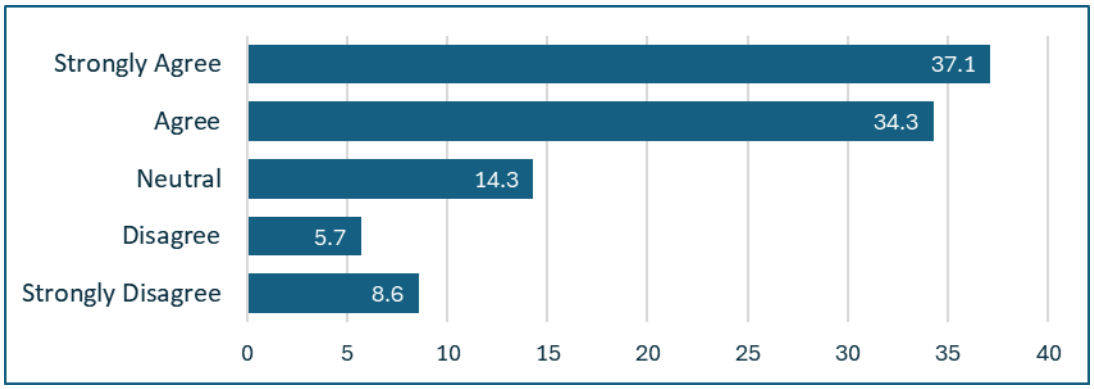

Figure 10 Survey response to "staff have opportunities to supervise UG and/or PGT educational projects"

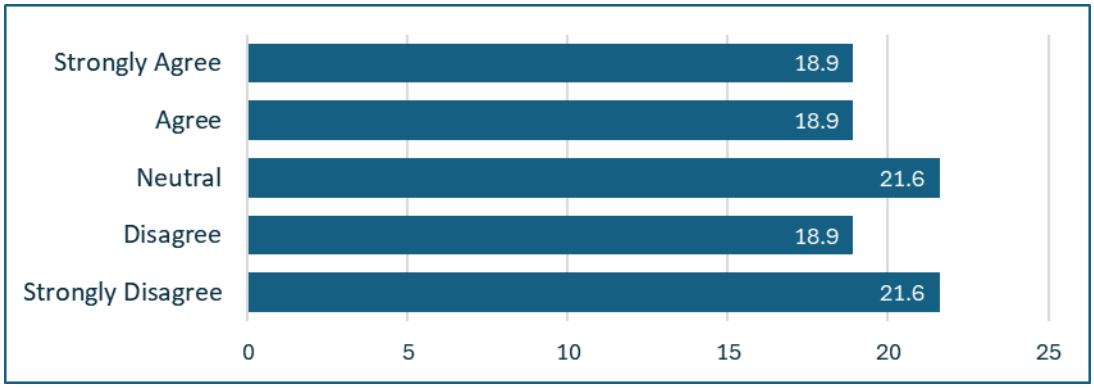

Figure 11 Survey response to "staff have opportunities to supervise PGR (e.g. PhD) educational projects"

An additional issue raised in focus groups was the cost of publishing – and the lack of funding to cover for this.

The focus group discussions highlighted that connecting to one's own institution's priorities around education can be a good way to get funding locally. Mobility grants can be a useful avenue to encourage contact with international researchers at relatively small costs.

Time is allocated by some Physics departments for teaching focused staff to work on the scholarship of teaching and learning. This represents a substantial investment in PER in principle but focus groups identified that this time is squeezed out by other responsibilities and by the lack of concentrated research time.

The survey responses and focus groups discussions made clear that, despite the differences in research management and organisation, the frustration regarding the lack of funding is felt as much in the UK as in Ireland.

Case study – Experiences of funding Physics Education Research in Ireland

Dr Eilish McLoughlin, Dublin City University

Over the past twelve years, I have successfully been awarded funding (over €1.5M across 14 awards) under SFI Discover Programme (Science Foundation Ireland). I have led multiple Physics/STEM education projects across formal, informal and non-formal contexts targeting STEM teachers of early childhood/primary/secondary level students, Youthreach Alternative Education educators, and the general public. The aim of the SFI Discover programme is to "empower and inspire deep public engagement, and the programme is a key part of SFI's Education and Public Engagement (EPE) activities". While SFI Discover funding has enabled me to run activities and events to support Physics/STEM Education learners and teachers, it frustratingly does not permit funding to be used to support "direct research costs, as research activity falls outside the scope of the SFI Discover Programme Call". While national funding opportunities for PhD and postdoctoral researchers exists through IRC (Irish Research Council) scholarships, these are extremely competitive and over the past decade only two PhDs scholarships in Physics education research have been awarded.

Over the past fifteen years, I have successfully been awarded funding, as coordinator and collaborator, (over €17.5M across 10 projects) from EU Framework, Erasmus+ and Interreg programmes (ESTABLISH, SAILS, INSTEM, OSOS, ENERGE, ATS STEM, 3DIPhE, RISE, STAMPEd, STEM Digitalis). These projects focussed on the development and implementation of Physics/STEM teacher education programmes, and innovative curriculum design using research-led approaches. Funding from these projects has been used to support 10 PhD and 1 MSc students in Physics/STEM

Education. It has been challenging to design coherent Physics/STEM education research studies that strongly align with the objectives of these competitively funded and large-scale projects.

Funding bodies in several countries provide a range of funding opportunities to support research in Physics/STEM education across formal, informal and non-formal contexts. E.g. the US National Science Foundation (NSF) allocates a significant proportion of its funding in link with its Strategic Objective "Unleash STEM talent for America" [1]. Nature Physics published an overview of the current state of physics education research (PER) in March 2024 to highlight both the importance of PER and their interest in publishing primary research in this field [2]. They emphasized the role of PER towards addressing important societal issues and challenges e.g. tackling outdated Physics curricula and education systems, creating more equitable and inclusive learning environments, and diversifying graduates' skillsets. However, the lack of a dedicated funding programme for PER in Ireland makes it very difficult to plan and conduct research to address these issues that dramatically affect physics learners and teachers, individuals and communities, and ultimately negatively impact on the Irish economy and society.

References

[1] U.S. National Science Foundation, 2022-2026 Strategic Plan

[2] Unlock the potential of a physics education. Nat. Phys. 20, 335 (2024).

Networks

Focus groups were asked to consider the actions that could be taken to improve PER in the UK and Ireland. The building of networks, within the PER community and beyond was felt to be key to developing a vibrant community. UK networks mentioned included IoP Higher Education Group (IoP HEG), Variety in Chemistry Education/Physics Higher Education Conference (VICEPHEC), JISC PER mailing list, LTHE-Physics, WRIPA and SEPNET, and the Association for Science Education (ASE). The UK and Ireland community can learn from the international community where PER is more embedded. European networks mentioned included the International Research Group on Physics Teaching (GIREP) and the European Science Education Research Association (ESERA). US networks mentioned included the American Association of Physics Teachers (AAPT), American Physical Society (APS) and the Physics Education Research Conference (PERC). There are of course many other national networks across the globe that UK and Ireland-based researchers engage with, building on personal professional links.

Case Study: Ongoing lessons from developing a national network: The Research Evaluation and Innovation in STEM Education (REISE) Network

Dr Helen Cramman, Durham University, Chair of the REISE Network

REISE (Research, Evaluation and Innovation in STEM Education) is a network of networks. It seeks to connect Discipline Based Education Research (DBER) colleagues across the UK to raise the profile of the fantastic work going on in this field in the UK by demonstrating the scale and excellence of the research that is already taking place, facilitating interdisciplinary collaborations, providing opportunities for sharing learning, enhancing access to professional development opportunities and vitally, to campaign for access to funding to enable the UK to compete as a leading nation in DBER.

REISE is for anyone who would like to be part of an interdisciplinary community and who has (or is developing) an:

- expert knowledge of their STEM discipline,

- understanding of the challenges of learning and teaching in their discipline,
- understanding of the science of learning and teaching,

and would like to undertake high-quality STEM education research and scholarship.

High quality DBER is vital for the advancement of STEM education. The benefits are clear within the definition of DBER proposed by Singer et al. (2012), who stated that DBER seeks to:

- understand how people learn the concepts, practices, and ways of thinking of science and engineering.
- understand the nature and development of expertise in a discipline.
- help identify and measure appropriate learning objectives and instructional approaches that advance students toward those objectives.
- contribute to the knowledge base in a way that can guide the translation of DBER findings to classroom practice; and
- identify approaches to make science and engineering education broad and inclusive.

Internationally, the field of DBER is well established, with large communities having been supported by national funding over time, such as in the USA and Australia. However, in the UK, DBER is relatively unrecognised with limited access to funding or opportunities for professional development. Excellent work is going on in the field in the UK, but often in isolated pockets and without the recognition is deserves within Higher Education Institutions or from funders and professional bodies.

REISE developed in late 2022 in response to EPSRC's call for Centres for Doctoral Training (CDTs). Within a couple of months of starting to discuss ideas for a potential CDT, a community had formed of more than 150 colleagues across 26 universities the UK, who were keen to advance development pathways for DBER. Despite the scale of interest, the proposal was not selected to progress to full application. Subsequent bids for an ESRC Research Centre and AHRC innovation grant were also unsuccessful. Feedback from selection panels focussed on a lack of understanding of the scale, depth and breadth of expertise within the DBER community in the UK. Additional challenges that REISE faced included falling between silos of funding remits within UKRI and having large numbers of members wishing to participate who were geographically widely spread in small pockets within universities across the UK, which was not the traditional arrangement for the funding being sought.

To address the barrier presented by the feedback from the funding panels, it was decided that it was vital that REISE first focussed on raising the profile and understanding of the scale and expertise in DBER within the UK. The REISE website is in development and a survey is about to go live gathering information from members of disciplinary STEM education research networks across the UK to understand the scale, experiences and development needs of the DBER community in the UK. We are also strengthening our connections to the individual disciplinary networks across the UK. Our plan is not to replace these fantastic communities, but to increase their visibility and to hopefully make the most of the limited resources available, by sharing learning and access to training where possible. We also want to share the stories of the excellent research that is already taking place and to help it grow through facilitating interdisciplinary collaborations.

We hope that through these small steps, we can overcome the barriers that we have faced so far in trying to get the recognition that is deserved for DBER in the UK and to enable a step change for it to be resourced and funded for excellence. If we are to effectively tackle global challenges and meet the UK government’s ambition of being a world-leading science sector, we need world-leading STEM education, which we believe can only be achieved through investment in world-leading Discipline Based Education Research.

References

Singer, S.R., Nielsen, N.R. and Schweingruber, H.A., 2012. Discipline-based education research. Washington, DC: The National Academies.

Case study: International Cooperation in Physics Education Research - The HOPE project and links with the earlier EUPEN Network

Emeritus Professor Gareth Jones – Imperial College London

The HOPE (Horizons of Physics Education) project involved about 100 academic staff from 55 physics departments of universities in Europe (not just the EU) along with the IoP, the Italian Physics Society, CERN and the European Physics Society. It started in 2014 and formally ended in 2018 although analysis continued for several more years. Most costs were met by The European Commission in its Socrates Programme. The participating institutions from the UK and Ireland were the physics departments of Imperial College London, the University of Manchester, the University of Strathclyde and Dublin City University. The project was a successor to a series of smaller projects carried out by the EUPEN Network (European Universities Physics Education Network, led by the University of Ghent) which provided information on comparison of curricula, teaching/learning methods and assessment methods in Europe. These greatly helped the ERASMUS student exchange programme. Several of the key academics involved in HOPE had previous experience of the design and delivery of physics degree programmes and of physics educational investigations and research. A few physics students also took part including some from the European Association of Physics Students.

HOPE went much beyond the needs of student exchange programmes and the specific aims were pursued by four Working Groups: (a) WG1: to examine the reasons why students chose to study physics and so to help the synergy between what students are looking forward to and the content and structure of physics UG degree courses, (b) WG2: to consider how their degree course can better prepare students to contribute to the growth of the European economy, (c) WG3: how physics degree courses can be modified to respond to new global challenges, and (d) WG4: how more well-trained physics teachers can be produced. WG1 was perhaps the most useful in terms of its outcomes. Reports were produced and a few papers were published in PER journals. Several specific recommendations were made for physics departments.

WG1 involved a questionnaire which was filled in by 1st Year physics students at most of the participating universities – a total of about 2500 students. This questionnaire went through 5 drafts and 2 trials. The delivery mechanism ensured a very high response rate (about 70%) so that sampling errors were small. It also enabled various modes of analysis including correlation studies and more sophisticated statistical methods. It also contained some “free comment” questions and was linked to sample interviews of students. One of the most important conclusions was that throughout Europe the main reason why students have chosen to study physics is because they want to acquire a deep understanding of fundamental physics and how it explains the universe. Other clear reasons were a wish to learn advanced concepts such as quantum mechanics and to learn how physics explains the world around us. Correlations with “age of 1st interest in physics” were particularly interesting. It was also clear that most students like maths for its own sake as well as for its use in physics. These findings are of particular importance for the design of the 1st Year of Physics degree courses.

Some points should be made about the way of collaborative working. Most work took place in workshops at partner universities which involved talks from invited experts and enabled useful discussions in groups of about 20 to 30 people followed by reports. These discussions and exchange of views were very fruitful and were essential to understanding the ways of thinking and resulted in creative thinking. They also resulted in personal friendships which have lasted. The whole process

was a good example of the major advantages of a network for considering external views and the disadvantages of just thinking of one own's university.

It would be possible, although difficult in present conditions, to establish similar international networks. EUPEN and HOPE were possible mainly because they met a need of the "Bologna Process" initiated by Ministers of Education of EU Member States and strongly supported by the European Commission. The possibilities for such funding mechanisms are now quite limited especially for the UK. So other funding sources would be needed to cover the costs of meetings and administrative costs. Also, the balance between competition and cooperation between universities in higher education might be a problem. Specific aims would need to be agreed. A network project within GIREP but with institutional support is one possibility.

Case study: The Physics-LTHE Network

Dr Helen Vaughan, University of Strathclyde

When the COVID-19 pandemic hit in Spring 2020, physics educators in higher education were desperately searching for advice and information about how they could teach and support students remotely. And thus, the Physics-LTHE network was born. Inspired by the chemistry network DryLabs, I proposed and subsequently coordinated this regular virtual space for the whole community of teachers of physics in higher education, welcoming all those involved in delivering or supporting teaching physics to come together online to share ideas and support each other in those uncertain times. With some meetings drawing over 200 participants, the need for information and moral support was evident.

This surfaced the great need for PER, to provide knowledge and understanding of how students learn the key aspects of physics. With the requirement for sophisticated mathematics, the need to be able to draw diagrams, and to undertake experimental investigation, the learning outcomes of a physics degree require carefully planned student engagement in normal times, and so much more when teaching remotely.

The series of 12 meetings (from May 2020 to March 2021) allowed many ideas to be showcased and discussed, surfacing good practice and evidence, to help the community find methods that they could use with remote teaching. This created a rich source of new ideas and methods to be further researched and evidenced. The world has changed in recent years, we now have new technology and an expectation to accommodate flexibility of learning styles. These Physics-LTHE meetings brought the physics teaching community together, and showed the appetite for PER, both in terms of finding answers to the challenges of teaching physics, but also to engage in PER themselves. Beyond the impact of a world pandemic there are many other grand challenges in teaching physics, and the higher education physics community will benefit from working together on these.

The series of meetings comprised a range of topics demonstrating the wide impact this series of meetings had on our community: Laboratory work; Assessment for learning; PGR supervision in the Covid-19 crisis; Inclusion; Taking teaching online; Group work; Communities; PGRs who teach; Sharing lab plans; Experiences of delivering semester 1 remotely; and Transition to year 1 in 2021.

Interfaces with other communities

PER significantly benefits from interfacing with other educational communities, such as those in mathematics, chemistry, computing science, engineering, and cognitive science. These

interdisciplinary connections foster an integrated understanding of how students learn complex concepts across different domains. For instance, insights from cognitive science can inform physics educators about the cognitive processes involved in learning and problem-solving, leading to the development of more effective teaching strategies. Similarly, collaboration with mathematics education researchers can help in aligning the mathematical rigor required in physics courses with pedagogical approaches that enhance student comprehension and retention. Integrating these diverse perspectives and methodologies enables the PER and cognate communities to address common educational challenges, such as student misconceptions and engagement, more comprehensively.

That said, the PER community could gain even more from stronger ties with these other educational communities. Enhanced collaboration can lead to the co-creation of interdisciplinary curricula that better prepare students for the multifaceted nature of modern scientific and engineering problems. Joint educational research initiatives and cross-disciplinary workshops will facilitate the exchange of innovative teaching practices and assessment techniques. Academic institutions could establish interdisciplinary research centres focused on STEM education and promote joint appointments for academic staff across different departments. Additionally, organising regular interdisciplinary conferences and seminars can provide platforms for ongoing dialogue and partnership. A good example of this is ViCEPHEC, the annual Variety in Chemistry Education / Physics Higher Education Conference organised as a joint event between the Chemistry and Physics higher education communities, which sees numerous talks on common themes offering ways to identify good practice and adaptable solutions to common challenges.

Another interface that could be explored more is that with high-school physics teachers. The relevance of this approach was demonstrated during the final Physics LTHE Meeting held in March 2021 which asked how we can work with school teachers to better understand the needs of students transitioning to university. The meeting discussed the challenges of supporting pupils going to study physics at university during lockdown. Several key points were identified that are still relevant and can be taken forward. School teachers and HE staff can work together to better understand the challenges faced by students transitioning to university, especially – but not only – those who experienced significant disruptions during their school years. Both communities can collaborate to create supportive environments that help students feel integrated and involved in their new learning communities. It was highlighted that understanding the differences in examination formats and expectations can help prepare students for university assessments.

Recent notable developments in collaborative efforts between school and university PER communities can be seen at various levels. For instance in Scotland, where these efforts are supported by the IoP Scotland and IoP HEG Committees, and across the UK, with the organization of a PER Symposium in 2024 at the IoP. Regular meetings and discussions can facilitate the exchange of best practices and innovative teaching methods. Both communities can learn from each other's experiences to improve educational outcomes.

Early career development and training

To develop a vibrant PER community in the UK and Ireland requires the development of a research culture supported by funding and development opportunities for those engaged in PER.

One comment raised the issue of what happens after a PhD in PER, echoing a sentiment expressed in the focus groups:

> *"For our current PhD students, it would be lovely to have a pipeline (including PDRA positions) for those committed to work in this area from an early stage. At present, I think many PER researchers have arrived in the discipline later in their careers."*

Focus groups identified the need for opportunities for training in educational research methods for those who want to get involved in PER. Some universities offer free Masters in Education but not all can do these. Opportunities for training in educational research methods would not only strengthen the legitimacy and quality of the research being carried out but also would provide confidence in less familiar methods – i.e. increase the level/community of qualitative PER research.

Case study – A Student-led Support Network

Astra Sword (Open University)

In Spring of 2021, I joined a group of other PhD students in the South-East Physics Network (SEPnet) to form IPPSnet, an *intersectional peer support network* for physics PhD students. Spurred on by the increasing awareness of equality, diversity, and inclusion (EDI) issues in physics in 2020, we began the network with the best of intentions, aiming to provide support for marginalized students across institutional boundaries. Our early activities were moderately successful, with high engagement at the initial meeting to set out the network's aims, good attendance at virtual "coffee breaks," and a well-attended virtual tour of the ATLAS detector. However, over the first-year engagement dropped off and we struggled to reach beyond the initial group that had shown interest. We identified three underlying problems with our approach:

• Time: PhD work needed to come first, and there was a difficulty matching up schedules.

• "Activation Energy": Delivering peer support is difficult for students already under pressure.

• Identity: Many students in our target audience considered themselves "not disadvantaged enough to join."

In Autumn of 2021, IPPSnet put in a successful bid for funding to run one of SEPnet's in-person student-led conference events. Considering the problems we faced, we designed *Open Dialogues across Physics and Astronomy* to address them, aiming to deliver:

• Tangible PhD benefits: By giving all students the opportunity to present their work, receive feedback, and discuss it with established academics.

• A Low Barrier to Engagement: By streamlining the application process and making pre-emptive accommodations to make applying for and attending the event as straightforward as possible.

• EDI-by-design without being about EDI: By focusing our messaging on being open to all physics and astronomy PhD students and cultivating an environment where participants could bring their "whole selves" to the conference.

The conference ran successfully over two days in September of 2022 at Southampton University, with 17 graduate students attending and 8 invited academics. We received overwhelmingly positive written feedback from every attendee.

Students from the first Open Dialogues conference went on to run a successful second Open Dialogues conference in 2023 with support from the original organising committee. Unfortunately, it has not been possible to obtain funding to run follow-up conferences for 2024 or 2025. Despite this, running Open Dialogues was an extremely encouraging experience. The aspect that has stuck with me most is how many of the attendees commented on how important the welcoming atmosphere was to them. I hope to revive the conference format through an alternative funding source after I complete my PhD, but regardless of whether Open Dialogues runs again I hope the lessons learned can benefit the wider physics and astronomy community.

Acknowledgements Particular thanks to other members of the IPPSnet and Open Dialogues organizing committees Laura Blackburn, Daisy Shearer, and Daniela Koeck; SEPnet's graduate network director Cristobel Soares; Marta Podgorny who led the second Open Dialogues; and all the PhD student and invited academic attendees for both conferences.

Research themes, international relevance and reputation

The research focus of Physics Education has a wide remit. Some aspects are subject based, for example, to develop conceptual understanding and visualisation of quantum physics. Others are around the use of mathematics and computer coding in the application and analysis of data in Physics, whilst others focus on the wider skills required for accreditation of physics degrees, namely experimental investigation, communication, collaboration, critical analysis, and problem solving. Newer areas of research focus on aspects like artificial intelligence, virtual reality and sustainability, and how to embed these in the curriculum, and yet others investigate ways to dispel stereotyping to support the diverse cohorts within physics, including minorities such as females, ethnic minorities and neurodivergent students. Methods of teaching and effective learning strategies are also widely researched to enhance engagement and understanding of our cognitively complex discipline.

A Vision for the future of PER

The findings from the desk-based research, survey, and focus-group discussions, enable us to draw a picture of the status of Physics Higher Education Research in the UK and Ireland. This project gives us incredibly positive and encouraging evidence that PER is an active and growing area of activity, with a lively community of individuals connected by a common desire to use evidence-based approaches in physics higher education. The increasing PER presence in an increasing number of institutions is likely due to a stronger acknowledgement at institutional level of the importance of discipline-based scholarship activities to enhance the student experience, which may have led to encouragements for further departmental commitment via e.g. institution-led subject reviews. However, two very important events further supported this change: the covid-19 pandemic which highlighted the urgency and relevance of sharing practice between colleagues based in very different departments, and the new degree accreditation framework of the IoP which is still driving significant evolution in the way physics departments design their degree programmes and articulate this to their students. In every aspect, engaging with PER remains the best possible strategy for teaching teams to deliver the required changes.

We are therefore at a crucial point as our community needs to build on this momentum to continue to successfully support the delivery of high-quality teaching and learning of physics. The value of PER has been demonstrated as explained above, but that does not mean that our job is done. We must continue and increase our commitment to disseminate our excellent research and to evidence our influence to obtain an adequate share of support from departments, institutions, and above all, funding bodies that support research in physics and other related disciplines. We have a role to play and a responsibility to teach and train the next generation of physicists who will take highly skilled employment, contribute to society, tackle global challenges, and educate the next generations. In the next section we make several recommendations to pave the way for this vision.

Recommendations

For the PER community

The PER community across UK and Ireland is diverse and reflects the specific challenges facing physics higher education in local contexts. By working together and sharing knowledge, the community will become stronger and will make its voice heard. Working together will also help to bring coherence and relevance across the different education systems.

We have recently taken a first step to facilitate the sharing of information by creating the **per-he website** (https://per-he.org/). This website is a direct outcome of the focus group discussions held in the context of this project. It enables the community to share information more visibly and effectively. Anyone can contribute news items, which are displayed on the website and circulated by email to subscribers. This initiative also brings in "PER nuggets". These are brief articles used to share ideas, questions, recent findings, good practice, meeting summaries, and any other food for thought, on anything relevant to physics (and cognate disciplines) in higher education. Anyone can contribute to writing a nugget, and over time we anticipate that this will constitute a useful archive of interesting initiatives and ideas for the community. Contributors can also use this to evidence dissemination and collegiality for professional development.

The website also provides a list of mentors offering to share their expertise in specific areas, and features a list of institutions with known PER activity. We welcome all institutions with any PER activity (however large or small) to be part of this. Finally, the site hosts the "Getting started in PER" resources that had been developed by the IoP HEG Committee as part of a previous project: these pages are designed to help PER colleagues formulate research questions and understand the different theoretical approaches and methodologies commonly used in educational research. They also contain a guide to publications in PER (and STEM Educational Research more generally).

Recommendation 1: We strongly encourage the PER community to take any opportunity, via the per-he website or otherwise (e.g. by submitting articles to Physics World or The Conversation) to enhance sharing of information and initiatives relevant to PER.

1.1 Evidence excellence in the PER work being carried out across our nations and further afield.

1.2 Share best practice and solutions to highlight, maintain, support and develop the research work in progress.

1.3 Use social media to share data, find new contacts, and stay connected with existing ones.

Recommendation 2: The PER community should work together to better evidence the impact of research and practice on others.

2.1 Engage with the IoP and with its Higher Education Group events.

2.2 Network at conferences and via other means, which will naturally lead to identifying colleagues with shared interests.

2.3 Organise PER seminars, leaving time for speakers to discuss with the audience. Inviting PER speakers from other institutions benefits both hosts and speakers alike, and is an excellent way to collectively raise the profile of PER.

2.4 Develop collaborations with other PER research groups and/or other fields such as social sciences, psychology and science education (e.g. by taking part in webinars, events and conferences).

2.5 Facilitate more collaboration on big issues such as decolonising, awarding gaps, inclusivity, Generative AI, by increased engagement with existing networks.

2.6 Design and establish a recurring event for the Physics Higher Education Research community to develop ideas for addressing grand challenges in university physics education. This could be done in partnership with the IoP and its Higher Education Group with e.g. an annual 1-day meeting enabling all to reflect on the most important objectives to tackle as a community.

Recommendation 3: The PER community should continue to support each other in career development.

3.1 Ensure that the career development needs of all teaching-focused staff are regularly explained and discussed with Heads of departments, highlighting, for example, the differences in metrics that enable promotion for staff active in PER.

3.2 Raise awareness of the challenges faced by teaching-focused PER staff and how they are perceived in physics departments, to better support physics higher education research activities.

For Heads of departments, Directors of teaching, and line managers

All staff who teach have a role to play in using evidence-based approaches in their teaching. The benefits are numerous and will directly enhance the quality of education of physics students – those who will eventually graduate with a physics degree to take highly skilled employment, contribute to society, tackle global challenges, and educate the next generations. Active engagement in PER and in scholarship of learning and teaching at departmental level also constitutes an ideal, evidence-based path towards evidencing good practice (e.g. to apply for degree accreditation to the IoP, or for submissions to internal and external reviews of teaching and learning practice) and tackling existing issues (e.g. with student satisfaction in learning and teaching areas). This should be done in a way that clearly highlights the specific needs of our discipline and the associated challenges of physics education to decision makers at higher levels in the university. That is the key strength of enabling and supporting discipline-based education research, and this gives additional weight to push back against top-down decisions affecting physics education that may not be best suited to our discipline.

Staff engaged in PER activities would benefit from more opportunities to carry out research, attend conferences, apply for funding, supervise students and postdoctoral researchers, to allow them to be successful in career progression. Departmental and institutional support is essential to realise the vision presented in this report.

Recommendation 4: Departments and institutions should actively support staff engaged in PER activities regardless of whether they are teaching-focused or on other career paths. Heads of departments, Directors of teaching, and line managers are the people who typically have responsibilities here.

4.1 Safeguard and advertise funding opportunities available for staff (teaching-focused or otherwise) to apply for to continue and strengthen engagement with PER activities.

4.2 Allocate funding to support postgraduate physics education research projects.

4.3 Actively become familiar and engage with the specific promotion criteria that enable staff undertaking PER to develop and apply for promotion. For example, it is essential that all Heads of Physics and line managers are familiar with, and fully understand, how PER-active staff are asked to demonstrate influence in the physics teaching community, locally, nationally and internationally, as appropriate to grade.

4.4 Provide opportunities for, or support staff to attend, training in educational research methods for those who want to get involved in PER. Some universities offer free Masters in Education, but not all staff have the opportunity to do these. For example, a week of training, or training days interspersed through the year, would upskill staff in qualitative and quantitative PER research. This would then not only strengthen the legitimacy and quality of the research being carried out but also would increase confidence in research methods that are less familiar to physicists – although essential in discipline-based education research.

4.5 Use available fora from professional bodies (e.g. via the IoP's Heads of Physics forum) to share outstanding work being done in learning and teaching in their own departments, but also share concerns, challenges, and possible solutions to common issues such as funding, workload allocation, mentoring, or promotion.

4.6 Support the formation of a PER group if there isn't already one in the department and ensure representation from that group at strategic levels in the department in the same way that other research groups are able to shape strategy.

4.7 Promote impactful work and ensure PER work is clearly present and highlighted on internal- and external-facing dissemination activities (including departmental web pages).

For research councils and funding bodies

We can learn a great deal about how a successful PER landscape might look like by observing what works elsewhere. In this regard, an obvious example comes from the USA. Over the years, the NSF has made possible a huge amount of excellent research in physics higher education and supported teams from early-stage researchers to high profile researchers (including Nobel Prize winners). Some of the most notable results have been published in high impact journals, including journals covering multiple research fields such as Nature Physics.

This is in stark contrast with the situation in UK and Ireland. Sustained support for PER is crucially lacking in physics departments, with no funding for physicists to conduct education research projects and disseminate findings, to support postgraduate research students, or to hire postdoctoral researchers. While the laws of physics are universal, learning and teaching physics is critically dependent on context: educational systems, societal expectations, and demographics all shape how we teach physics at university, and how our students learn. It is possible to build on PER findings from other regions of the world, but to expand on those and progress in our objective of enabling the best possible physics education in our universities, it is crucial that physics education research projects are supported in UK and Ireland.

All research councils and funding bodies which include physics research in their remit have a strong role to play in funding physics education research. In the UK, EPSRC and STFC are best placed to step up to that role. In Ireland, this responsibility belongs to IRC and SFI. It is important to note that at this stage, the funding required is not high, as there are no demands for expensive facilities or equipment.

Recommendation 5: The absolute priority strongly expressed in our community survey and across the discussion groups that were held for this project is to secure funding to strengthen research activity and disseminate findings. Thus, we recommend that research councils and funding bodies:

5. 1 Enable sustainable funding and develop spending to support discipline-based education research. The funding would be used to take part in conferences, fund PhD projects, and recruit postdoctoral researchers to undertake high-quality, impactful research.

Conclusions

The methodology employed in this project involved a desk-based review, an anonymous staff survey, and two focus groups. These provided a robust framework for gathering insights into the current state of PER, the challenges faced by educators, and the opportunities for growth and development within the PER community in the UK and Ireland.

Our findings revealed a vibrant and active PER community, albeit one that faces significant challenges in terms of visibility, recognition, and sustainable funding mechanisms. The survey and focus group discussions highlighted the need for better career progression opportunities and support. This project has identified the establishment of dedicated PER groups within departments and the promotion of collaborations as key strategies for enhancing the impact and reach of PER. These strategies must be fully supported financially and professionally by the sector.

Looking ahead, a vision for the future of PER involves building on the momentum gained in recent years and leveraging the new IoP degree accreditation framework to drive further advancements in

physics higher education. It is imperative that the PER community continues to advocate for the importance of evidence-based teaching practices in partnership with the IoP, and that it is fully supported by Heads of departments and by all relevant funding bodies (EPSRC and STFC in particular) to secure the necessary resources to support ongoing research and development. A collaborative and supportive environment is key to ensure that PER remains a cornerstone of high-quality physics education in universities, ultimately benefiting students, teaching staff, the reputation of our institutions, and the broader scientific community.

In conclusion, this report has highlighted the importance of Physics Education Research (PER) in the UK and Ireland. The context and motivation for this study stemmed from the recognition of the growing need for a structured and well-supported PER community. The Covid-19 pandemic, and the current transformation brought by Generative Artificial Intelligence, have underscored the necessity for innovative teaching methods and the rapid adaptation of educational practices, which further emphasize the value of PER in enhancing the quality of physics education. Within a fast-moving teaching landscape, it is crucial that all stakeholders – the PER community, physics departments, institutions and funding bodies - work together to deliver university physics education of the highest possible quality, based on research-informed evidence. In doing so, we will go beyond improving on the metrics that drive so many decisions that affect teaching and learning physics at university: we will be in a much better position to educate good citizens with the knowledge and skills that they need to make the world a better place, and in turn educate our grandchildren and their descendants.

Acknowledgements

The authors gratefully acknowledge the financial support of the Institute of Physics towards the realisation of this project. They express their heartfelt thanks to all who participated in the survey and focus group discussions, as well as to the authors of the case studies presented in this report.

This investigation has been conducted with full ethical approval through the University of Leeds (reference LTPHAS-002).

About the authors

Nicolas Labrosse is Senior Lecturer in Physics and Astronomy at the University of Glasgow. His educational research focuses on assessment in physics and quantitative disciplines, inclusivity, student transitions, and belonging. He co-founded and co-chairs Glasgow's Astronomy and Physics Education research group. He chaired the IoP Higher Education Group committee between 2017 and 2021 and then served another term as Ordinary Member on the committee. He created and maintains the per-he website.

Alison Voice is a Professor of Physics Education and head of the Physics Education Research Group in the School of Physics & Astronomy at the University of Leeds, a group that she founded in 2016. She is a National Teaching Fellow and Senior Fellow of the Higher Education Academy (SFHEA) and has been teaching physics for many years. Her specific research interests relate to enhancing students' effectiveness in engaging with and learning physics, and to supporting students in the transition to university and in preparing them for their onward journey into employment.

Helen Heath is a Professor of Physics and University Education Director (Quality) at the University of Bristol. She was secretary of the Institute of Physics Higher Education Group from 2016 – 2021. She founded the Physics Education Group in Bristol and now leads the University Academic Integrity Network. She has interests in Transition to University and also in assessment.

Glossary

DBER: Discipline-based Education Research
HEFCE: Higher Education Funding Council for England

HEG: Higher Education Group
IoP: Institute of Physics
EPSRC: Engineering and Physical Sciences Research Council
ESRC: Economic and Social Research Council
IRC: Irish Research Council
NSF: National Science Foundation
OfS: Office for Students
PER: Physics Education Research
SFI: Science Foundation Ireland
STEM: Science, Technology, Engineering, and Mathematics
STFC: Science and Technology Facilities Council
UK: United Kingdom

Appendix Survey Questions

This survey is part of a research project to investigate the status of Physics Education Research (PER) within Higher Education in the UK and Ireland. In this context PER is related to learning & teaching in Higher Education.

Questions 1 – 3 gather information on the nature of PER and visibility of PER research

1. As a starter to this survey, we would like to better understand how you view the difference between research and scholarship in Physics education. Research can be defined as contributing to new knowledge. Scholarship can be defined as the process of updating or maintaining the knowledge, skills and experience of an individual. Do you agree or do you see it differently? Please explain.
   OPEN TEXT RESPONSE.

2. According to your definition of research and scholarship, is there any Physics Education Research and/or Scholarship activity within your Physics department?

   - Yes, predominantly research
   - Yes, predominantly scholarship
   - Yes, roughly even split
   - No
   - Don't know

2a. Are the people engaged in this research / scholarship activity in your department recognised as a formal group? YES/NO/DON'T KNOW

3. Is this activity featured on a dedicated website? YES/NO/DON'T KNOW

   3a. If yes, is it linked from one of the main Physics Department pages? YES/NO

   3.a.i. And if so, is it listed under 'TEACHING' or 'RESEARCH' or 'OTHER'?

   3.b. If there isn't a web page, do you know the reason? Have there been any obstacles to obtaining one? OPEN TEXT RESPONSE

Question 4 gathers information about contracts for teaching-focussed staff

4. In your department, are staff engaged in physics education research/scholarship mainly on short-term contracts or permanent contracts?
   - Mainly short term
   - Mainly permanent
   - Evenly split
   - Don't know
   - I'm not aware of such staff in the department

4.a. Are the staff engaged in physics education research/scholarship mainly on...
   - Teaching and Research track (i.e. a standard lectureship type post)
   - Teaching track
   - Research track

4.b. What is the range of grades (e.g. from junior lecturer to professor) of staff undertaking physics education research/scholarship activities in your department? (Please do not give any names) OPEN TEXT RSPONSE

Question 5 gathers information about promotion opportunities for teaching focussed staff

5. Does your institution have a separate career/promotion route for staff who are teaching focussed? YES/NO/DON'T KNOW

5.a. If no, do the criteria recognise (enable promotion for) teaching focussed staff? YES/NO/DON'T KNOW

5.b. How far do you agree with these statements? Answer on scale:
Strongly Agree / Agree / Neutral / Disagree / Strongly Disagree / N/A

i. Promotion criteria in my institution match the job description for teaching focussed staff
ii. Promotion criteria in my institution are effective for teaching focused staff
iii. Recent revisions to promotion criteria better support engagement in physics education research/scholarship
iv. Teaching focused staff are as likely to be promoted as staff on research & teaching contracts
v. For staff on research & teaching contracts, engaging in physics education research/scholarship is valued by the promotion procedure

5.c. The following questions ask about the values and opportunities for influence in PER

i. Engaging in physics education research/scholarship is valued by my department
ii. Engaging in physics education research/scholarship is valued by my university
iii. Engaging in physics education research/scholarship is valued by my colleagues
iv. Staff can access funding to attend education conferences
v. Staff have opportunities to supervise UG and/or PGT educational projects

vi. Staff have opportunities to supervise PGR (e.g. PhD) educational projects
vii. Physics education projects in my department have influenced change in learning & teaching practice beyond my department
viii. Physics education projects outwith my department have influenced change in learning & teaching practice in my department

5.d. Please add further information or insight on the topics raised above. OPEN TEXT RESPONSE

Question 6 asks about expectations in a teaching focussed role

6. Many universities expect staff engaged in physics education research/scholarship to do the following. Tick the relevant boxes to show if and where these expectations apply in your institution:

	Job description	Promotion criteria	Departmental expectations	N/A
Publish papers	☐	☐	☐	☐
Supervise research students	☐	☐	☐	☐
Obtain funding	☐	☐	☐	☐

Question 7 asks about funding opportunities

7. Do you see physics education research as physics research that should be funded by research councils (e.g. EPSRC or STFC)? YES/NO/DON'T KNOW

7.a. If possible, please expand on your answer. OPEN TEXT RESPONSE

7.b. If you or your colleagues have previously managed to obtain funding to do physics education projects, at what level did you get it from:

- Department
- Faculty
- University
- UK-based Research council
- Charity
- Commercial company
- Other

7.b.i. If you selected Other, please specify: OPEN TEXT RESPONSE

7.b.ii If possible, please give more details on your answer. OPEN TEXT RESPONSE

Questions 8 – 10 gather information about networking in PER

8. Are physics education research/scholarship staff in your department part of PER networks? If so, which ones are valued? Would new networks in this area be appreciated? If so, what sort of thing (e.g. topical or regional networks)? OPEN TEXT RESPONSE

9. To what extent are you aware of PER activity elsewhere (beyond your own institution)? E.g. do you, or your PER staff, collaborate with other PER groups? OPEN TEXT RESPONSE

10. Are there any other aspects about working in PER that you would like to raise? In particular what things would improve the opportunities for PER staff to advance their careers and make a bigger impact in the national / international arena? OPEN TEXT RESPONSE

Questions 11 and 12 ask about the respondent's role.

11. And lastly, a little about you and an opportunity to share more ideas. Do you take part in physics education research/scholarship? YES/NO

12. Is your current role...
    - Teaching and Research (i.e. a standard lectureship type post)
    - Teaching focused
    - Research focused
    - Other
    - Prefer not to say