Engineering and Physical Sciences Research Council

Review of EPSRC-funded Doctoral Education

OCTOBER 2021

Foreword

I am pleased to outline the recommendations and findings from EPSRC's review of Doctoral Education. I would like to thank all those who participated in the engagement activities over the course of this review, your input was critical and formed the foundation of the outputs of the review.

We publish this document at an unprecedented time, recognising now, more than ever, the importance of science and innovation for public good, the need to invest in talented individuals, and the role both of these can play in the economic recovery. As laid out in the Innovation Strategy, doctoral training is essential if we are to realise the PM's ambition for the UK to be a science and technology superpower. The researchers who are undertaking doctoral education are central in creating an effective ecosystem for engineering and physical sciences research in the UK.

By investing in doctoral students, EPSRC is ensuring that the UK has the next generation of creative researchers and critical STEM leaders, who will deliver innovation, economic growth, and prosperity for the UK across all sectors. This review sets out the recommendations for EPSRC's future approach to supporting doctoral education.

The review recognises the success of EPSRC's framework for supporting doctoral education, but we must continue to build upon our exemplary and innovative support for doctoral education. We seek to provide continuity in these challenging times and help the sector to reach its full potential. I look forward to working with the wider community to realise our vision and deliver the recommendations of this review.

Professor Dame Lynn Gladden
Executive Chair of the Engineering and Physical Sciences Research Council

Executive Summary

To be productive and competitive, the UK needs a diverse workforce with the right skills. As an investor in research and doctoral education, EPSRC currently supports 11,000 engineering and physical sciences (EPS) doctoral students, spending approximately £200 million each year.

This results in highly employable, talented researchers who make valuable contributions to the UK's science and technology base, both in industry and academia.

With a recognised need to increase the UK's productivity and competitiveness, this review makes recommendations to accelerate progress towards the target of 2.4% of GDP on research and development and ensuring the UK is recognised as a science superpower.

EPSRC will be using the recommendations to guide future activity in doctoral education, and we will publish an action plan detailing how we will take forward the recommendations from this review following some initial community engagement.

Executive Summary cont...

The research and innovation system and its funding

As a public funder, the findings and recommendations of the review need to be put in the context of Government ambitions for research and innovation. The recommendations have been written to align with the Government R&D roadmap, the Innovation Strategy, the People and Culture Strategy, and Build Back Better.

These include a target to spend 2.4% of GDP on research and development by 2027 and for the UK to be a science superpower. Through the People and Culture Strategy, UKRI has committed to looking at a broad suite of sector wide doctoral issues, including funding levels and studentship status. EPSRC is committed to working with UKRI, the other research councils and the wider stakeholders, on this 'New deal for postgraduate research'.

EPSRC is the largest single funder of doctoral students in the engineering and physical sciences and supporting approximately one third of all Engineering and Physical Sciences (EPS) doctoral students. EPSRC spends approximately £200 million per year on doctoral education through three distinct routes: Doctoral Training Partnerships (DTPs); Centres for Doctoral Training (CDTs); and Industrial Collaboration Awards (ICASE).

The number of EPS doctoral students in the landscape has been stable for the last 5 years. EPSRC has been able to maintain the number of doctoral students it supports due to the presence of additional funding from the National Productivity Investment Fund (NPIF). However, without continuing to secure additional investment, it is likely that there will be a decline in the number of students EPSRC is able to support in the future.

EPSRC funds students across all areas of its remit and there have been no significant changes in the proportion of students in each discipline (Theme) over the last 5 years. The review found that there need to be mechanisms of funding doctoral education which allow EPSRC to support the creative and innovative fundamental research community, but also provide more support for emerging strategic priority areas.

Postgraduate researchers make an enormous contribution to the research knowledge base whilst developing skills that will benefit their careers. Doctoral research projects occupy a unique space in the research landscape, giving students freedom to explore their research activity and new directions, without being tied to pre-set deliverables.

This allows doctoral research to be more creative and explore areas that would otherwise be considered too risky for other funding opportunities. Allowing the overall number of students in the landscape to fall would cause long term impacts to both the academic and industrial research sectors. Therefore, there is a need for all stakeholders to ensure that the talent pipeline is maintained.

EPS doctoral graduates are highly employable with over 80% in some form of employment, 6 months after graduation. EPSRC graduates are more likely to be employed in industry (40%) or to have a STEM-related career (77%) than the EPS doctoral graduate population overall. For those that continue to a career in academia (35%), EPSRC funded students are also more likely to hold a research or research-related role (65%).

While less likely to enter the public sector, probably due to the high number entering industry, those that do, again, are more likely to occupy research/research-related positions (24%). The main sectors EPSRC doctoral graduates go into are Manufacturing, Information and Communication and Professional, Scientific, and Technical activities.

Executive Summary cont...

The importance of a doctoral education and the variety of routes to support research and talent development are not always clear to stakeholders.

This can impact on their support of doctoral research, their recruitment of doctoral graduates, and the diversity of career pathways.

With an ambition to increase UK research and innovation activity, stakeholder understanding and investment in doctoral research, and the talented researchers and innovators it produces, is more important than ever. As the largest funder, we have a role to play in the expansion of R&I talent in the UK, but we also need to use our position of influence to encourage others to do likewise.

This review makes the following recommendations in this area:

Recommendation 1: To stimulate economic growth, EPSRC should increase the number of students it supports and the professional development that they receive. EPSRC-funded doctoral students go onto careers in innovation and research in manufacturing, information and communication technologies and other scientific and technical careers in industry and academia. To become a global science superpower, the number of people with these skills must grow and EPSRC must lead by increasing the number of students it supports. EPSRC should bid for an uplift of investment in EPS for doctoral education from the spending review and other opportunities.

Recommendation 2: EPSRC should better demonstrate the value of a doctorate, its outcomes, and the destination of doctoral graduates, so that this is understood by all key stakeholders.

Recommendation 3: EPSRC should continue to provide thought leadership in doctoral education to the EPS community by investing in the highest quality doctoral education provision which supports a diverse range of career paths.

Recommendation 4: EPSRC should provide a stable long-term baseline of investment to support a creative and innovative fundamental research community (such as the current algorithmic DTP investment), alongside a more dynamic framework to respond to and support emerging strategic priorities (for example, by investing in more frequent CDT competitions and including studentship investments alongside research investments in top priority strategic areas).

Recommendation 5: To effectively support the UK's increasing STEM capability, the system needs to grow. Recognising the high value placed on doctoral studentships by industry, EPSRC should engage with industry (both the current and new sectors) to encourage and enable increased industry funding and co-funding of doctoral students. These are effective ways of attracting industry investment into the R&D landscape.

Recommendation 6: EPSRC should showcase the ways small and medium enterprises can and do engage with doctoral students, to widen participation and enable overall growth in the system.

Recommendation 7: EPSRC should work with UKRI on doctoral student issues covered by the Government's People and Culture Strategy, ensuring that issues facing the EPS community are addressed. In particular, the New Deal for postgraduate research is expected to address areas such as the stipend level for doctoral students, the rights and conditions of doctoral studentships, financial sustainability of doctoral education investments, doctoral student recruitment policies, and the health and wellbeing of students.

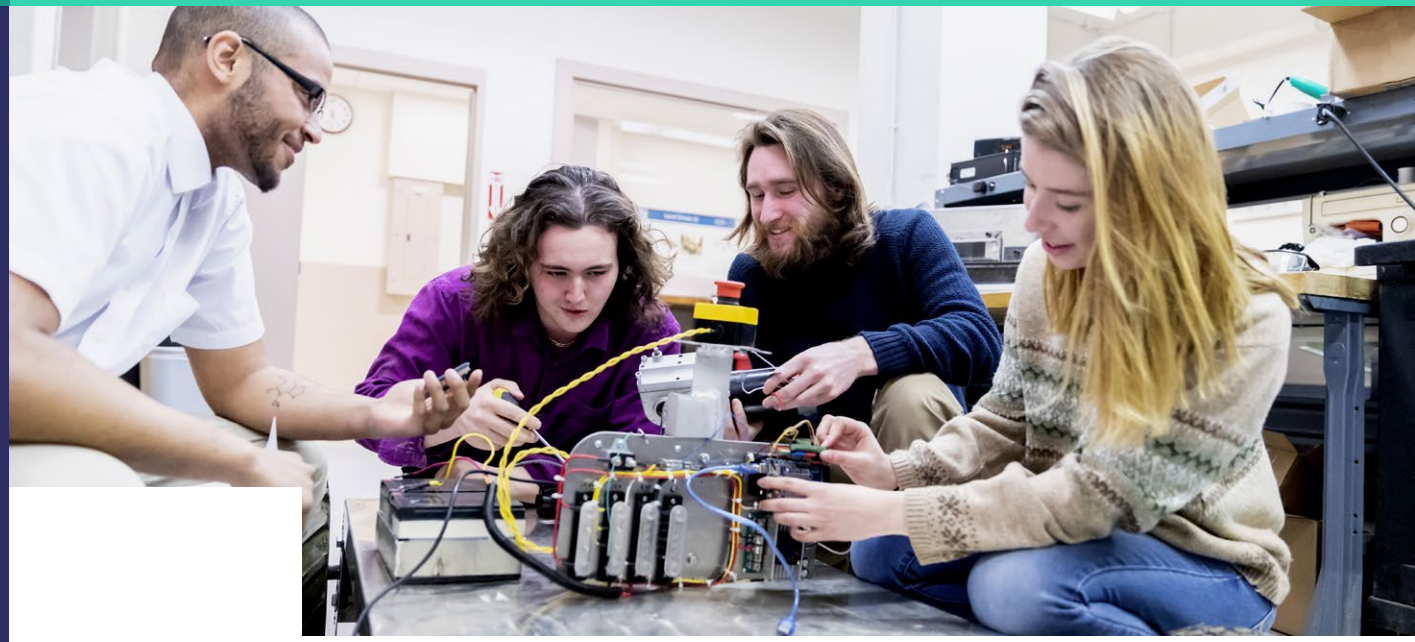
Recommendation 8: The existing opportunity to employ graduates on UKRI grants does not replace our main route to doctoral education but could provide a valuable alternative career path. EPSRC/ UKRI should explore this opportunity further particularly with reference to innovation and career mobility.

Executive Summary cont...

The Doctoral Experience

The experience that individual students receive impacts on the success of their research and their choice of career. This experience depends on both the research culture in which the students work and the opportunities that are available to them. This review has found that all students should have the opportunity to participate in additional activities beyond their research project. While the majority have some access to additional activities, there are inconsistencies in the levels of access. Therefore, a combination of increasing awareness and expectations, reducing barriers, and providing appropriate financial support is required.

It is imperative that research, and the training acquired though conducting research, remain front and centre of the doctoral experience. We need to ensure that that activities or experiences considered to be standard parts of a doctoral experience including presenting to a team or department, writing progress reports, writing papers, training others, and collaborating with colleagues in both academia and industry, are recognised for the skills they provide doctoral students. The review highlights the importance of striking the right balance between the time used for activities that are valuable but additional to the research project, and the time dedicated to the research itself.



Recommendation 9: EPSRC should work with the sector to provide greater recognition and visibility of the wider skills developed alongside research skills during a doctorate to ensure the employability of all doctoral graduates.

Recommendation 10: All EPSRC funded students should have access to opportunities outside of their research project (e.g., conferences, placements, public engagement), irrespective of the funding route. EPSRC should be explicit within each scheme that funding should be made available for opportunities outside of the research project.

Recommendation 11: EPSRC should prioritise funding excellent doctoral experiences and access to opportunities over student numbers, while ensuring value for money.

Recommendation 12: EPSRC should assist those who deliver the EPSRC doctoral investments in developing and sharing good practice.

Executive Summary cont...

EPSRC approaches and support

The review found that the current training approaches employed by EPSRC are well regarded, as the variety in mechanisms allows Research Organisations to provide a set of offerings that are suitable for a range of individual needs. However, it is clear that the flexibilities and support already available within our schemes are not well known across the range of stakeholders. Greater awareness of these would help overcome a number of issues raised in the review and support greater innovation and diversity within doctoral training approaches.

It is unlikely that increasing the number of schemes we support would have a positive impact and, unless specific aspects of training are missing and unable to be accommodated through adjustments to the existing approaches, we should avoid increasing the complexity in the funding system.

EPSRC supports students in every nation and region of the UK. The proportion of EPSRC students tracks EPS academics and EPSRC research funding by region. As students need access to state-of-the-art facilities and supervision by experts in their chosen field of study to get the best research education, this is not surprising. For those who are unable or do not wish to relocate, geography affects their ability to access doctoral opportunities. There is an opportunity to consider how doctoral education investment can support the UK government's levelling up agenda (Build Back Better), but any intervention will need to ensure it does not diminish the success of the UK's existing outstanding research institutions and knowledge-based economies.

The EPS student population is not as diverse as one would expect and the EPSRC population within it is even less so. A lack of diversity shows that the UK is not accessing the full breadth of its talent pool. This diversity relates to both protected characteristics and support for career mobility and lifelong learning. The review finds that there is a need for much more detailed understanding of the barriers within each EPS discipline. These are likely to be complex and nuanced, needing different approaches to improve diversity for different subject areas and characteristics.

Recommendation 13: It is essential that EPSRC continues to invest through a diverse range of flexible approaches so that we continue to support doctoral students' varied needs, backgrounds, and potential careers as well as the differing requirements of the research and innovation communities.

Recommendation 14: As EPSRC's current mechanisms are well regarded, new initiatives should only be introduced where there is a compelling case for an alternative approach.

Recommendation 15: EPSRC should work with all stakeholders to ensure the current flexibilities relating to both collaboration and supporting students are well known and used.

Recommendation 16: Doctoral education should be available to people following a variety of career paths. EPSRC should work with stakeholders to continue to improve access, diversity of entry points to doctoral education and tailored support for individuals.

Recommendation 17: EPSRC should understand detailed EDI issues in each of our research areas or sectors and work with our community and representative bodies to address them. EPSRC will continue to work within UKRI on broader EDI initiatives.

Recommendation 18: EPSRC should explore how doctoral training investments can support the levelling up agenda.

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Background

To be productive and competitive, the UK needs a diverse workforce with the right skills. For research and innovation (R&I) specifically, the Government has set a target to spend 2.4% of GDP on research and development by 2027[1] and this requires a significant uplift in people with relevant skills. EPSRC funds studentships to provide the next generation of skilled people in the Engineering and Physical Sciences.

Through a combination of research-based and professional training, doctoral students make an enormous contribution to the research knowledge base whilst developing skills that will benefit their careers. Doctoral students and graduates are an important contributor to the UK's R&I ambitions. It is imperative that our doctoral training investments continue to enable Higher Education Institutions to support postgraduate researchers to acquire the skills and knowledge required by a wide variety of careers (both academic and business). In doing so, we ensure UK-trained people have the skills our economy needs, and they remain globally competitive with high employability.

Working with our community, EPSRC investments train a diverse population of researchers who can work effectively across academia and business. We support around 11,000 doctoral students at any one time through three distinct routes: Doctoral Training Partnerships (DTPs) with universities across the breadth of discovery research; Centres for Doctoral Training (CDTs), which develop students as part of a multidisciplinary cohort, often working with business and other partners; and Industrial CASE (ICASE) awards, where businesses select university partners and projects. These mechanisms are designed to allow students to carry out high quality research and acquire the relevant skills for their future careers as well as to align training with the priorities of different stakeholders and the needs of the engineering and physical sciences (EPS) research and innovation community.

We launched this review of our doctoral education support in February 2020. The review will help to ensure that our investments continue to support the research and innovation system to adapt to future needs by having the people and skills it requires. As an investor in research and doctoral education, we are also committed to attracting the best researchers from a diverse population into research and innovation careers. As part of this review, we are looking to unlock this diverse talent, increasing our ability to achieve our ambitions set out in this EPSRC Delivery Plan and beyond.

During the review, EPSRC carried out stakeholder engagement and evidence analysis. This evidence base has been used to develop a set of principles and recommendations that will guide EPSRC's future support of doctoral education. This report lays out information from the findings of the review and information on the current doctoral landscape.

1 UK Research and Development Roadmap – GOV.UK (www.gov.uk)

Introduction

EPSRC's remit covers engineering, physical sciences, mathematical science, Information Communication Technologies (ICT), and applied areas of these disciplines such as manufacturing and energy research. As shorthand, this report uses EPS to mean all of these disciplinary areas.

The review has resulted in a series of recommendations on EPSRC's future approach to supporting doctoral education. EPSRC will be using these recommendations to guide future activity in the doctoral education. We will publish an action plan detailing how we will take forward the recommendations from this review following some initial community engagement.

Review objectives and context

This review has looked specifically at the doctoral education and students supported with EPSRC investments. It has not reviewed doctoral education in its entirety or that of all EPS postgraduate researchers. The aims of our review were:

1. **To consider the current national and international doctoral landscape, the doctoral education being provided and how EPSRC/UKRI support compares with this.**
2. **To understand the outcomes required from EPSRC doctoral education investments, in terms of knowledge, experience and skills. This will include considering the breadth of careers of doctoral graduates, enabling lifelong learning, and enhancing mobility between academic and other sectors.**

The review has considered the following aspects of doctoral education:

- The value of doctoral education: to the individual and their career, to the research landscape and to employers
- Skills and experiences: what skills and experiences should be provided by a doctorate
- Student population: how to enable a more diverse student population, including increased mobility between academia and industry
- How the doctorate is provided: including different qualifications, ways of providing the doctoral experience and how support is provided
- Ways of identifying, developing, and responding to strategic priorities: how can the landscape respond to changing directions and needs

EPSRC is recognised as a leading influencer in the area of doctoral support, with the centres for doctoral training model being taken on by other research councils and other funders for example. We are also the largest single funder of EPS postgraduates. It is important that we take the opportunity to consider the current and future EPS landscape and ensure our support is suitable. The education sector is also changing significantly, and we need to ensure that our doctoral education accounts for any changes in the skills of entrants and their points of entry.

EPSRC carried out the majority of the review of doctoral education during 2020. This was a period of time between committing major training investments through two of the main routes. Current EPSRC and UKRI AI Centres for Doctoral Training support recruitment up to (and including) the 2023/24 academic intake, while our Doctoral Training Partnership allocation is made every other year with the next allocation due for the 2022/23 academic intake.

With the publication of the Government Roadmap, we have additionally been able to conduct the review within the context of the developing talent and skills work in UKRI. There are a number of activities occurring across UKRI in relation to talent and skills and the review has been designed to be complementary to these and ensure EPSRC is well placed to contribute.

One critical activity for UKRI is the new deal for funding postgraduate research as committed to in the Government R&D roadmap[1] and the People and Culture Strategy[2]. UKRI is the UK's single largest funder of Doctoral Students and an indirect funder through its Quality Related (QR) funding elements[3], and its policies often set standards which the wider sector follows. As such, we have a responsibility to ensure postgraduate research training meets the needs of the system, from the students themselves and their research organisations, to the economy and wider society.

The new deal is a long-term programme of change, requiring deep sector engagement and buy-in to produce the vision of diverse, dynamic, attractive, and competitive postgraduate research training. The full project will be developed and implemented in stages over a number of years. Policy decisions will be informed by evidence, analysis, and engagement with the wider research and innovation sector. UKRI is committed to engaging extensively with the sector to inform the outcomes of this work. UKRI will be engaging with postgraduate researchers, as well as those who have completed their doctoral studies.

The new deal for postgraduate research will address four priority areas:

- **Funding and stipend levels**
- **Working rights and conditions**
- **Routes in, through and out**
- **Diversification of models and access.**

UKRI is in the early stages of developing this work. EPSRC will work closely with UKRI to ensure the knowledge gathered by this review is used by the new deal work and the outcomes are appropriate for our community.

How the review was conducted

Launched in February 2020, the review consisted of an evidence collection stage followed by synthesis and development of the outputs of the review.

The evidence collection stage comprised the following activities:

- Workshops with the various stakeholders of EPSRC funded doctoral education. Workshops were held with the academic community, business community, representative bodies, and students. The student engagement was carried out by Vitae on behalf of EPSRC. The reports of these workshops are available on EPSRC's website.
- Data Analysis. EPSRC performed analysis of our own data and that available via HESA to understand the wider landscape. The outputs of this analysis are included within this report.
- Literature review. EPSRC engaged RAND Europe to perform an analysis of the existing literature. This report is available on EPSRC's website.

A subgroup of our Strategic Advisory Network (SAN) provided advice throughout this work. The SAN working group were involved in:

- Scoping the review
- Advising on the review activities
- Assessing the evidence collected
- Identifying the key messages
- Creating the recommendations
- Advising on issues arising from the pandemic.

1 UK Research and Development Roadmap – GOV.UK (www.gov.uk)
2 Research and development (R&D) people and culture strategy - GOV.UK (www.gov.uk)
3 Quality-related research funding - Research England (ukri.org)

The SAN members were:

- Professor Andrew Wright, Director Strategic Technology for BAE Systems Plc
- Professor Nick Jennings, Vice-Chancellor and President at Loughborough University
- Dr Ceri Williams, Director of Research, and Innovation Development at the University of Leeds
- Dr Gareth Jenkins, Science and Technology Director, Science & Technology Projects for Quotient Sciences
- Dr Paul Gosling, CTO for Thales UK
- Professor Ifor Samuel, Professor of Physics at the University of St Andrews
- Professor Julie Yeomans, Associate Dean, Research, and Innovation, Faculty of Engineering and Physical Sciences, Professor of Ceramic Materials at the University of Surrey

Covid-19 Pandemic

With the global population affected by the COVID-19 pandemic, which the UK has largely felt from March 2020, the review timeline was lengthened. This released time from EPSRC and stakeholders alike, enabling organisations to respond to emerging issues and support current students.

With the review taking place during the pandemic, we engaged the community (academia, companies, and students) when the immediate impacts were at the forefront of people's minds. To ensure that the input to the review has remained focussed on the long-term needs of doctoral education, engagement activities have been carefully facilitated. As understanding the impact of the pandemic across our stakeholders is important, throughout the last 18 months we have made space either as part of our review activities, or as additional engagement, for those discussions to take place.

This has allowed us to hear the thoughts and experiences of the immediate and longer-term impacts of the pandemic, and we continue to welcome input on the impact and mitigation needed for our doctoral students.

The impact of the pandemic is being considered separately from this review by UKRI as a whole. Any information we have gathered that specifically relates to the pandemic will be fed into that activity and does not form part of this report. During the pandemic, we have also provided regular updates to our governing and advisory bodies on the policies we have developed as part of the UKRI family, the outcomes of those policies to date[4], and shared the key messages we have been receiving from stakeholders.

Structure of the report

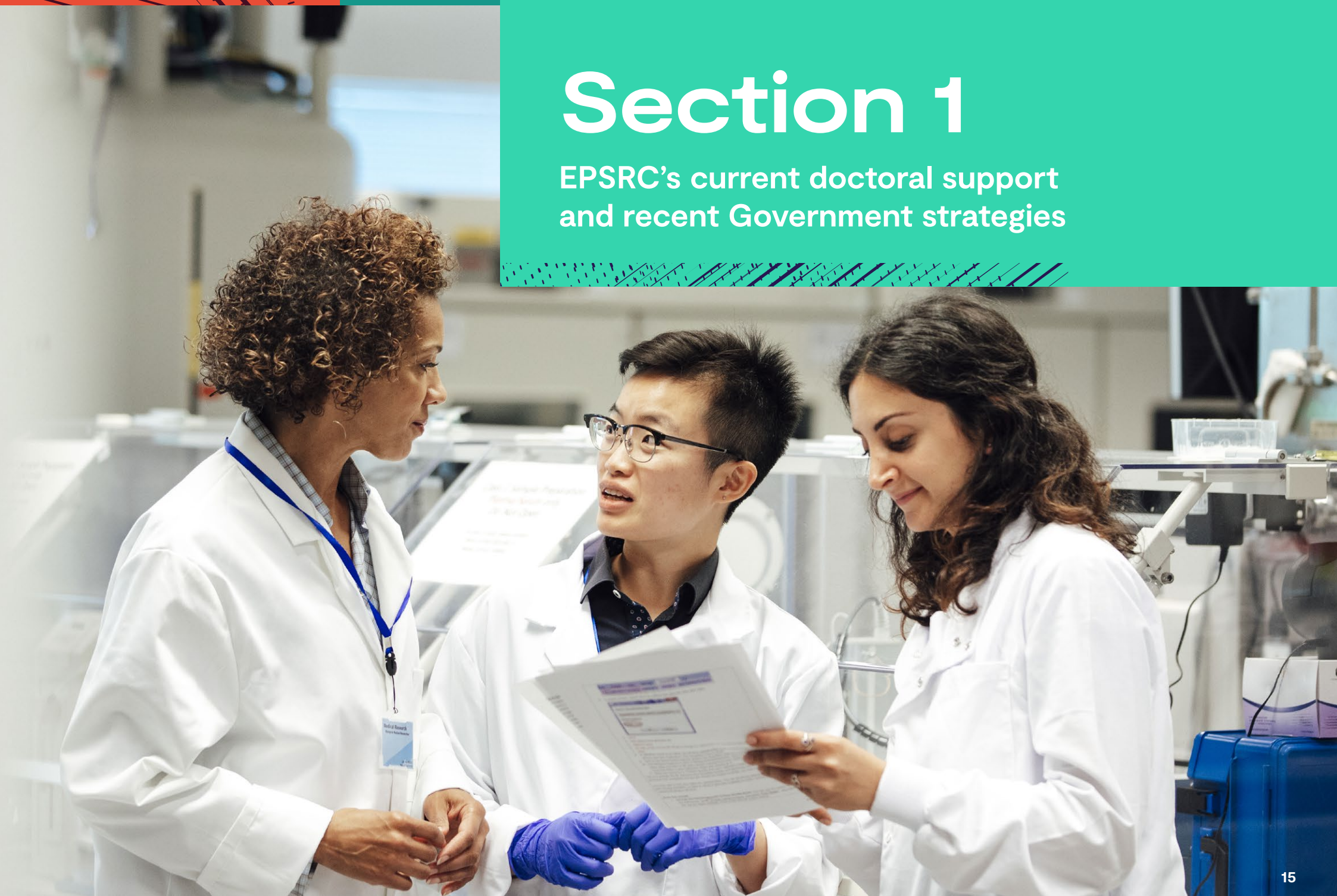
The report is split into two sections. The first section provides context for EPSRC's current doctoral support and recent Government strategies. It covers information on our current mechanisms of support and the expectations we have for our doctoral funding, and also provides relevant excerpts from Government documents that should be considered as part of the review findings.

The second section details the information gathered by the review. This section is structured into key questions, with the information being combined from all the relevant activities that were carried out during the review. This structuring allows key messages from multiple sources to be identified and critical issues to be explored. All of the EPSRC held data that has been used to develop the findings is available in the public data set, see Annex 1 for information.

4 https://www.ukri.org/our-work/tackling-the-impact-of-covid-19/guidance-for-applicants-and-awardholders-impacted-by-the-pandemic/

Section 1

EPSRC's current doctoral support and recent Government strategies



The funding EPSRC issues to support doctoral students

EPSRC plans commitment to doctoral investments on a basis of around £200 million expenditure per year. In 2019/20, for example, EPSRC spent £205 million on training grants, which was approximately 20% of EPSRC's overall budget.

We support around 11,000 doctoral students through three distinct routes: Doctoral Training Partnerships (DTPs) with universities across the breadth of discovery research; Centres for Doctoral Training (CDTs), which develop students as part of a multidisciplinary cohort, often working with business and other partners; and Industrial CASE (ICASE) awards, where businesses select university partners and projects.

These mechanisms are designed to allow students to carry out high quality research and acquire the relevant skills for their future careers.

When supporting students, EPSRC provides the funding as a training grant to the university. Our training grants provide funds that can be used towards core studentship costs (stipend, tuition fee, and project costs) as well as for additional training and development activities. The university is responsible for recruiting students and managing the award. Across UKRI, we have a set minimum stipend and fee rate, but universities can choose to set higher stipends and fees if they want to.

The level of support for project and other training costs are decided by the university. EPSRC expects project costs to be dependent on the project type, and to be sufficient for the student to complete their doctoral research and undergo relevant training and development activities. Additional funding is available to support students with disabilities. Universities are expected to provide a suitable working space and standard office equipment (including computing equipment) as well as appropriate supervision and general administration support.

Centres for Doctoral Training

Doctoral Training Partnerships

Industrial CASE

Centres for Doctoral Training (CDTs)

EPSRC-funded centres for doctoral training bring together diverse areas of expertise to train engineers and scientists. They aim to create new working cultures, build relationships between teams in universities and forge lasting links with industry. They also provide a supportive and exciting peer-to-peer environment for students. CDTs account for approximately 45% of EPSRC's spending on doctoral training. In addition to EPSRC's commitment to CDTs, the centres leverage additional studentship funds from other sources (e.g. university funding, EU funding, industrial funding, private funding etc.).

EPSRC has been funding CDTs under various guises since 1992. In 2013, all previous centre names were replaced with the single umbrella term, CDT (previous terms include Industrial Doctoral Centres (IDCs), EngD Centres, Life Science Interface Centres (LSI centres), and Doctoral Training Centres (DTCs)). Centre partnerships also take a number of forms from single institution to multiple academic partners to academic/business/charity partnerships. Under the CDT framework, all previous centre approaches and partnership types are allowed, giving the EPS communities the flexibility to request the type of centre model that best serves their vision and supports the required skills development.

EPSRC funds CDTs through competitive calls targeting areas or research challenges that require students to undertake additional technical training and where a cohort-based approach is beneficial. Proposals for centres undergo peer review to ensure they are providing an excellent training environment; are in areas that require a significant quantity of trained individuals and additional training programmes; and meet EPSRC's expectations of a CDT.

The 2013 and 2018 calls process was as follows:

- Call launches. Applicants have a period of time to write an outline
- Outlines are assessed by peer review
- Successful outlines have 8 weeks to write a full proposal
- Full proposals undergo peer review and interview
- The grants are awarded

CDT opportunities usually support a minimum of three intakes. The majority provide EPSRC funding to support 40 students across five intakes. Applicants request the level of funding they require to support the student numbers and intakes indicated in the call. How many centres EPSRC is able to support then depends on the budget available and the cost of applications. The last two CDT calls were five years apart, each supporting five intakes. Through the most recent call (2018), EPSRC supported 75 centres from its baseline funding, plus another 16 through additional funding allocated to EPSRC specifically to support cross-UKRI, artificial intelligence focussed, CDTs. This call launched in April 2018 and the grants were awarded in January 2019, with students starting in October 2019.

CDTs are required to provide a cohort experience to the students, with additional training and support, alongside the research training individuals receive through their doctoral project. Students are funded on four-year doctoral programmes (FTE) to accommodate this. From 2018, EPSRC has made it mandatory for students funded via CDTs to be trained in responsible research and innovation. Beyond these requirements, centres have the freedom to outline their training plans and to decide what types of opportunities they will offer to students, so that the training experience best meets the needs of students in that particular area. Like the DTP scheme, universities may support collaborative studentships.

Doctoral Training Partnerships (DTP)

EPSRC Doctoral Training Partnerships fund doctoral training in UK Higher Education Institutes (HEI's). They are flexible awards to support doctoral training in any areas of engineering and the physical sciences in EPSRC's remit. The purpose of the EPSRC DTP is to align part of our training investment with the underpinning EPS research that our Council supports. Doctoral training partnerships account for around 45% of EPSRC's spending on doctoral training.

The funding is allocated to UK universities with significant EPSRC research activity, by means of an algorithm, usually every two years and to support studentships across two intakes. The algorithm is based on a comprehensive profile of EPSRC research funding, awarded competitively from EPSRC's core resource baseline. The allocation is run in the spring/summer of the year before students start (e.g. 2019 for 2020/21 and 2021/22 intakes) with the amount allocated to each university based on a snapshot of their EPSRC research grant portfolio on the 1 April of that year.

To ensure DTP funding is used appropriately, EPSRC carries out an assurance activity before providing the funding. After EPSRC has indicated the allocation to an organisation, the universities provide EPSRC with a Statement of Intent which details how they will use the allocated funding, support the students they recruit, manage the grant, and use different flexibilities allowed under this scheme. This information is assessed by a panel of experts to ensure it meets EPSRC's expectations. Providing the statement has satisfied the panel, grants are awarded before the end of that financial year.

The number of universities who receive an award varies depending on the spread of the research grant investments across them and the DTP budget available. Typically, a DTP award is allocated to just over 40 higher education institutions.

The university holding a DTP manages the allocation of funding between studentships and additional activities, the advertisement of opportunities and recruitment to studentships funded through the DTP. As well as aligning studentships to EPSRC's research portfolio, this approach enables studentships to be aligned to the university's own strategy for EPS research - reflecting its research activities and priorities - and respond dynamically to emerging opportunities. Universities have a number of flexibilities within the DTP investment.

They can choose the number and duration of studentships offered (up to four years full-time equivalent (FTE)), and the level of funding individual students receive for project costs and other training activities. They have the flexibility to use a proportion of the DTP funding to support internships for promising undergraduates (vacation internships) and they may also fund opportunities beyond the doctorate for the best doctoral students to further develop their research (Doctoral Prize – all EPSRC funded students are eligible regardless of scheme). Universities can also use the DTP to support co-funded studentships in collaboration with other parties such as industrial or charitable organisations.

Industrial CASE ICASE

Industrial CASE provides funding for doctoral studentships where businesses take the lead in arranging projects with an academic partner of their choice. The aim of these awards is to provide doctoral students with a first-rate, challenging research training experience, within the context of a mutually beneficial research collaboration between academic and partner organisations, for example, industry and policy making bodies. ICASE funding accounts for around 10% of EPSRC's spending on doctoral training. In addition to EPSRC's commitment to ICASE, the industrial partners provide additional funding of a minimum of a third of the EPSRC funding.

The funding is allocated to businesses and related organisations, by means of an algorithm, currently awarded each year and supporting one intake of students. The algorithm is based on financial contributions (cash and in-kind) to EPSRC-funded research, aligning the ICASE investment to our research portfolio where there is mutual interest by non-academic partners. The allocation is run in the spring/summer of the year before students start (e.g. 2019 for the 2020/21 intake) with the amount allocated to each organisation based on a snapshot of their contributions to the EPSRC research grant portfolio taken on the 1 April of that year. Companies are not funded directly, rather they are given a voucher per studentship which they allocate to UK universities. Grants are then awarded to the universities around summer, to support students beginning in the following academic year. We typically support around 200 new studentships each year through this route.

The industrial recipients of ICASE define research projects which can support doctoral training in any area of engineering and the physical sciences in EPSRC's remit. They also choose the academic partner/s to collaborate with (providing that academic partner holds Doctoral Training Partnership funding from EPSRC). ICASE studentships are four years (Full Time Equivalent (FTE)), and the student must spend at least three months at the industrial partner.

Who receives our funding and delivers the training?

There are a variety of roles associated with EPSRC's doctoral investments and they vary by the scheme. For all training grants, the UKRI grant system (Je-S/Siebel) can only contain a single contact, the grant holder. This person is responsible for the grant, funding, and compliance with the UKRI/EPSRC terms and conditions.

For the DTP scheme, the training grant holder is decided by the university and is most often someone within the management or administration of the university. While ultimately responsible for the funding and compliance, they typically have little direct involvement with the individual students supported by the grant. They are responsible for allocating studentships across the organisation in line with the university's expectations (as set out in their Statement of Intent). Some DTPs have an additional person or team to help with the day-to-day management of the funding while others are solely managed by the training grant holder. The experience and training received by students is largely determined by the supervisory team.

For ICASE, the funding for studentships is received by universities. EPSRC provides a single grant for the studentship costs associated with all the vouchers they have been allocated by companies. Therefore, as well as the training grant holder at the university, EPSRC liaises with a contact at each company that is allocated a voucher. Like DTP, the training grant holder is decided by the university and is most often someone within the management or administration of the university. The studentship allocation is determined by the company, so the training grant holder's role is mainly seen as one of fund management with little direct involvement with the students the grant supports. The experience and training received by students is largely determined by the supervisory team.

For CDTs, the training grant holder is the director of the CDT. They are chosen by the centre partnership ahead of submitting a funding application. In addition to the responsibilities already discussed for all schemes, the director is responsible for the strategic direction and overall delivery of the centre. They tend to be more directly involved with a student's training experience compared to the other two schemes. CDTs have a wider management team, comprising a selection of academic and administrative staff. The management team are responsible for the day to day running of the CDT.

Regardless of scheme, the supervisor/s hold a significant role in delivering and supporting the training of doctoral students. Every doctoral student has at least one supervisor, who is normally an academic responsible for providing guidance and ensuring the student's work is of the doctoral level.

Many students have secondary supervisors, these might be other academics with specific domain knowledge or supervisors from the project partner organisations, who provide guidance on the collaborative aspects of the project. Supervisors receive the funding for the research project costs they need from the appropriate training grant holder.

How EPSRC manages doctoral education investments

How EPSRC manages its training investments once awarded depends on the funding mechanism but all UKRI training grants are required to complete annual monitoring (introduced 2019). This collects aggregate information on:

- The EDI characteristics of the students who applied and were recruited
- The training activities provided
- The engagement with other partners
- Scheme specific information
- Case studies.

In addition, the universities are required to provide information on individual students supported by the training grant via Je-S[5]. This includes information on the student's identity, funding arrangements and project details.

DTPs and ICASE training grants are managed centrally. Questions can be raised by the training grant holder, administrative staff, and students via email. For ICASE, these are managed by the EPSRC business and university partnerships team while DTP is managed by the EPSRC EDI & People team. The teams work closely together on cross cutting issues. For the DTP, scheme specific information collected in the annual monitoring includes information on their use of funding for doctoral prize and vacation internships.

The CDTs are managed collaboratively by the EPSRC themes. Each CDT has an EPSRC portfolio manager as their primary contact and the portfolio manager is a member of their advisory board. The EPSRC EDI & People team provides central support, providing advice and guidance to CDT contacts so that they may work effectively with their CDTs. All CDTs must have an independent advisory board and most also have a management board. These provide guidance on all aspects of the management and direction of the CDT, ensuring the CDT fulfils the original objectives and that the overall strategy remains high quality and ambitious. For the 2018 CDTs, the annual monitoring collects information such as how they have implemented mandatory aspects of the CDT scheme such as responsible research and innovation training.

The training doctoral students are receiving or should receive

UKRI has published a statement of expectations for postgraduate training that it expects all recipients of UKRI training grant funding to uphold. This supersedes prior statements published by Research Councils UK. The statement lays out the expectations of the training environment being provided to UKRI funded students.

EPSRC studentships include funding for the project costs and training and development opportunities, and therefore EPSRC expects all students to have access to training opportunities. There is guidance provided in the training grant terms and conditions and guidance documents on the types of experiences that are available to students.

EPSRC recognises that students enter doctoral programmes with a diverse range of skills and experience. The provision of training should be kept as flexible as possible allowing customisation to suit the individual needs of students (and the research area). Universities manage this in different ways, and it can vary by scheme. Some examples include allocating funding per student, keeping a central budget that students can apply for, or a combination of both.

Students and the supervisors should recognise doctoral study as a wider training opportunity beyond conducting the research necessary for the doctoral project and ensure that participation in additional activities is designed into the studentship plan.

As well as the development of technical skills, EPSRC expects students to have access to opportunities that allow them to develop:

- A broad understanding of their research areas
- Transferrable skills, including those related to research conduct
- Their horizons beyond the 'home' research organisation via collaborations with others, participation in conferences etc.

5 Je-S is the system used by UKRI to provide the community with electronic grant services.

How we expect partners to engage

EPSRC expects the following kinds of engagement between partners and studentships:

- Funding and co-funding studentships
- Being involved in the doctoral research project
- Participating in training activities
- Participating in the design and governance of doctoral training investments.

Co-funding

Partners can engage by co-funding studentships with EPSRC on all of the current investment mechanisms. The amount a partner can co-fund the studentship varies between 100 % – 1% depending on the scheme and the amount of involvement the partner wishes to have with the project.

- For the ICASE scheme, the partner must provide an annual cash contribution to the Research Organisation which is at least one third of the funding provided by EPSRC (e.g., if EPSRC funded £90k, the minimum would be £30k, making a total of £120k)
- On the CDT scheme, partners can provide either 100% of the studentship or between 50-1% of the studentship
- On the DTP scheme, partners can provide between 50-1% of the studentship funding. To be considered a CASE conversion (equivalent to ICASE), an additional 30% must be added to the studentship.

Research project involvement

Partners are involved in doctoral research projects in the following ways:

- Designing the doctoral project
- Contributing to the design of the doctoral project
- Acting as a supervisor on the doctoral project
- Providing advice/mentorship to the doctoral student
- Hosting placements
- Providing short term projects.

By designing or contributing to the design of a doctoral project, companies can explore pre-competitive aspects of their technologies/products, that would not be possible via other routes. Working on doctoral projects also provides companies with opportunities to create and maintain links with the academic community. This provides a novel project grounded in real world problems, which is often desirable for prospective students. It also provides significant contextual awareness, which is identified as making a doctoral student more employable.

Having a member of staff acting as a supervisor or mentor is a really valuable way for doctoral students to broaden their awareness of the wider context of their research. It also provides the opportunity for the student to learn about other ways of working and the differences in academic and industrial cultures.

Providing additional opportunities

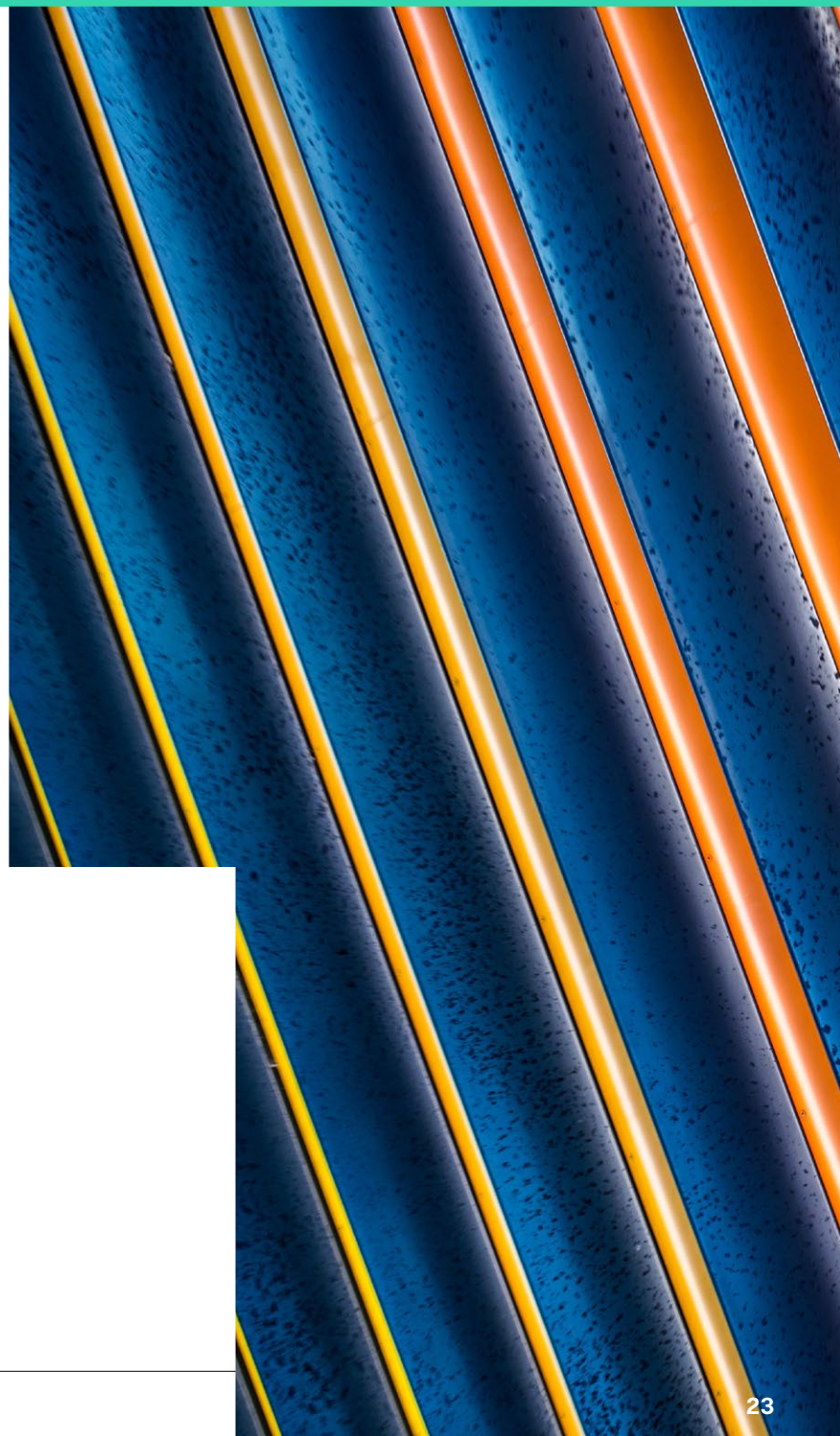
Partners can give a provision of placements and short projects. Some, such as ICASE studentships, are linked to the doctoral project and usually contribute directly to the doctoral research project. Other opportunities allow companies a way of having a high-quality researcher work on a smaller or more immediate activity, that would not be appropriate for a whole doctorate (e.g., due to complexity or immediacy of need). The company receives the benefit of having the academic expertise and problem-solving capacity of the doctoral researcher, for the time of the project, and can target the capabilities they need. It can also be a way of the company testing their engagement with an academic group or institution before making a larger commitment. Students benefit from experiencing research or related work in a different setting and developing or enhancing skills and expertise in ways that are different from their research project. Companies can make these available to any doctoral student and do not need to be co-funding their doctorate. An example of this type of arrangement is the UKRI Policy Internship scheme, though such placements can also be arranged independently by students, academics or businesses.

Partners in CDTs are expected to be involved in both the training activities and the governance of the investment. CDTs are expected to identify the relevant training requirements by working with partners. Many CDTs then work closely with their partners to develop and deliver training activities.

There are varying levels of involvement, but engaging with training activities can include:

- Recommending training in specific areas
- Being involved in the development of the training
- Providing the training.

Having partners involved in the training ensures it is relevant across multiple sectors. Having training created by or delivered by the partners, makes it clear to the students that these skills are valued by industry, which can enhance their interest/participation in the activity. Partner involvement in the CDT governance and management structures ensures that best practice is shared across sectors and that the CDTs continue to provide cutting edge relevant training.



Recent Government strategies

On 22 July 2021, the Government launched its People and Culture Strategy[6] and its Innovation Strategy[7]. In March 2021, the Government also launched Build Back Better[8] which includes looking at levelling up regions across the UK. The review needs to be placed into context with those ambitions.

The People and Culture Strategy recognises the "constantly growing demand for R&D skills" and the Government has "estimated the R&D sector will need at least an additional 150,000 [people] by 2030 to sustain the UK's target of 2.4% research activity". The strategy emphasises the importance of "attracting and retaining people of all ages and at all career stages into R&D roles" and they point to broadening and providing more stability for career paths and entry routes; creating a positive working environment; and encouraging a greater number and wider diversity of young people from all parts of the UK to consider careers in research and innovation, as ways of achieving this.

Barriers the People and Culture Strategy discusses that are relevant to this review are that 1) while "The UK's research organisations, particularly universities and research institutes, have been highly effective in utilising diverse funding streams… the demands of different funders and the need to continually compete for funding has increased the burden of bureaucracy on researchers." 2) UK academics may not have all the skills they need to train and support the next generation. "A large proportion of R&D managers acknowledge the need for upskilling" with "one survey of UK academic leaders [finding] that only around a quarter feel fully confident in managing performance (22%) or providing career advice (29%)."

In the Innovation Strategy, 'People' forms pillar 2. It outlines the ambition to "promote a richer diversity of skills critical for innovation and ensure our training pipeline delivers the diverse set of skills needed by presenting a broad skills agenda" and acknowledges both that "the innovation workforce is built by the education and skills system" and that "STEM skills are critical to the innovation process". The strategy talks of initiatives to increase the number of young people considering STEM careers. Acknowledging that these focus on pre-university, if these are successful, they should nonetheless be expected to increase the demand for further and higher education in STEM areas in years to come, which remain important routes into R&D careers.

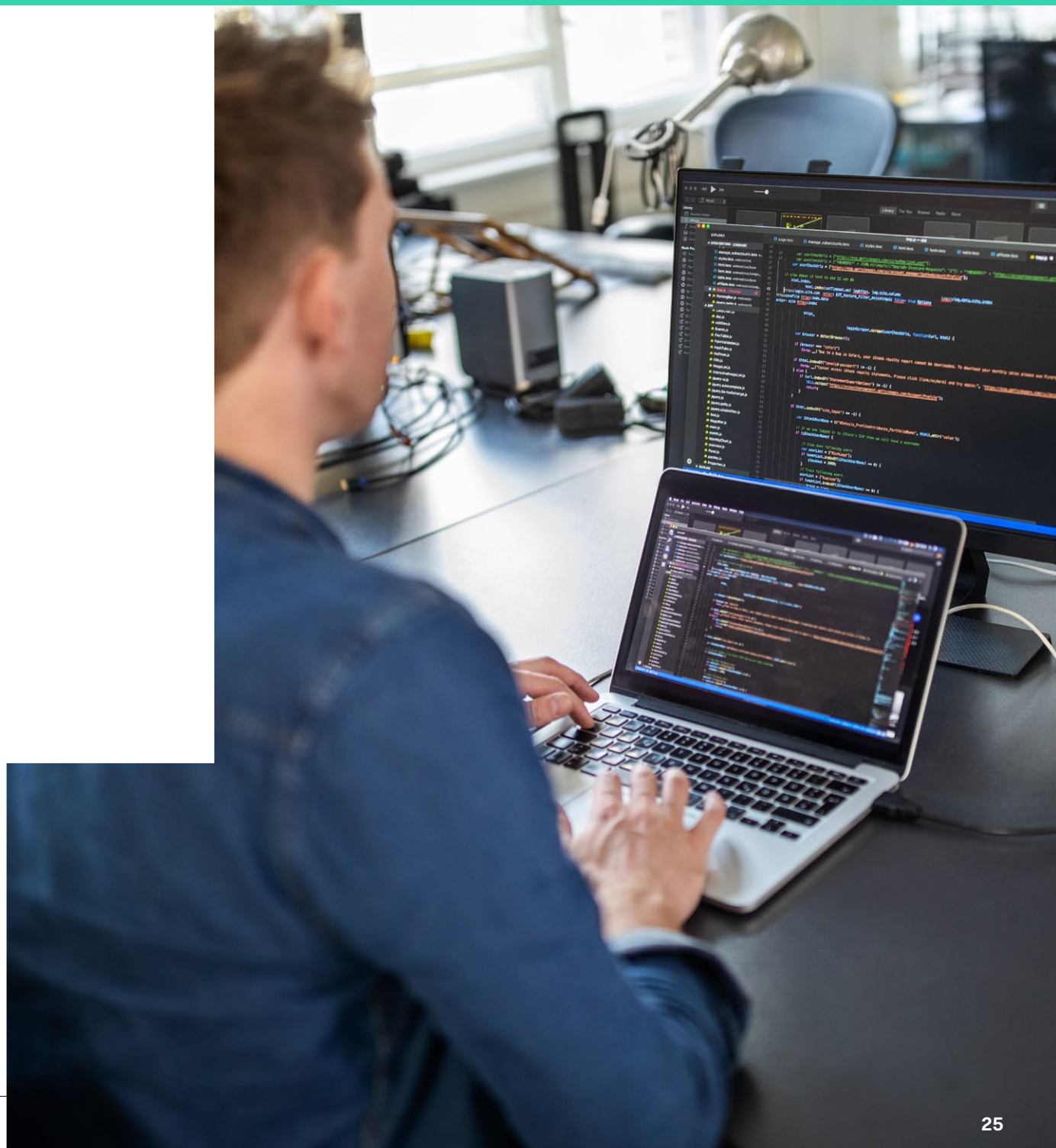
The Government is also considering how to level up UK regions. The central tenet being that "where people live should not be a barrier to their life chances". Skills are seen to play a "vital role in sustaining productivity growth and our international competitiveness" and that "creating opportunities to improve the skills of people in all regions is critical to the future success of the country". It also acknowledges that "the contribution of skills to productivity growth [historically] can be attributed to higher skilled cohorts".

The role science and technology can play in levelling up has been considered by the Place Advisory Group, Council for Science and Technology (CST) and the Government Office for Science (GOS). The Place Advisory Group has advised that R&D interventions seeking to make the most of places' potential must be part of a wider strategy for that place, considering skills, infrastructure, business support and regeneration, tailored to each place's needs.

6 R&D People and Culture Strategy (publishing.service.gov.uk)
7 UK Innovation Strategy: Leading the future by creating it - GOV.UK (www.gov.uk)
8 Build Back Better: our plan for growth – GOV.UK (www.gov.uk)

In letters to the Prime Minister,[9] Boris Johnson, CST and GOS highlight that "achieving our goal of becoming a science superpower means a significant increase in research and innovation intensity, which will require the development across the UK of greater capacity and capability to perform excellent research, development, and innovation activity."

They go on to say that the "impact of R&D investment depends on several inter-connected factors, including the availability and access to a skilled workforce; social and connective infrastructure; and strong local leadership". "Universities, Catapults, public sector research establishments (PSREs), and other major national facilities are important to their local area's innovation system" and "universities provide skills and attract knowledge-intensive industries that promote agglomeration and specialism in their cities and nearby regions". It also states that "incentivising partnerships across regional boundaries, between stronger and weaker regions, will be essential" and that "support for collaboration and partnerships are particularly important for structurally weaker regions to link to partners outside the region with complementary strengths." In a note of caution, CST and GOS highlight that "actions taken to level up low research and innovation intensity regions should not diminish the success of the UK's existing outstanding research institutions and knowledge-based economies".



9 The contribution of science and technology for levelling up - GOV.UK (www.gov.uk)

Section 2

The findings from our analysis and engagement activities

1. The importance of doctoral education to EPSRC

By funding doctoral education, we are ensuring that there is a future pipeline of excellent researchers and innovators. Having a doctoral qualification is often a crucial aspect of an academic career but is being increasingly recognised as valuable to other career routes. The opportunity to undertake an original piece of research trains the doctoral graduate in the fundamental skills required to be a researcher and also provides a much wider set of skills relevant for a diversity of careers. During all the community engagement carried out as part of this review it was recognised that the skills developed by completing a doctorate map onto all quadrants of the Vitae researcher development framework[10]. While students may not begin their doctoral studies with a specific career in mind, many are at least considering pursuing an academic career. However, there is significant change in students' career intentions over the course of their doctorate. Given the variety of careers that can benefit from a doctoral background, it is not appropriate to target doctoral opportunities solely at those who intend to pursue an academic career and important to prepare students for the breadth of careers they may follow[11,12].

Students are significant contributors to the research landscape as their doctoral projects have to provide an original contribution to knowledge.[13] The value that doctoral education provides through the research it generates was evidenced in the RAND literature report produced as part of this review,[14] and reflected in EPSRC Research Fish data which found that each student publishes an average of 1.4 publications over the course of their doctorate.

When compared to research grants (normalised to the amount of funding spent on staff effort on a research grant and to the stipend and fee component of studentships), EPSRC's studentship funding provides ~20 publications per £1 million and EPSRC's research grant funding provides ~85 publications per £1 million. This difference is expected and reflects that 1) doctoral students are new researchers who may require more lead-in time and have other commitments during their funded period and 2) the nature of the projects is often different to research grant projects. Students carry out individual research projects while research grant projects, by comparison, are often team activities with multiple contributors.

It was also noted repeatedly (in engagement activities) that doctoral students research projects occupy a unique space in the research landscape. Doctoral students have the freedom to truly explore their research activity and follow new directions, without being tied to pre-set deliverables that are more common with other funding routes. This allows doctoral research to be more creative and explore areas that would otherwise be considered too risky for other funding opportunities.

Doctoral projects are a good way for partners to build collaborations. Industry values engaging on doctoral research projects as it is an effective way for them to co-solve problems, especially those at low Technology Readiness Levels (TRL) with academic support. This allows industry to tackle issues they would not have the funding or capacity to address via other routes.

There is then a secondary benefit to industry that by engaging with a doctoral student they have access to this person as well as their wider network in academia. The important role of postgraduate researchers as knowledge conduits was highlighted in the RAND literature report. This is true in many partnerships types, whether between different academic research groups for multidisciplinary projects, or collaborations across sectors and organisations.

In addition to considering the career routes of students and ensuring they are sufficiently supported to understand and have the skills for the options available to them, it is important that we do not lose sight of the significant contribution they are making to the research and innovation landscape during their doctorate and that this is recognised and valued.

10 About the Vitae Researcher Development Framework — Vitae Website
11 PhD students and their careers - HEPI
12 Vitae Report of student engagement.
13 Data from Researchfish.
14 Rand Europe: EPSRC review of doctoral education – A review of the literature.

2. What proportion of UK EPS doctoral students does EPSRC fund?

Within the UK, there are approximately 112,000 doctoral students at any one time, with approximately 36,000 new students beginning their doctorate each year. Engineering and physical sciences students make up about 30% of the total student population.

EPSRC is currently able to support around 3,000 new students each year, with a total of ~11,000 students supported at any one time. This is about a third of the total number of doctoral students who are studying topics within EPSRC's remit. On average (reflecting annual fluctuations), across all EPS doctoral students, EPSRC funds 27% EPS doctoral students, 24% are university funded, and 23% are self-funded. While it is not the majority, as well as being the largest funding organisation, we also support the largest proportion, equal to funding from all universities combined.

While the largest single funder, UKRI does not fund the largest proportion of all doctoral students in the UK. Across all doctoral students, regardless of subject, 35% are self-funded (which includes students with personal scholarships), 20% are funded by a university and 15% are UKRI funded. The proportion of industry funded students is 5% for both the overall population and EPS relevant students.

The comparison between all doctoral students and EPS students suggests that EPSRC funding appears to result in fewer self-funded students, rather than replacing university or industry funding. In fact, university spending on EPS students is higher than it is across the whole population.

This information shows that EPSRC funding has a significant impact on the funding landscape for EPS doctoral students. We are the largest funder, but still do not support the majority of doctoral students in areas of our remit, nor are we or UKRI as a whole, a regulator. This means we have some influence in the higher education sector, but that we cannot drive sector-wide change in EPS doctoral education without engagement and buy-in from other funders.

3. How many students will EPSRC be able to support in the future?

UKRI receives its funding from Government through Spending Reviews and the period these allocations cover varies. How many students can be supported depends on the settlement that EPSRC receives, as well as what percentage we are able to target at training investments.

Since 2014, as seen in Table 1, EPSRC has made commitments that increase our expenditure on studentships to around £200 million per year. This increased spend has resulted in an increased number of students overall between 2014 to 2020. However, the funding from EPSRC's baseline has remained effectively flat, with EPSRC benefitting from additional funding through the Government's National Productivity Investment Fund (NPIF) since 2017/18. Over this same period, the minimum cost for stipend and fee increased from £17,859 p/a in 2014/15 to £19,692 per year in 2020/21. This reflects that the UKRI minimums for stipend and fee increase annually with inflation. In addition to these costs, studentships incur other costs including project costs (such as consumables) and training opportunities (Corporate Professional Development (CPD), technical courses/summer schools, conference attendance, etc.).

Students can also get higher stipends. Any university has flexibility to pay students a stipend above the minimum and students registered at a London-based university typically get a ~2k p/a 'London Weighting'. This means the average cost of a studentship is greater than the ~£20k p/a mentioned above.

The cost to EPSRC is different again, as studentships can be co-funded. In simple terms, by dividing our annual expenditure on training grants by the total number of students supported that year, the average EPSRC cost per student has changed from just under £16k pa in 2014/15 to £17k in 2019/20. This demonstrates the amount of leverage EPSRC gets from its investments and changes in the ability of other parties to co-invest with us will influence student numbers.

EPSRC has not only benefitted from additional funding for specific doctoral student investments from NPIF. During this time, EPSRC also received additional funding for research grants from sources such as the Industrial Strategy Challenge Fund (ISCF). The impact of these additional funds is that EPSRC has spent an increasing proportion of its total funds on research over this period. This means that, including the NPIF funding, while in cash terms EPSRC's spend on studentships has increased, proportionally it has decreased from 25% of our total spend between 2006/07-2010/11 to 20% for 2015/16-2019/20.

It is unclear what opportunities will be available to EPSRC for additional funding for studentships in the future. It is clear that the number of students we are able to support from our baseline settlement will continue to decrease unless the training budget begins to rise at least in line with rising studentships costs. If not for NPIF, EPSRC student numbers would already be in decline and it is predicted that, for the next few years, the number of students supported will remain the same or decrease. There is also a risk of partner contributions (leverage) reducing from the economic impact of the pandemic which would further effect student numbers.

Table 1: EPSRC spend on training grants and research grants

	2014/ 2015	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020
Number of active EPSRC funded students	11258	11875	12578	13371	13500	12084
£M on training	178	182	177	184	194	205
£M on research	715	672	706	804	912	840

4. Where does EPSRC's Doctoral Education funding go?

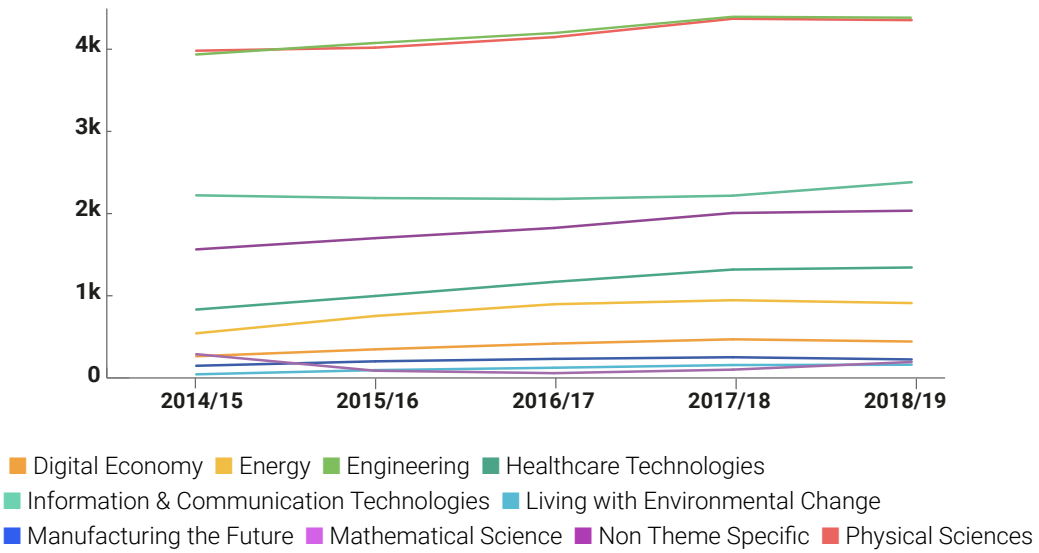
By scheme

The proportion of our students supported under each scheme closely maps our expenditure on the three main schemes, suggesting the financial support per student overall is similar across our different schemes. As discussed in the previous section, EPSRC funds students across three main schemes: Doctoral Training Partnerships (DTP); Centres for Doctoral Training (CDT); and Industrial Collaborative awards in Science and Engineering (ICASE). The proportion of students across these schemes is approximately 45% registered on DTPs, 45% at CDTs and ~10% registered on the ICASE scheme since 2015, matching the average proportion of expenditure for each scheme. There was some change in this proportion around 2014 and 2015 associated with the late commitment to 2013 CDT investments which led to some under recruitment of the first intake, but the CDTs compensated for this in later intakes.

By research area

EPSRC funds students across all areas of its remit. EPSRC categorises its remit at two different levels, themes and research areas. There have been no significant changes in the proportion of students in each theme over the last 5 years with student numbers rising in all theme areas relative to the overall increase in students (Figure 1). In addition to the theme, student projects are coded to EPSRC research areas. This looks at fields within a theme. The changes in the proportion of students in each research area tracks the changes in the proportion of research funding in each research area. During the years being considered, the main driver for these changes was the balancing capability strategies. Research areas which had a grow or reduce strategy saw their student numbers grow or reduce respectively, whereas the research areas which had a maintain strategy saw no change. The one exception to this was the significant increase in the Artificial Intelligence research area which saw a growth in both the research and student population, reflecting additional targeted investment.

Figure 1: Number of students by EPSRC theme between academic year 2014/15 and 2018/19



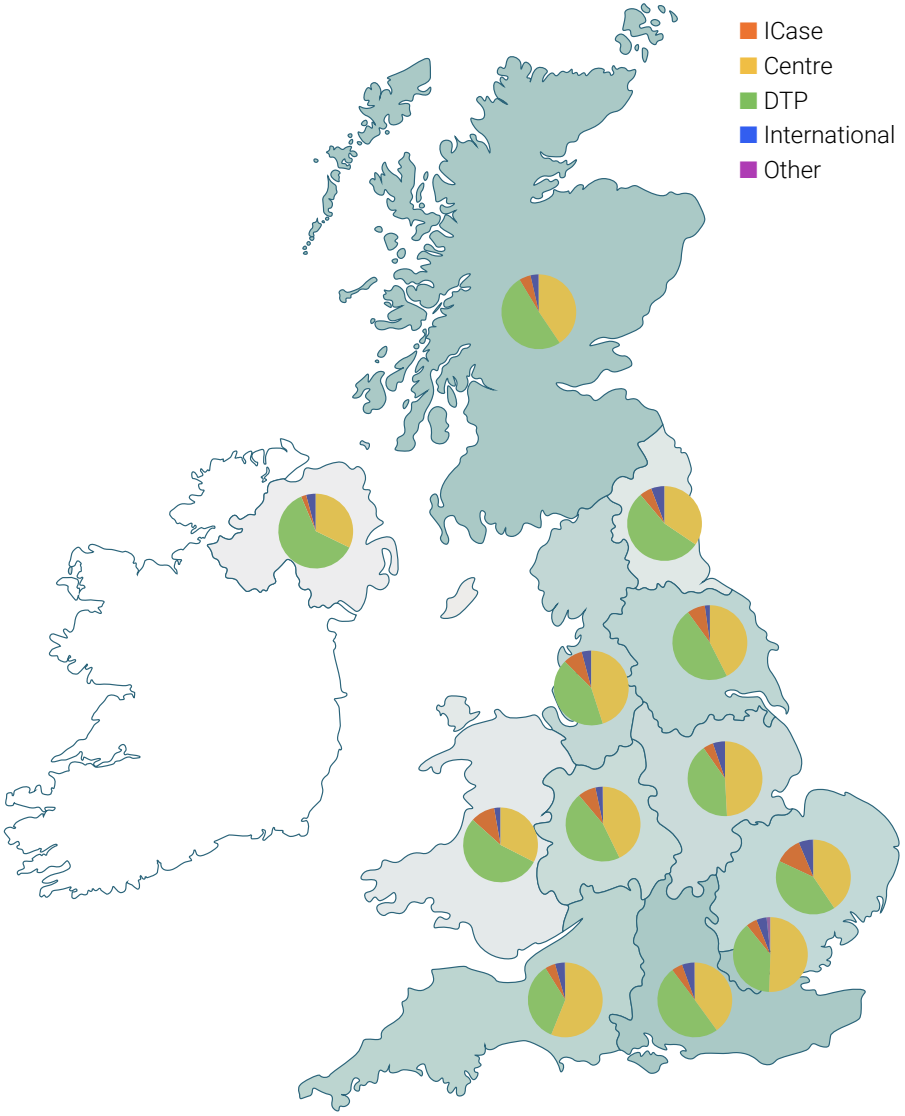
By location

EPSRC supports students in every region of the UK with the distribution of EPSRC funded students more or less identical to the distribution of EPS students across the UK[15] The map (Figure 2) shows the spread of EPSRC funded students by region in the UK in 2019. The darker the shade of green the more students are registered at universities in that region.

For the whole doctoral student population (all subjects) the geographic spread was effectively static between 2014/15 and 2018/19. Over the same period, the spread of EPS students underwent some changes, with a growing proportion of EPS students studying in Scotland. Meanwhile, the difference in EPSRC funded student numbers between regions has decreased, predominately driven by an increase in the number of EPSRC funded students in the East Midlands between 2014/15 to 2019/2020.

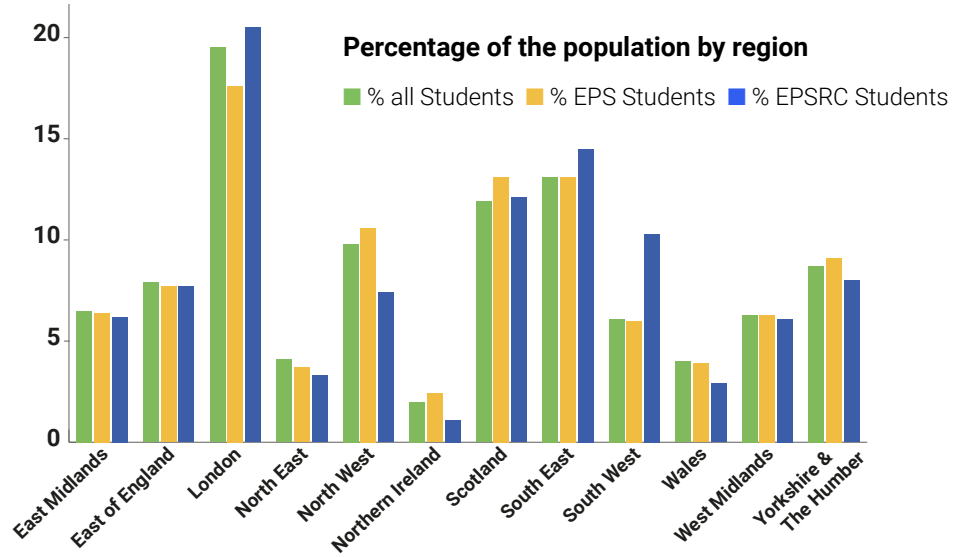
15 Information on EPSRC students from EPSRC data. Information on EPS students from HESA.

Figure 2: Map showing the proportion of new EPSRC funded doctoral students in 2019, in each region of the UK. The pie chart shows the breakdown by scheme.



The proportion of EPSRC funded students tracks the proportion of EPS students and the overall proportion of the student population (Figure 3). The differences are small and statistically insignificant in all regions except the South West and Northern Ireland (percentage difference between EPS students and EPSRC students < 0.5). The South West has more EPSRC students than expected considering the number of EPS students (percentage difference 0.7) and Northern Ireland has fewer than would be expected on this basis (percentage difference 1.3). The increased numbers of EPSRC students in the South West is likely linked to the success of Bristol University in securing CDT investments.

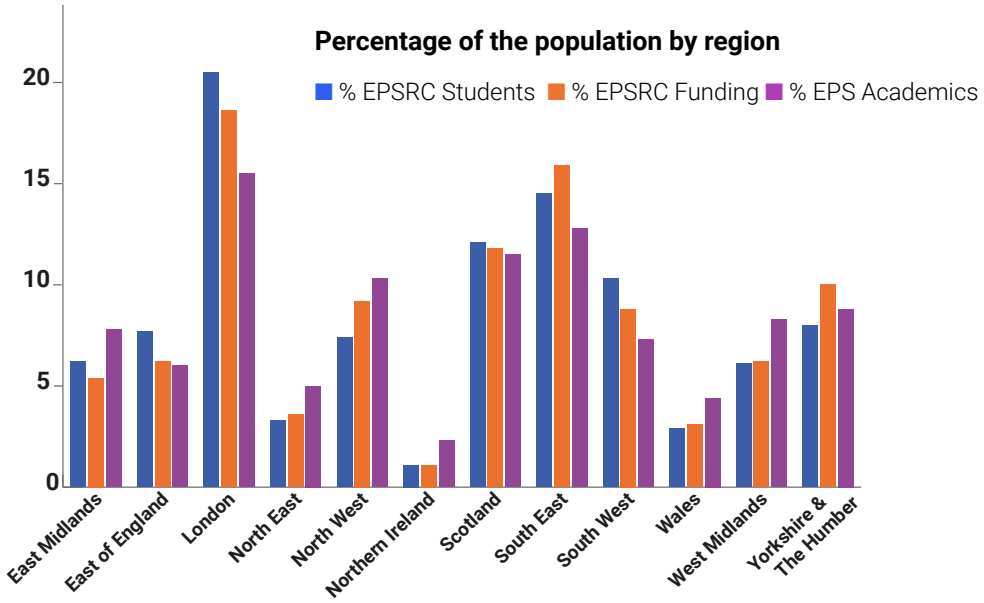
Figure 3: This graph shows the proportional spread of new students in 2019, by UK region. The green bars show all doctoral students, yellow all doctoral students studying in an EPS area and the blue bars show where EPSRC funded students are studying.



The proportion of EPSRC students also tracks EPS academics and EPSRC research funding by region (Figure 4). There is a very strong correlation between the proportion of EPSRC students and EPSRC research funding (percentage difference < 0.3) and between the proportion of EPSRC students and EPS academics (percentage difference <0.5), in all regions except Northern Ireland (percentage difference 1.2).

As the EPS academic population is also significantly correlated with the geographic spread of research organisations that are eligible for UKRI funding, the number of organisations in a region also influences student location.

Figure 4: This graph shows the proportional distribution of new EPSRC funded students across UK regions (blue) compared to EPSRC research funding (orange) and the distribution of EPS academics (purple) in 2019



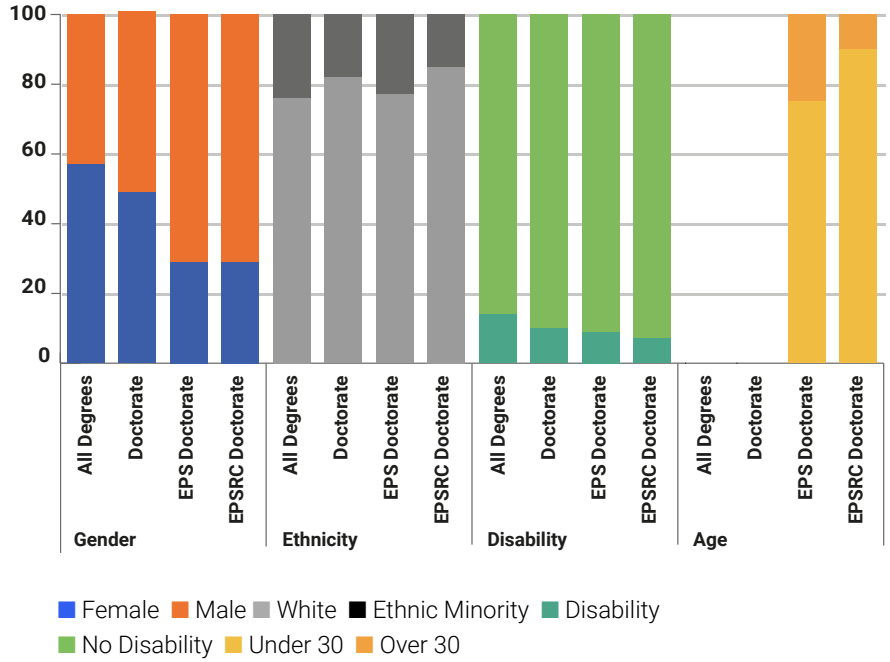
For students to get the best research education, they need access to state-of-the-art facilities and supervision by experts in their chosen field of study. For those who are unable or do not wish to relocate, geography affects their ability to access doctoral opportunities. However, these results show the tight interplay between these opportunities and the distribution of expertise. Any drive to alter the distribution of students across regions would likely need to be accompanied by the movement of EPS academics and associated research funding.

5. Who currently undertakes doctoral studies?

To better understand the make-up of the student population we support, we examined protected characteristic information held by EPSRC-UKRI[16] , the UK government[17] and Advance HE[18]. The majority of the information in this section comes from Advanced HE's statistical reports from 2015/16 (which focussed primarily on the 2013/14 academic year) and 2020 (for the 2018/19 academic year). All the following analysis has occurred on the population of people who have declared their characteristics. The rate of non-declaration varies and is often high, which may have an impact on the proportions.

As Figure 5 shows, there were some significant differences between the population of EPSRC funded doctoral students, EPS doctoral students and the general population of doctoral students. These are discussed below.

Figure 5: Graph showing the differences in characteristics between various student populations. Data drawn from a variety of sources, as detailed above. Proportions are calculated from the declared population, and the declaration rates vary based on the source, but are often high



Age

90% of the doctoral students funded by EPSRC are under 30 and EPS doctoral students overall are significantly more likely to be younger than the general population of doctoral students. This suggests that the majority of EPS PGRs (Postgraduate Researchers) are undertaking doctoral studies immediately or very soon after a first degree or taught postgraduate degree.

The main finding relating to age is the impact on the mode of study. Across the whole population, the Advance HE data shows that research postgraduate students in higher age brackets are more likely to be studying part-time. Less than 10% of the students under 26 studied part-time compared to 60% of those over 36 years of age. The proportion of all PGRs undertaking study part-time is higher than the proportion of first year research postgraduate students. While this could indicate a significant recent decrease in the availability of part-time options, it is more likely that this reflects changes in circumstances during study, with more students starting full-time and then changing to part-time part way through. This highlights the need to ensure doctoral models can accommodate people's changing needs during their studentship.

16 The 'EPSRC doctorate' information comes from data held in Je-S by EPSRC.
17 UK population by ethnicity, 2011 census
18 Equality in higher education: statistical reports | Advance HE (advance-he.ac.uk)

Disability

For EPSRC, the proportion of doctoral students declaring a disability increased from 4% of new students in 2014/15 to 7% in 2019/20 while the HESA PGR data showed this group steadily at 8% of first year PGR students over this time. This could show an improvement in accessing EPSRC funding, or simply a greater willingness to declare this status, but there is still a gap compared to the most traditional pool of applicants i.e., first-degree students (according to Advance HE in 2018/19 15.5% of first-degree undergraduate students had declared a disability).

Looking at disability by subject, it is clear from Advance HE that the proportion of declared disabled students in SET (Science, Engineering and Technology – as used by Advance HE) subjects is lower than non-SET. In 2018/19, while the average across all research postgraduate students was 10% with a declared disability, this was 12% for non-SET and 8.9% for SET. The participation gap at PGR level was 7.8 with 56.6% of disabled students studying a SET subject area compared to 64.4% of students not declaring a disability. For EPS, disabled students made up 8.1% of PGRs.

Of the four main EPS categories, computer science, physical sciences and mathematical sciences all had small participation gaps (0.5, 0.4, and 0.8 respectively). However, participation in engineering & technology was significantly lower with just 6.5% of PGR students in these subjects declaring a disability, a participation gap of 5.0 - the largest gap of all subject groups.

The reasons for lower participation are likely to be complex. One aspect that the data allowed us to consider was the attainment gap for first degree undergraduates as this could influence the diversity of the candidate pool and of those given offers for doctoral study. We compared the proportion of students who obtained a first or 2:1 in their degree as achieving a degree at this level is a common expectation of PGR candidates. It was not possible to make an absolute comparison between attainment and participation gaps because the student populations are not the same people and the attainment gaps (i.e., the difference in the proportion of students getting a first or 2:1 depending on disability declaration) vary significantly between subjects and academic year. However, it was notable that for engineering, while the attainment gap for first degrees in both 2013/14 and 2018/19 was the lowest of the EPS subjects, it had the highest PGR participation gap in 2018/19. These findings suggest that we should look to better understand the issues associated with undertaking doctoral study in EPS subjects as a disabled student. Certainly, for engineering subjects, attainment is not an apparent issue. We should consider how we can encourage and support wider access to doctoral opportunities.

Ethnicity

UKRI eligibility for funding students is based on residency criteria not ethnicity or nationality. It is important when reading this section not to conflate these. For example, there are scenarios where a UK citizen would not be eligible to receive UKRI funding. It is also important to separate changes to policies that allow a proportion of our support to be used for students who do not meet the residency criteria. While international students provide access to a much larger pool of ethnically diverse individuals, we would be doing the UK and its citizens a disservice if we focus on global talent movement as a means of resolving any ethnic diversity issues within the doctoral community. It is important that the UK addresses the causes of participation and attainment gaps that exist for UK domiciled people while ensuring an inclusive experience for all.

In 2018/19, the Advance HE report showed a research postgraduate population for UK domiciled students that was 82% white and 18% ethnic minorities. We compared this to the diversity of the principal candidate pool to enter research postgraduate studies (UK domiciled undergraduate and taught masters students) and to the general population in the most relevant age groups. In 2013/14, 20.4% of the principal candidate pool was from an ethnic minority group, rising to 24.5% by 2018/19. This time period covers those individuals most likely to be in doctoral studies in 2018/19. As most research postgraduate students are currently 21-35, we combined the 2011 census ethnicity data for the 18-24, 25-29, and 30-34 age groups to provide the most comparable general population information. Across this age range, the census data showed a general population where 19.5% of people were from ethnic minorities (11.3% Asian or Chinese, 3.9% Black) and 80.5% white. Both these information sources suggest that the PGR population is less diverse than would be expected.

When looking at ethnicity by subject studied, the Advance HE 2020 statistics report showed that the research postgraduate student population from ethnic minorities was skewed towards SET subject areas, with a participation gap of -1.9 (63.2% of all white PGR students study a SET subject compared to 65.1% of ethnic minority PGR students). This means a higher proportion of students from ethnic minorities studying these subjects compared with white students.

However, there were significant differences when looking at specific ethnicities and specific subjects. For engineering and technology, there was a negative participation gap across all minority ethnic groups, but it was much larger for Asian students than other minority ethnicities (i.e., a bigger proportion of Asian students study engineering and technology than the proportion of all ethnic minorities and compared to white students).

For mathematics, the participation gap was small when considering the overall ethnic minority population. However, the participation gap was large and negative for the Chinese population (i.e., more likely to study maths) and large and positive for the black population (i.e., less likely to study maths). For physical sciences, there was a positive participation gap across all ethnicities (i.e., they are less likely to study physical sciences). It had the second largest participation gap across all SET subjects after biological sciences and this gap was particularly high (8.9) for the black students.

As we did for disability, we considered the outcomes of people who undertook a first undergraduate degree, recognising this as only one facet of a complex landscape. Attainment information was only available from Advance HE as a binary split (white/ethnic minorities) at the subject level. It showed high attainment gaps in the four EPS subject groupings of 11.1 for computer science; 9.9 for engineering and technology; 8.1 for mathematical sciences; and 12.8 for physical sciences. As previously discussed, it is not possible to make a comparison between attainment and participation gaps because the student populations are not the same people. However, there is likely to be a potential impact of large attainment gaps such as these on the doctoral student candidate pool and recruitment processes.

Each year since 2014/15, around a third of new doctoral student records held by EPSRC do not include ethnicity information (either because it is not known, or the student has chosen not to disclose it). For HESA this is 3%. We know that around 56% of EPSRC's new students starting each year have declared themselves to be white, and 10% from an ethnic minority. This means within the population declaring their ethnicity, 85% are white, 15% from an ethnic minority. The HESA information for EPS first year PGRs in the same years is 77% white. Given the large number of students for which we do not have information, it is not possible to say if there is a particular problem accessing EPSRC doctoral opportunities, but we can see from the Advance HE reports that more could be done to encourage and support participation.

Gender

The Advance HE 2020 statistics report shows that between 2003/4 and 2018/19 the student population across all university level qualification types has stayed consistently around 57% female, 43% male. In 2018/19, the research postgraduate student population however was 48.9% female, 51.5% male. The information also shows that while UK domiciled PGR students are 50:50 across these binary genders, PGR students originating from the EU or a non-EU country are more likely to be male (53%). The reports covering the 2013/14 and 2018/19 academic years also showed that females were more likely to study part-time (2013/14: F - 29.0% M - 24.3%, 2018/19: F - 26.2%, M - 22.3%). This reinforces the importance of support for different study modes across all our training approaches.

Within EPS, female representation is much lower. For EPSRC, the proportion of doctoral students identifying as female has been around 30% since 2014 (only 1% of our students did not declare their gender). HESA's comparative data for 2018/19 showed 29% of all EPS PGRs identified as female.

The participation gap for female research postgraduate students in 2018/19 was 8.8 across the SET subject areas. The EPS subject grouping had the highest positive participation gaps across all subject groupings. Looking individually at the four EPS subject areas, engineering and technology, and mathematical sciences, had similar participation gaps at the undergraduate (first degree) level compared to PGR. Engineering and technology had by far the highest gap at 11.9 at PGR and 11.2 for undergraduate.

This means that while 18.5% of all the male PGRs studied engineering, only 6.7% of all female PGRs did. In mathematical sciences, participation gaps at undergraduate and postgraduate levels were 1.8 and 2.2 respectively. For physical sciences, the data suggests a significant increase in the participation gap from 2.2 for first undergraduate to 5.3 for PGR. While this could have indicated a drive to improve diversity at undergraduate level, similar figures were seen in the 2013/14 data suggesting that even if this was the case, it has not followed through to doctoral studies. Computer science bucked the trend with a larger participation gap at undergraduate (8.8) than PGR (3.9) and there may be positive lessons to be learnt from any computer science focussed initiatives that have encouraged women into postgraduate studies.

Attainment gaps do not appear to contribute in any way to the participation gap at PGR. Indeed, in 2018/19, the attainment of first or 2:1 class degrees by first degree female undergraduates was higher in all subject groupings (with the exception of social studies) compared to males. The barriers preventing women undertaking PGR studies are complex and require nuanced understanding.

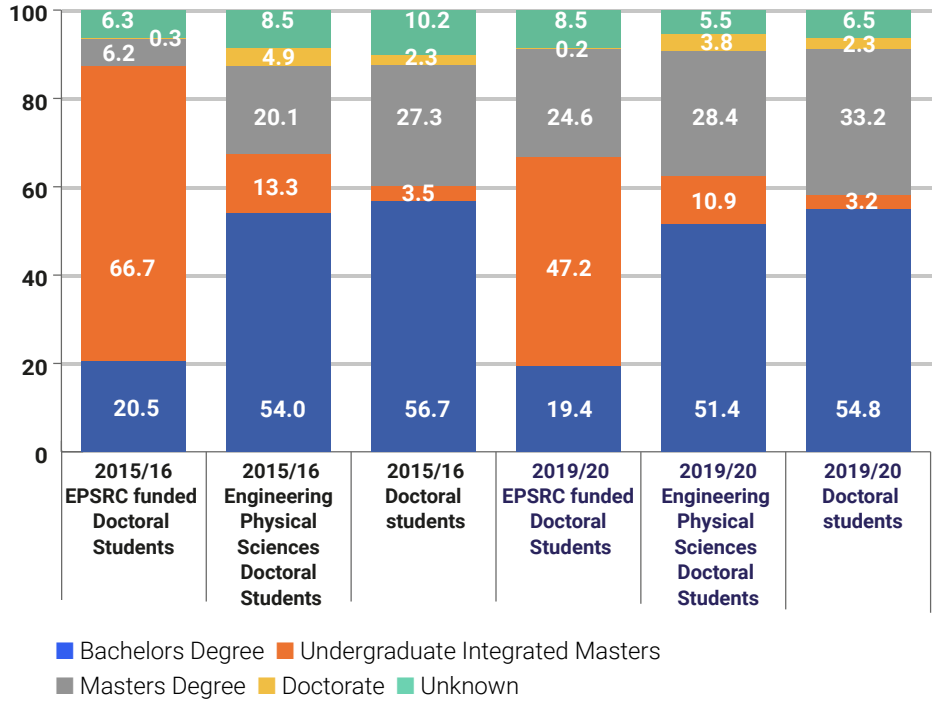
6. What qualifications do doctoral students have when they start their doctorate?

As described in the section above, the majority of EPSRC funded students are under 30, which suggests that the majority are undertaking doctoral studies immediately or very soon after a first degree or taught postgraduate degree. An analysis of our information on the most recent qualification of students before entering the doctorate[19] shows that the majority of EPSRC funded doctoral students begin their doctorate having completed an integrated undergraduate masters degree. Since 2015/16, there has been an increase in the number of students starting with a standalone masters degree. This may be due to the changes in funding available for taught postgraduate degrees.

There are significant differences between the most recent qualifications of EPSRC funded students to the wider population of doctoral students (Figure 6). Integrated masters are more common in EPS disciplines than other fields. However, this does not explain why EPSRC funded students are more likely to begin their doctorate with an integrated masters degree compared with other engineering and physical sciences doctoral students.

We know from age information that EPSRC students are more likely to have started a doctorate straight, or very soon after, this qualification. Particularly relating to widening participation, we need to consider if this indicates too much focus on candidates meeting specific qualifications requirements, preventing people with equivalent experience from effectively competing for places for example, or simply a product of the type of candidates our funding attracts. The possibility of contextual offers for doctoral places has also been raised by some stakeholders, as is now used for undergraduate offers. The implications of this could also be explored.

Figure 6: Comparison of the most recent qualification of doctoral students

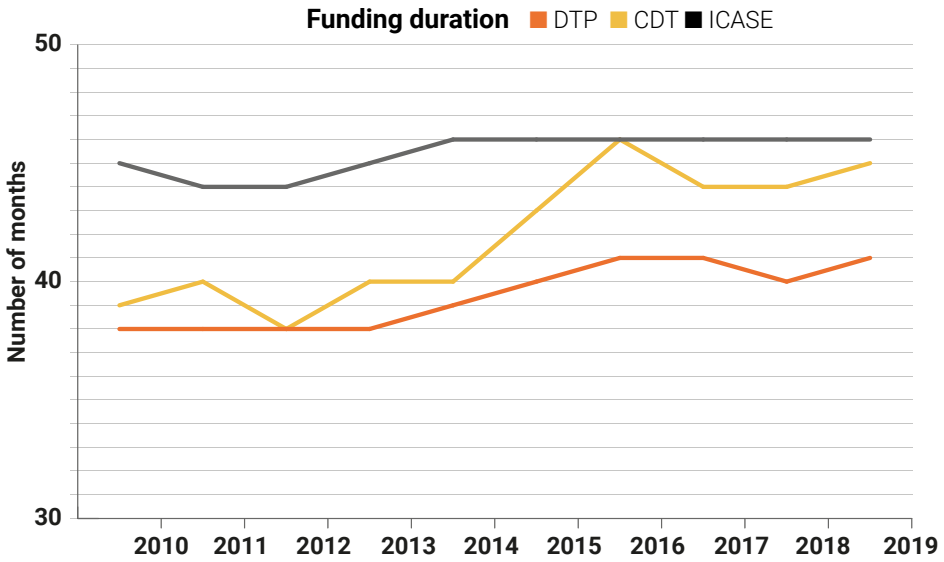


19 Data on EPSRC funded students from EPSRC data. Data on other categories from HESA.

7. How long does a doctorate take?

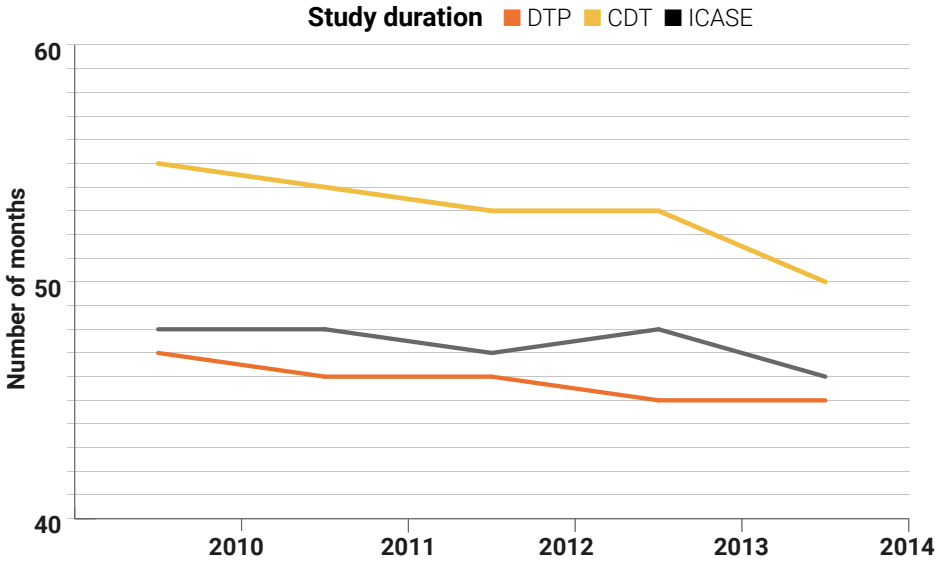
EPSRC provides studentship funding for between 3 and 4 years (full-time equivalent). The CDT scheme has always provided 4 years of funding (48 months) while the ICASE scheme transitioned to 4 years funding in 2015. In the DTP scheme, universities have the flexibility to offer studentships between 3 and 4 years. Figure 7 shows that since 2010, the average duration of a DTP studentship has risen and is now providing just over 3.5 years of funding[20].

Figure 7: The average number of funded months for students who started in that academic year.



Prior to 2018, EPSRC guidance stated that students could submit their thesis up to a year after the funded period ends. While we still provide this one-year flexibility to students, we do not expect students to require unfunded time to submit their thesis. In 2018, we made this clearer by including guidance to the training grant terms and conditions stating that all doctoral projects should be designed so that they can be completed and written up in the funded period. The effects of this change are only just beginning to be seen in the data. As can be seen from Figure 8,[21] the study duration for DTP and ICASE has remained fairly stable. However, we know that the funding duration for these schemes has been increasing, bringing study and funding durations more in line. For CDT students, the reduction in the time taken to submit suggests that projects are being better designed and managed to be achievable within the funded period.

Figure 8: The average number of months taken to submit a thesis, for students who started in that academic year.



20 The data includes both part-time students who have longer funded durations and students who complete early.

21 The study duration data is only complete once EPSRC receives the data on thesis submissions, each autumn. Therefore, only years where the majority of students have completed, are included here.

Most stakeholders felt that doctorates were long enough. While UK doctorates are not as long as in the US, for example, UK doctoral students are not expected to hold many of the additional responsibilities that US graduate students are, such as extensive teaching, tutoring, and marking. 75% of EPSRC funded students submit a thesis, most (98%) being a doctoral thesis. There are some small differences between the schemes, with CDT and ICASE students being marginally less likely to submit a thesis. Anecdotally this is prescribed to these students receiving offers from industry partners and not completing their thesis. There has been no change in the proportion of students who submit a thesis since the rule regarding designing projects to be completed in the funded period was introduced. This also suggests that 3-4 years is sufficient to complete a doctoral project. Reasons for students submitting after their funded period vary. Research by its nature is hard to predict so even projects thought to be suitable for the timeframe can prove not to be. All students face challenges. For some students their research takes a tangent, while others try to reach the same end point but using different methodologies. Research does not have a strict end point and students have told us they can find it hard to know when they have done enough, particularly if they are unable to reach a goal set at the start of the project. The interest of students and/or supervisors in the research, or in achieving a specific result, can lead to tension between recognising when sufficient work has been achieved to meet the needs of a thesis and wanting to progress the research as far as possible, reach a particular scientific outcome, or achieve enough for a/another publication. This can put pressure on students to not leave sufficient time for writing up during their funded period or leave writing until after their funding ends.

There were mixed views in the community about whether all studentships should be the same length. While this has the advantage of simplicity, it would fail to cater to the individual needs of students. In later sections, more bespoke or flexible approaches are seen as desirable by a number of stakeholders, including students. In general, it is not expected that students should have different amounts of time to spend on their research projects, rather that differences in funded periods should reflect a need for additional activities or take into account prior experience. This could be because of individual student needs, or the nature of the research challenge (interdisciplinary research can require a student to undertake more technical training for example).

8. Why do students undertake doctoral education?

Doctoral education is undertaken by students for a variety of reasons, but the most common is having an interest in the subject (35%), followed by it being required for a career in academia/research (30%).[22] This shows that doctorates are still seen by prospective students as a route into academia or other research careers. While this is a significant reason for entering doctoral education, the majority of doctoral students eventually go on to careers outside of academia.

The participants in EPSRC's student focus groups (run on our behalf by Vitae) were asked about their motivations for undertaking doctoral education and their responses matched the trends described in the HEPI student experience data[22]. The participants were mostly undecided about their career intentions. The students who had worked in other sectors before their doctorate were the most definite about their career intentions but were split regarding whether that was to remain in academia or return to industry.

Students were attracted to undertaking a doctorate for a variety of reasons:

- It provided them the time to be able to focus on research: to ask deeper questions and to investigate a topic fully or explore new ideas
- They would have the opportunity to engage in critical thinking and problem solving to come up with innovative solutions
- It would allow them to build networks with people with similar interests
- They would be able to undertake interdisciplinary research and collaborate with industry.

While students were mostly positive regarding the doctoral experience, they recognised that there would be challenges along the way. The key challenges identified were:

- The high workload. There was a concern that the lack of contracted work hours and the commonness of long working hours in academia meant that it was more difficult to maintain a work/life balance
- Working independently. As the majority of students are new to the area of their doctorate, there were concerns raised about their abilities compared to their peers. The independent working style of a doctorate also means that it is up to the individual

While enabling students to pursue a range of careers (and develop the associated skills) is important, research and training through conducting research must remain front and centre in the doctoral experience. We need to look at what can be done to improve the support and culture of the doctoral experience, but students largely enter a doctorate because they want to do research. Too much mandated time for non-research activity could reduce the attractiveness of doctorates. This means there needs to be a balance between the time used for activities that are valuable but additional to the research project and for the research itself, to stay motivated, prioritise workload and identify when to ask for support, which can be a steep learnings curve for those without experience of this working style.

22 PhD Life: The UK student experience – HEPI

9. What are the common experiences of doctoral students?

There are three areas that were raised as having a key impact on the overall experience of a student's doctorate: supervision, the training offering, and institutional/EPSRC support.

Supervision

The majority of students were positive about their supervisory experiences. However, there was recognition that they are highly dependent on their supervisor and that there is a power imbalance within the relationship.

Students identified the following positive supervisory traits:

- Knowledgeable
- Supportive
- Flexible
- Engaged
- Available
- Able to intercede and step back as appropriate.

When poor supervision was mentioned, a compounding issue was the lack of visible routes to raise and resolve issues. Even where the students were aware of complaint procedures, they were sometimes reluctant to go down this route due to concern about the power imbalance and (perceived) possible consequences for their research and career prospects. A wide range of supervisory structures were mentioned by the students. This meant it was sometimes difficult for students to relate their situation to standard procedures/advice.

It is fairly common for students to have multiples supervisors of varying sorts. Students with industrial supervisors were generally positive about the opportunities this provided them to engage with industry and access internships. Supervision by multiple people was found to be beneficial only in arrangements where the roles were clear, and every supervisor was bought into the structure and their roles. The most common feedback on supervision was the challenge in balancing the different requirements from within the supervisory team, particularly between academic and industry supervisors. This results in the student having to independently negotiate a path between these different expectations and ways of working.

Training offering

Most students were positive about the range of training and professional development available to them across a wide range of topics delivered through a central researcher development programme or locally through CDTs. However, it became clear that there is significant variation in the amount of training that is required and available to individual students. Where students had the flexibility to choose the activities that provided them the skills they deemed useful, they had more positive experiences. This was especially true when the activities included less formal activities that also provide training (e.g. conference attendance, outreach activities). Those who had a set of fixed training requirements found it restrictive and felt it took time away from pursuing other training opportunities that they wanted to participate in.

The largest barriers students raised in relation to accessing training activities were not being able to identify appropriate activities and not having the time available to participate. Students typically found the university was supportive in making an opportunity available when they had identified the activities that they wanted to participate in.

However, understanding what their future needs would be and identifying appropriate activities sufficiently far in advance was felt to be particularly difficult. Not having time to participate was usually associated with the supervisor. It was difficult for students to attend activities where they had supervisors who were not overtly supportive of participation in additional training. More discussion of the barriers can be found in section 12.

Institutional/EPSRC support

As students are not funded directly by EPSRC, their first port of call is, and should be, the support structure within the university they are registered with. This support is often complicated by the differing structures within universities and the fact that doctoral students are not undergraduate or taught students or staff. This can lead to postgraduate researchers having to navigate complex systems on their own, without clear signposting, at a period of complexity in their life. It was very clear that the students were not aware of the support available to them from EPSRC funding, via their university. This includes sick pay, parental leave, disability support and support for people with caring responsibilities. As only a third of doctoral students are funded by EPSRC, there can be differing levels of support available for doctoral students within an institution. When this is compounded with a lack of visibility of who their funder is, and EPSRC's policies, it can result in students not receiving the support they require and are eligible for.

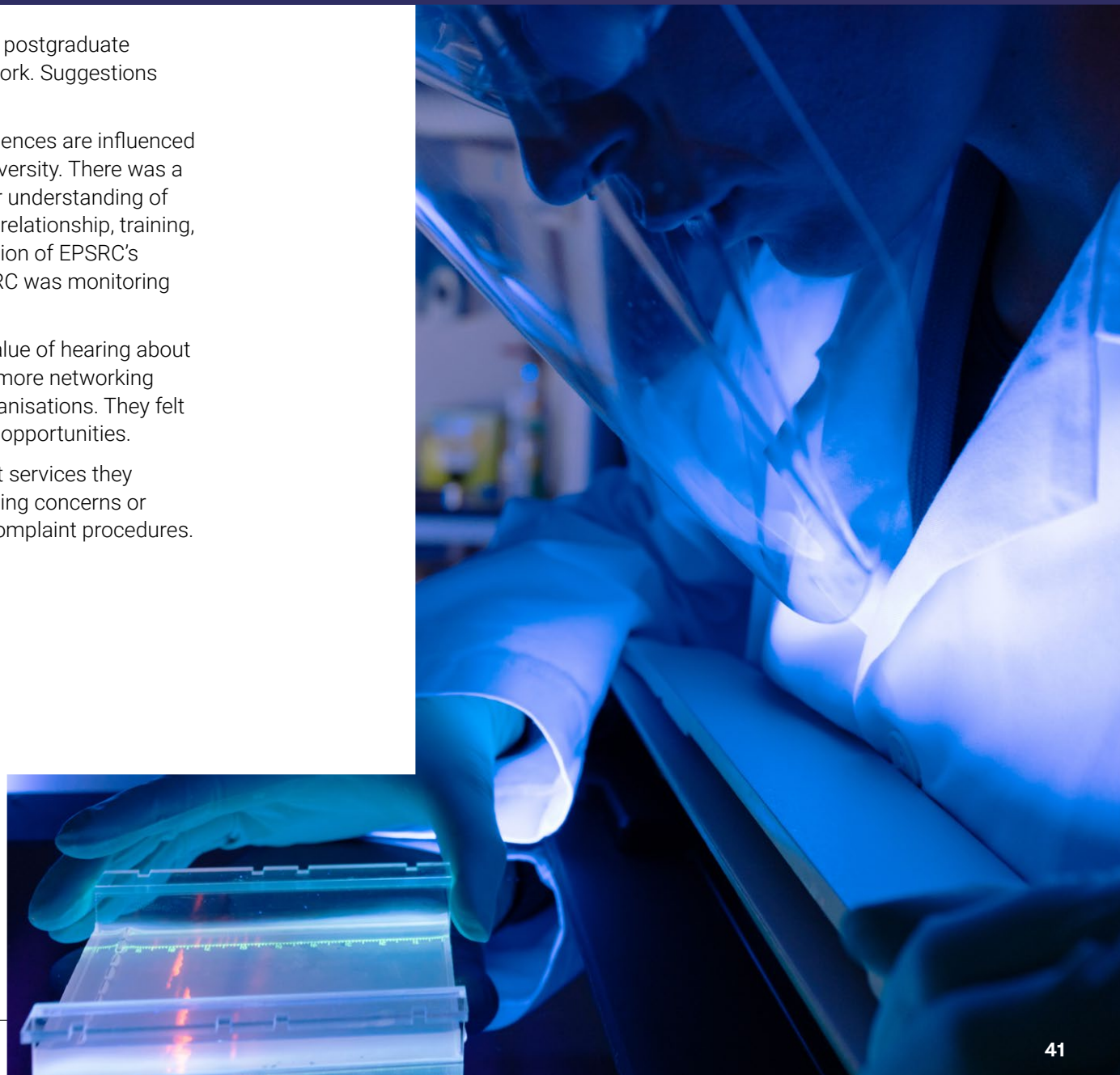
10. What improvements do students want to see to the doctoral experience?

A lot of the suggestions by students related to the UKRI new deal for postgraduate research and the information provided by them will be used in that work. Suggestions that relate to EPSRC are summarised below.

It was clear that students are confused by which parts of their experiences are influenced or mandated by EPSRC, and what falls under the purview of their university. There was a clear request for guidance on EPSRC's existing policies and a greater understanding of the expectations we hold of organisations regarding the supervisory relationship, training, and professional development. The students asked for a clear definition of EPSRC's and the university's responsibilities, and more reassurance that EPSRC was monitoring university adherence to the policies.

The students who participated in the focus groups recognised the value of hearing about other doctoral students' experiences. Another main request was for more networking and cohort activities with other students, both within and across organisations. They felt EPSRC was particularly well placed to facilitate cross-organisational opportunities.

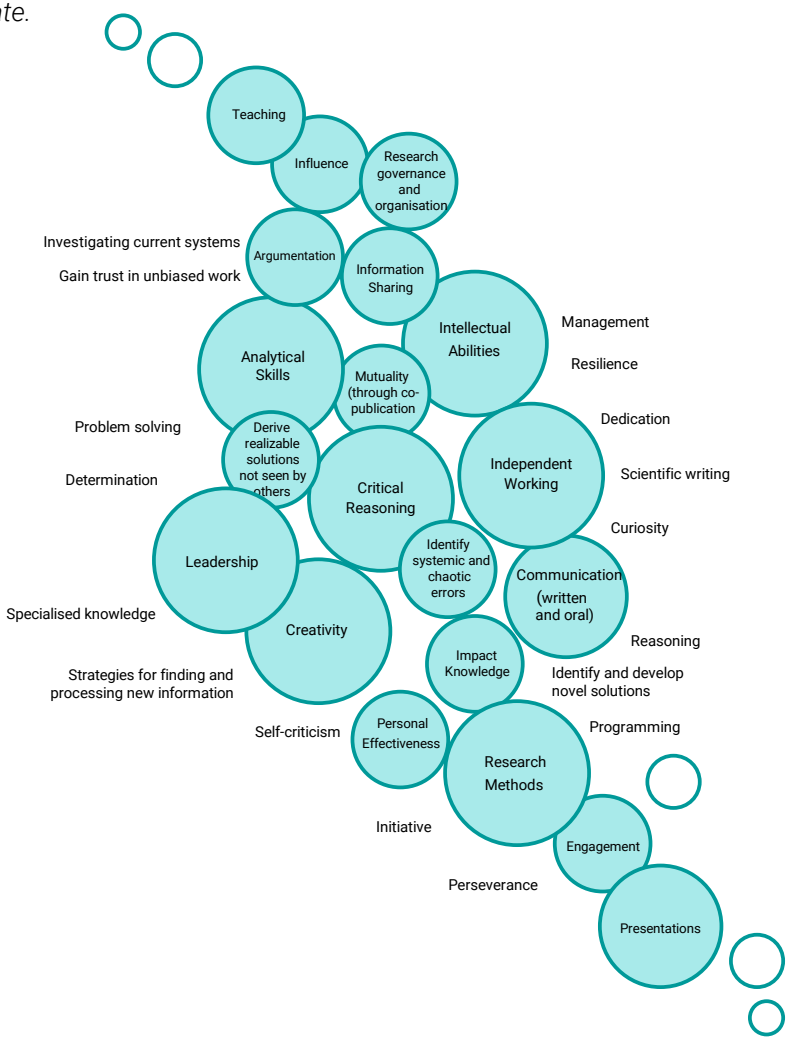
Within organisations, students requested clearer signposting of what services they can access and how. This included a request for more routes for raising concerns or problems informally before having to report issues through formal complaint procedures.



11. What skills do students develop by completing a doctorate?

EPSRC engaged with a wide range of stakeholders regarding skills development within a doctorate. The skills that the community identified as being developed by completing a doctorate map well onto the researcher development framework from Vitae (Figure 9).[23]

Figure 9: The skills recognised by the EPS community as being developed during a doctorate.



The key skills identified by academics, industry and students as being developed within a doctorate were:

- **Research methods.** This included both the fundamental practice of undertaking research, identifying problems, designing experiments, and critically assessing results, as well as the technical skills developed.
- **Communication skills, both verbal and written.** The ability to breakdown complex information for a lay audience was specifically highlighted.
- **Independent working.** This included ability such as time management, project management, resilience, and self-motivation.
- **Problem Solving.** Critical thinking skills and an ability to challenge the status quo were highlighted as being honed during a doctorate.
- **Collaboration and teamworking**. Many doctoral students work in teams and carry out collaborative research with colleagues and so develop critical teamworking skills.
- **Networking.** The ability to engage and work with others, especially across technical field boundaries.

All of the skills above were considered valuable, regardless of the eventual sector of employment of the doctoral graduate.

There was a recognition that students should develop these skills in a number of ways. This includes activities that are often considered standard parts of a doctoral experience such as presenting to a team or department, writing progress reports, writing papers, training others, collaborating with colleagues in both academia and industry, and teaching undergraduates. It is important that these kinds of activities are recognised for the skills they provide doctoral students.

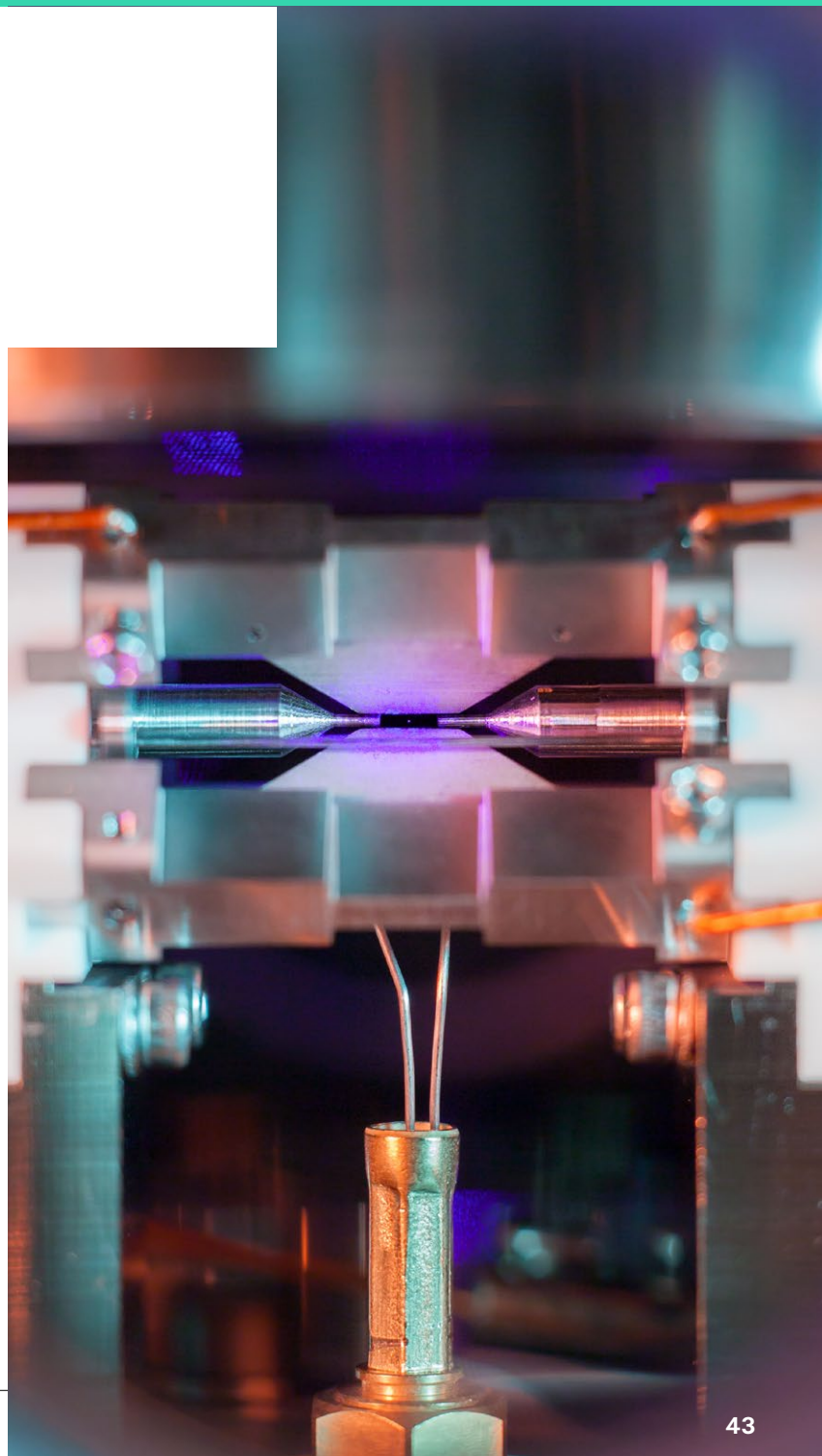
23 The full set of suggestions are available in the report of the student focus groups https://www.vitae.ac.uk/researchers-professional-development/about-the-vitae-researcher-development-framework

Students should also have the opportunity to participate in additional activities beyond their research project as these develop significant and useful skills, enhance those they are developing through their research, or give them a different perspective on how they can be applied. This is especially true of the skills that fall into domains regarding personal effectiveness, research governance and organisation and engagement, influence and impact. The types of additional activities vary from formal professional development opportunities e.g. training courses, to activities such as participating in conferences, public engagement, and work placements.

Sector specific skills relating to the sector a student wishes to enter were also recognised as useful for doctoral students to develop. For academia, these more specific skills include writing grant proposals and teaching. For industry, these specific skills were focussed on knowledge of industrial working such as: sector awareness; business management; commercialisation and technology transfer; and financial skills. While developing expertise is important, the RAND literature report highlights that specialisation in a narrow field, without broader disciplinary or sector awareness and additional transferrable skills, does not prepare doctoral students for varying and multidisciplinary environments. These environments are found across sectors, including academia.

With so many students changing their career aspirations over the course of their doctorate, it is important that students keep their options as open as possible. They should consider developing some experience across a range of sector specific skills while they decide their preferred route, in addition to broader training. This ensures students can make an active choice of the career they wish to pursue rather than feeling bound to a path because of the skill set they have developed.

In general, the majority of students participate in a wide variety of activities that allow them to develop a wide skill set. There is some variation in how easy it is for students to participate in these activities based on the funding mechanism, availability of activities at their institution, and levels of support from the supervisor. The one activity that was considered valuable by all stakeholders, but not widely available, was specific career guidance tailored for doctoral students.



12. What are the barriers for students to accessing experiences?

While universities provide a wide variety of experiences to doctoral students, not all students are able to access these equally. As part of the review, EPSRC has been considering what barriers exist that prevent students from accessing additional experiences. These experiences can be those we would generally expect should be available to all students, such as participating in conferences or presenting at seminars, to more discipline or individual specific experiences such as accessing specialist equipment/facilities or technical courses.

There are several key barriers, identified by the community, to accessing different experiences. These barriers apply to multiple activities and can arise due to a wide variety of personal circumstances. While varied, the barriers often relate to the need for equal availability to opportunities regardless of the study location, research group size, or funding mechanism. There is also a need for clear advertisement of what a doctorate entails, what opportunities should be available, and the benefits of these opportunities to the doctorate and individual.

The barriers identified were:

- **Ability to participate in activities that are out of working hours**
  A lot of activities that are a core part of academic culture have aspects that occur outside of standard working hours. These can vary from networking events, conferences, to use of experimental facilities.
- **Ability to travel**
  Many experiences require a student to travel, whether to singular events such as a training course or conference, or more regular travel, away from their normal place of study e.g., placements. The effect of this barrier is more pronounced the greater the distance travelled. For example, international travel is likely to pose a barrier to more students than travel within the UK. Currently there are some doctoral courses where travel is a mandatory aspect of the provision (multi–site experiences).
- **Time being available**
  Participation in additional experiences requires time to be available. A lack of time can be due to the student having a shorter funded period or because the time to participate in experiences has not been designed into the doctorate. The time to participate in experiences needs to be adequately resourced and participation valued by both the student and the supervisor.
- **Funds being available**
  Participation in additional experiences requires funding. While the costs of additional activities are an eligible cost on training grants, there is a significant variation in how the organisations that receive funding allocate training grant funds to support such activities. Enabling opportunities to be more accessible also often incurs an additional cost. Where a student requires additional support (outside of their standard doctoral activities) to attend an activity, EPSRC allows the additional cost of enabling them to participate to be charged to the training grant. For example, a student needing childcare over and above their normal arrangements could have the additional childcare costs covered. However, this flexibility does not appear to be widely known. Also, currently these costs must be drawn from within the existing funding envelope. The smaller or less flexible the award type, the more constrained that funding envelope is likely to be.
- **Availability of experience**
  Experiences are often only available at specific times or locations. This combined with some of the other barriers above means that they will not be accessible to all students or a student may find out about an opportunity too late. This is especially key when the experience has limited capacity or have short application periods.
- **Knowledge of activity**
  In order to participate in experience, the student needs to know it exists and that they are able to participate in it as part of their doctorate. Knowledge of opportunities is not equally available to all students. It depends on how their doctorate is being supported at the university, the knowledge and support of their supervisor/s, and their access to wider networks. A needs analysis by which there is early exploration of the types of opportunities a student may benefit from, and planning these into the doctoral timeline (at least approximately), could be beneficial.

The barriers which prevent students from accessing experiences cut across a number of levels in the system. Some relate to the personal circumstances of students; the knowledge, experience, and attitudes of supervisors; and support and expectations of universities, partners, and EPSRC. What is clear is that early in a doctorate, students should be having active discussions about the opportunities available (or that they should look out for) and what they might benefit from.

This will allow the time and funding available, and ways of supporting personal circumstances, to be considered. For some individuals, barriers to accessing a specific opportunity may be too high, but through early identification of the need, alternatives can be explored.

Before studentships begin, it is also important that EPSRC, universities and supervisors ensure that the time, funds, and support routes for experiences are actively considered during the allocation and project design stages.

13. How do partners want to engage with studentships in the future?

EPSRC engaged with a wide range of companies throughout the stakeholder engagement section of the review. There was a strong theme for the need for more investment in collaborative doctoral education across all discussions, both through the use of the current schemes and the development of new bespoke schemes. Greater involvement of Small and Medium Enterprises (SME) was often raised with the SME environment recognised as providing benefits for the doctoral student as it is a focussed environment, where the impact of the project is tangible. The benefit to the SME is that the doctoral project can inject critical knowledge into the company, give the SME access to a network of experts, and be a key aspect of their longer-term development.

The ICASE scheme is well liked by both those who currently receive vouchers and those who are currently unable to participate. Many companies would like to see the number of available vouchers increased. However, there was also recognition that the ICASE scheme is not appropriate for all companies and that there needs to be more consideration for how companies (and SMEs in particular) can be enabled to be more greatly involved in doctoral education and given better visibility of the different options available across schemes. There is a lack of visibility of the opportunities to collaborate through the DTP and CDT schemes, with some stakeholders believing only ICASE supports these.

As part of better promoting collaboration through the other schemes, there were requests for the current flexibilities available on the DTP and CDT scheme to be both:

- Better advertised, so that companies were more aware of what is possible and how to utilise them
- Better incentivised, so universities were encouraged to participate in collaborative doctoral education and make the processes for engagement more user friendly

There was a recognition that the provision of doctoral education at universities follows a fairly standard model and that this can prevent employees participating in doctoral education or bespoke arrangements with companies being developed. It was considered by stakeholders that increasing the use of alternative doctoral qualifications (e.g., EngD or doctorate by portfolio) and training models (remote learning, better supported part -time learning) would enable more companies and individuals to participate.

Many companies requested that there was a way to prioritise the students in areas where there are currently fewer doctoral students. This was raised in the context of both research areas and geographical areas. Prioritising niche research areas would ensure that all areas of research are moving forward and allow new discoveries to occur, which may end up evolving into significant areas of activity. If EPSRC were to consider place when prioritising studentships this would allow wider benefit from the investment and would also allow EPSRC to increase the value of national institutes in relation to doctoral education.

There were significant discussions around non-academic partners engaging with doctoral education by providing training. The majority of companies were positive about the idea of providing training but there were limitations on their ability to do so relating to funding and the capacity of their personnel.

Lots of companies wanted to be able to learn from others regarding a variety of topics relating to doctoral education. They wanted more opportunities to engage with each other, doctoral students, and academics. Suggestions ranged from buddying schemes for smaller companies to partner with larger ones, networking events between academics and companies, training on how to provide placements and supervision, engaging with Research Organisations and opportunities for companies to advertise problems for which students then pitch solutions or research projects.

14. Why should companies employ a doctoral student?

Doctoral graduates are highly trained researchers who also have a wide range of transferrable skills.

There are three key areas where doctoral graduates bring benefits to companies:

- **Scientific knowledge which is directly relevant for the company**
- **General scientific research knowledge and approaches**
- **Transferrable skills gained as part of completing a doctorate.**

Scientific knowledge which is directly relevant for the company

Doctoral graduates with scientific knowledge of direct relevance to a company bring in new technical expertise. This can also provide the company with an awareness of competing technologies and access to a network of academics working in relevant fields. An additional benefit of hiring doctoral graduates with direct technical knowledge is that the company is able to bring in technical leadership, start succession planning and accelerate the development process. Where a company is looking to diversify or open up new technical areas, hiring technical experts at the doctoral graduate level allows the company to bring in cutting edge knowledge and enable the company to upskill other employees.

General scientific research knowledge and approaches

There are significant benefits to hiring doctoral graduates who are trained to the doctorate level in scientific disciplines, even if the topic area is not directly relevant to the company.

Doctoral graduates going into a research or research related role have more practical experience than undergraduates. They are able to become acquainted with new areas of science rapidly; this means they require less training.

Doctoral graduates have a solid training in applying research methods to challenging questions. Over the lifetime of someone's career, it is likely that both the role they are in and the topics of interest to a company will change. Hiring someone who is able and willing to apply their knowledge of research to new areas provides resilience to an organisation, enabling them to redeploy existing staff rather than hiring new employees.

By coming into an area, doctoral graduates are often able to spot problems, or possible improvements, quicker than people who have been working in the area for some time. A doctoral degree trains someone to think critically about things and to solve problems and also often provides them with the confidence to question why things are being done in a certain way. The recent Government Innovation Strategy recognises that "those fresh minds at the start of their career can be especially effective at bringing new ideas and perspectives, break down paradigms, and may be less scarred by failure". Identifying these improvements, can result in significant benefits and savings for a company.

Doctoral students build significant scientific networks during their studies. Hiring doctorate graduates means companies have access to those networks. Graduates not from a directly relevant field broaden the expertise that can be accessed as part of the company's overall network. This can increase the awareness of companies of new research or fields, allowing new connections, innovations, and applications to be identified and used in ways that would not have otherwise been considered. This could lead to a competitive advantage. The Innovation Strategy recognises that "many great innovations have come about from people moving between fields and bringing new ideas".

Transferrable skills gained as part of completing a doctorate

Many organisations hire doctoral graduates into roles that are not research related, although few specifically recruit doctoral graduates to these roles. Having people with doctoral level scientific knowledge and experience in these roles helps build cross organisational knowledge and is beneficial in engaging with stakeholders. The communication skills developed by completing a doctorate are beneficial in a variety of roles. They have usually had to tailor content and communicate technical information for a range of audiences. Having employees in non-research roles who can confidently and knowledgably communicate technical aspects helps lend credibility to an organisation. In areas of a company that are not strictly research related, but are research adjacent e.g., patents, having doctoral graduates can lead to efficiencies. This is because doctoral graduates are more familiar with the scientific process and able to assimilate information quickly.

Across any role, the following skills are valuable to the organisation and common in doctoral graduates:

- Independence and resilience – these two aspects mean that doctoral graduates are able to hit the ground running and take ownership of their work. They are also used to facing challenges and have the skills to overcome them
- Analytical skills – EPS doctoral graduates all have high level analytical skills that are beneficial to a wide variety of roles
- Communication skills – the ability to explain highly complex information to a variety of audiences is necessary in both technical and non-technical roles
- Team working – where doctoral graduates have experience of team working this develops valuable skills as the majority of industry projects are team based.

In the engagement EPSRC had with stakeholders, the value of employing doctoral graduates was clear to the organisations. However, there was an indication in the literature that the value of hiring doctoral students is not always clear to non-academic employers. As EPSRC predominately engages with organisations with an interest in scientific research, this suggests that there is not the same level of awareness of the valuable skills doctoral researchers possess in the wider industrial landscape. The Government ambition to increase the UK's research and innovation activity affects the private sector as much as university-based R&I activity. It is important companies are able to expand as they wish, with access to skilled people. Greater awareness of how doctoral graduates can help companies to achieve their own ambitions is important.

15. Where do the doctoral graduates go?

Geographically

As can be seen from Table 2, 18 months after finishing their doctoral studies, over half of EPS doctoral students (54%) had stayed in the region in which they studied. London, Scotland, and Northern Ireland retained the largest proportion of the individuals who trained in that region while the East and South East regions of England lost around 60% of their students.

Overall, 46% of all doctoral graduates were employed in a different region from the one in which they studied. However, there was a wide variation between regions. Through the combined effect of doctoral graduates leaving an area after study and doctoral graduates moving in, most regions saw net immigration. Only three regions had net migration with increased numbers of doctoral graduates – the East and South West regions of England, and London (Figure 10).

Figure 10: The location of EPS doctoral graduates was considered relative to the location of the university they were registered at for their doctoral studies. This graph shows the number of EPS doctoral students who has stayed in the same region, had left that region, and the number of doctoral graduates who had moved into that region after study. The net movement that resulted is also shown.

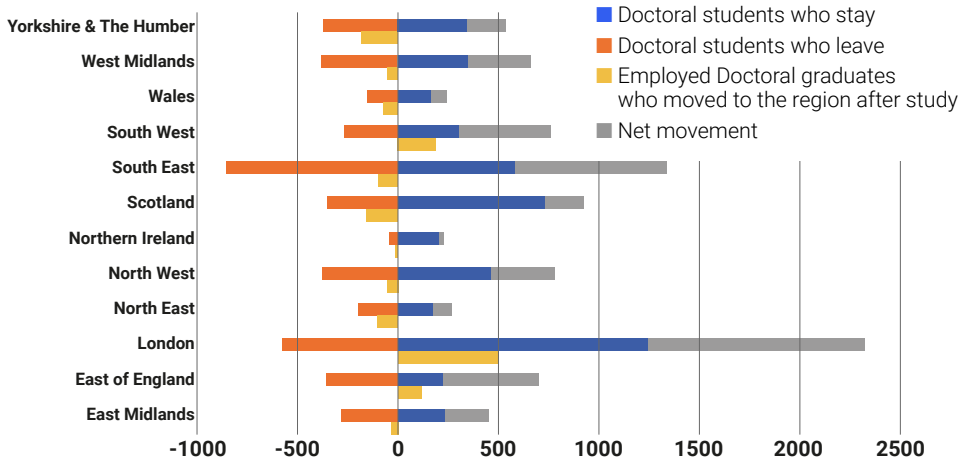


Table 2: How EPS students and graduates are located across the UK[24]

Region	Studied	Employed	Proportion of doctoral students who: Stayed in region for their first employed position	Proportion of doctoral students who: Left the region for their first employed position	Proportion of doctoral graduates who: Moved to the region for their first employed position
East Midlands	486	450	42	58	58
East of England	584	703	38	62	62
London	1,831	2,327	68	32	32
North East	369	268	46	54	36
North West	838	783	55	45	41
Northern Ireland	245	229	82	18	12
Scotland	1,086	928	67	33	21
South East	1,441	1,340	40	60	57
South West	574	763	53	47	60
Wales	316	243	51	49	34
West Midlands	719	664	46	54	50

24 From HESA data. This information is not always reported for all graduates and only one third of the EPSRC graduates can be identified, therefore this analysis is carried out on the population of all EPS students.

In order to achieve net migration, the East and South West regions of England, and London employed more doctoral graduates than they trained. The East of England was the region that was most reliant on attracting graduates from elsewhere through the combination of having more job opportunities than doctoral students and losing the majority (68%) of the students it trained.

Some areas with net immigration employed significantly fewer graduates than students trained while the rest employed around the same number. For the North East, Yorkshire and the Humber, and Wales, the number of doctoral graduates employed was under 80% of the number of doctoral students they trained. As they typically retained around half of their students, it meant proportionally, around a third of employed graduates had moved into that area after study. Scotland was in a similar position (86% jobs compared to students) though higher retention (67%), meant that 79% of all EPS doctoral graduates employed there had also studied there. The East Midland, North West, South East, and West Midland regions of England also retained around half of their students but employed approximately the same number of graduates as students they trained. Northern Ireland employed around the same number of graduates as students they trained but with over 80% of students staying in the area, doctoral graduates who were already in the area accounted for 88% of the EPS graduates employed.

Each region will have its own unique circumstances. The difference between the number of doctoral graduates employed compared to students trained means each region will have its own challenges when considering the net movement of people with doctoral qualifications. Given the UK aspiration to increase research and innovation activity, we can assume a corresponding increase in demand for doctoral graduates. Regions increasing job opportunities, or already struggling to fill vacancies, will need either strategies to encourage students to stay in the area or to attract graduates to move into the region, or both. For example, as it already retains 82% of its students, Northern Ireland is likely to need to look at how it can attract more graduates to move into the region while the East of England, which already attracts most of its graduates from other regions, might choose to concentrate on retaining students.

Without strategies that change retention or movement into a region, the impact of globally increasing student numbers will be dampened in regions with low retention or less inward flow of graduates. If UK student numbers overall do not increase in line with job opportunities, the ability of a region to meet its needs will come at the cost of another region. For example, London is already retaining and attracting a relatively large number of individuals. If student numbers do not increase, the flow of students to London will reduce if other regions better retain or attract individuals. It is important for EPSRC to consider the interplay of student numbers when developing regional aspirations and strategies.

Careers

The majority (over 80%) of EPS doctoral students are known to be in some form of employment, 6 months after graduation (Table 3)[25] . However, it is well known that the intended careers of doctoral students change over the course of their doctorate.[26] The majority of those entering their doctorate intend to pursue an academic career (67%) but over the course of their doctorate, an equal proportion of students change their mind from their original intention. This means that, for example, while the number of individuals intending to pursue an academic career stays relatively constant by stage in the doctorate, individuals change their minds. Only a small proportion of students enter doctoral education with the intention of going into non-research careers (20%).

EPSRC graduates are much more likely to enter employment in industry than EPS graduates overall, with industry employing over 40% of EPSRC graduates (around half of those known to be employed) compared to 20% across the EPS population (Table 3). When looking at the type of role they undertake in industry, little difference is seen in the proportion that undertake a research or research-related role compared to EPS students overall (Table 4), but a higher proportion remain in a STEM-related career (86%) than the EPS population (77%) (Table 5). When looking at the sectors of those employed in industry, EPSRC doctoral graduates and EPS doctoral students are comparable. The main sectors EPSRC doctoral graduates go into are Manufacturing, Information and Communication and Professional, Scientific, and Technical activities (Table 6). One explanation for the larger proportion of EPSRC graduates in industry is that the high levels of industry engagement on some EPSRC studentships result in a greater awareness of industry careers, as well as allowing industry partners greater awareness of potential future employees.

25 HESA DEHLI data.
26 PhD students and their careers - HEPI.

Around 35% of EPSRC graduates remain in academia (Table 3). While this is lower than the EPS population overall (42%), engagement activities with the community suggest no indication that EPSRC funded students are less appropriate for academic careers than those funded from other sources. Rather, it is more likely an effect of the higher proportion being employed in industry. For EPS as a whole, these two employer types (academia and Industry) employ 62% of EPS graduates but 77% of all EPSRC graduates.

A smaller proportion of EPSRC graduates also enter the public sector (5%) compared to the EPS population (14%), again likely reflecting the increased concentration in industry. Despite smaller proportions compared to the overall EPS population, those EPSRC graduates who do enter this type of employment are much more likely to be in a research or research-related career. 65% of the EPSRC funded graduates employed in a Higher Education Institution (HEI) are in a research or research related role compared to 38% of EPS doctoral graduates overall, and 24% of EPSRC graduates in the public sector are in such a role compared to 7% of all EPS graduates (Table 4). When employed in a university, EPSRC graduates are also more likely to be in a STEM-related career within these employer types (87% compared to 54% for all EPS, Table 5).

EPSRC graduates are more likely to enter a STEM-related career compared to EPS graduates overall. While most doctoral graduates (78% of all EPS and 69% EPSRC) go into non-research careers (Table 4), the majority do enter a STEM-related career with 51% of EPS doctoral graduates doing so and 72% of EPSRC graduates entering a STEM career (Table 5). We see that EPSRC graduates in engineering are more likely to go into industry than those in a science area.

Table 3: The proportion of doctoral graduates in each employment type

	EPSRC funded Doctoral Students	All EPS Doctoral Students	Difference
Engaged in Study	2.2%	2.7%	-0.5
Employed in Higher Education Institute	34.1%	41.7%	-7.7
Employed in Industry	42.4%	20.1%	22.3
Other employment	1.2%	2.1%	-0.9
Employed in the public sector	5.2%	14.4%	-9.2
Self Employed, Voluntary and Unpaid work	3.1%	4.6%	-1.5
Unemployed	3.7%	5.5%	-1.8
Not known or not reported	8.0%	8.8%	-0.8

Table 4: The proportion of the EPS or EPSRC graduates going into a career of a given role[27] with a particular employer type is shown. The total at the bottom of the table provides the total proportion of EPS or EPSRC graduates undertaking a particular role irrespective of employer (as not all employers are shown in the table, the value is not the total of the column). Within an employer type (row), the proportion of graduates in different roles is provided in brackets for the EPS and EPSRC groups. The total columns provide the total proportion of the EPS or EPSRC graduate population that go to an employer type, irrespective of role type.

	EPS				EPSRC			
	Not research	Research	Research related	Total	Not research	Research	Research related	Total
Employed in Higher Education Institute	25.7 (61.5)	15.5 (37.2)	0.52 (1.3)	41.7	11.9 (34.9)	21.8 (63.8)	0.4 (1.3)	34.1
Employed in Industry	16.6 (82.7)	2.8 (14.1)	0.64 (3.2)	20.1	36.5 (86.0)	5.2 (12.3)	0.7 (1.7)	42.4
Employed in the public sector	13.4 (93.0)	0.5 (3.6)	0.49 (3.4)	14.4	4.0 (77.0)	0.7 (12.8)	0.6 (10.7)	5.2
Total * includes other categories not shown in the table	**78**	**20.1**	**1.8**	**76.3**	**69.5**	**28.8**	**1.8**	**81.7**

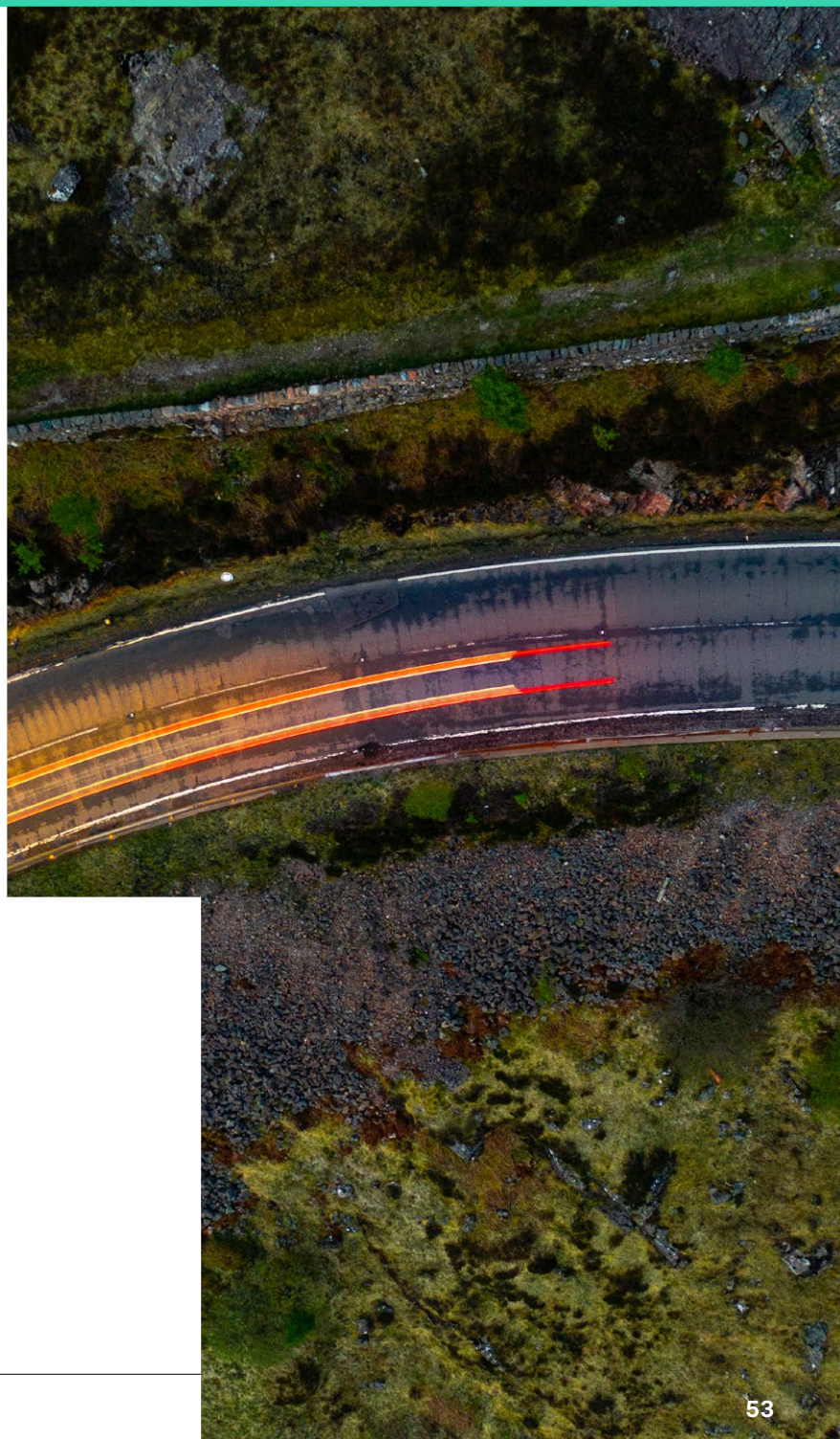
Table 5: The proportion of the EPS or EPSRC graduates going into STEM or Not STEM related careers with a particular employer type is shown. The total at the bottom of the table provides the proportion of EPS or EPSRC graduates undertaking a particular career irrespective of employer (as not all employers are shown in the table, the value is not the total of the column). Within an employer type (row), the proportion of graduates in different career type is provided in brackets for the EPS and EPSRC groups. The total columns provide the total proportion of the EPS or EPSRC graduate population that go to an employer type, irrespective of career type.

	EPS			EPSRC		
	Not STEM	STEM	Total	Not STEM	STEM	Total
Employed in Higher Education Institute	19.4 (46.4)	22.4 (53.6)	41.7	4.3 (12.7)	29.8 (87.3)	34.1
Employed in Industry	4.9 (23.3)	15.4 (76.7)	20.1	6.1 (14.3)	36.3 (85.7)	42.4
Employed in the public sector	5.1 (35.2)	9.3 (64.8)	14.4	2.9 (56.7)	2.4 (45.4)	5.2
Total * includes other categories not shown in the table	**49.0**	**60.0**	**76.3**	**28.1**	**71.9**	**81.7**

27 Only job classification known to be research, or research-related were classified as such.This means some, more ambiguous job titles, have not. It is likely the analysis overestimates the proportion entering a non-research role.

Table 6: Proportion of EPSRC doctoral graduates by sector

	EPSRC
Mining and Quarrying	0.9%
Manufacturing	23.9%
Electricity, gas, steam, and air conditioning supply	0.9%
Water supply, sewerage, waste management, and remediation activities	0.7%
Construction	2.3%
Wholesale and retail trade; repair of motor vehicles and motorcycles	2.7%
Accommodation and food service activities	0.9%
Transport and storage	0.7%
Information and communication	20.7%
Financial and insurance activities	6.2%
Real estate activities	0.3%
Professional, scientific, and technical activities	38.9%
Administrative and support service activities	1.0%



Summary, conclusions, and recommendations

Doctoral students make a significant contribution to research and the wider economy

The evidence gathered during this review shows that doctoral students continue to be significant contributors to the research and innovation system. They make both an original contribution to the research landscape through their doctoral research projects, and support the replenishment and growth of talent, becoming the UK's future excellent researchers and innovators.

Doctoral research

It is important that we recognise both the contribution of students during their doctorate and throughout their careers afterwards. Doctoral studies may be considered as training positions, but the students are not just taught. These degrees should not be mistaken for the type of training experienced during an undergraduate and taught masters degree. As postgraduate researchers, they themselves generate new knowledge. This is exemplified by EPSRC's students, who publish an average of 1.4 publications each over the course of their doctorate.

Doctoral research projects occupy a unique space in the research landscape. Doctoral students have the freedom to truly explore their research activity and follow new directions, without being tied to pre-set deliverables that are more common with other research activities. This allows doctoral research to be more creative and explore areas that would otherwise be considered too risky for other funding opportunities. They can often be the precursor to further research projects, catalysing new research challenges, avenues, and innovations.

Careers after a doctorate

EPS doctoral graduates are highly employable with over 80% in some form of employment, 6 months after graduation. Industry and academia are the main employer types, with 62% of all EPS doctoral graduates, and 77% of EPSRC graduates, employed in these organisations. While most doctoral graduates go into non-research careers, the majority of doctoral graduates continue in a STEM-related career with EPSRC graduates more likely to do so (72%) than all EPS graduates (51%).

Over 40% of EPSRC graduates enter employment in industry, a significantly higher proportion than EPS graduates overall (20%) and around 35% of EPSRC graduates remain in academia. The main sectors EPSRC doctoral graduates go into are Manufacturing, Information and Communication and Professional, Scientific, and Technical activities.

For both the public sector and academia, a higher proportion of the EPSRC doctoral graduates employed at these organisations are in a research or research-related roles (24% and 65% respectively) compared to EPS students overall (7% and 38% respectively).

The Government ambition to increase the UK's research and innovation activity will need increased investment by the private sector as much as increased university-based R&I activity. It is important companies are able to expand as they wish, with access to skilled people. The literature points to a need for greater awareness amongst non-academic employers of how doctoral graduates can help them achieve their ambitions.The benefits of employing a graduate with scientific knowledge of direct relevance to a company are clear. The postgraduate researchers bring in new technical expertise as well as providing the company with an awareness of competing technologies and access to a network of academics working in relevant fields.

Non-academic employers can benefit from hiring doctoral graduates from fields different to those they typically focus on. Doing so can increase the awareness of companies of new research or fields, build new connections, and enable new innovations and applications to be identified and used in ways that would not have otherwise been considered. This could lead to a competitive advantage. Where a company is looking to diversify or open up new technical areas, hiring technical experts at the doctoral graduate level allows the company to bring in cutting edge knowledge and enable the company to upskill its workforce.

Doctoral graduates are highly trained researchers who also have a wide range of transferrable skills. This makes them valuable employees, even for organisations outside of research and innovation. Doctoral graduates have a fundamental training in applying research methods to challenging questions and have experience in learning, analysing, and communicating highly complex, technical information. Doctoral graduates are often able to spot problems or possible improvements, quicker than people who have been working in the area for some time. A doctoral degree trains someone to think critically and often provides them with the confidence to question why things are being done in a certain way. They are trained not only to spot problems, but to hypothesise and test solutions and this is a skill that has many applications outside of scientific research or innovation. Identifying improvements can result in significant benefits and savings for a company.

EPSRC funding and co-investment

Since 2014, EPSRC has made commitments that increase our total expenditure on studentships to around £200 million per year. While the funding we have been able to commit to training investments from EPSRC's baseline Spending Review allocation has remained flat for a number of years, we have benefitted from additional funding through the Government's National Productivity fund (NPIF) since 2017/18. EPSRC also received additional funding for research grants from sources such as the Industrial Strategy Challenge Fund (ISCF). The impact of all of these funding opportunities is that EPSRC has spent an increasing proportion of its total funds on research. This means that while EPSRC's spend on studentships has increased, proportionally, it has decreased from 25% of our total spend between 2006/07-2010/11 to 20% for 2015/16-2019/20.

Without making any changes to our approaches for doctoral education support, it is predicted that for the next few years, the number of students supported by EPSRC will remain the same or decrease. As student costs continue to rise, at least with inflation for fees and stipends, it is clear that the number of students we will be able to support from our baseline settlement will continue to decrease unless the training budget increases. If not for NPIF, EPSRC student numbers would already be in decline, but it is unclear what opportunities will be available to EPSRC for additional funding for studentships in the near future.

The Government R&D roadmap states that "Our strategy will allow us to create a new deal for funding postgraduate research – increasing the investment in research training, numbers supported, models of delivery, stipend levels and helping graduates transition successfully into the next stage of their career, whether that is in academia, industry or in the public sector". UKRI is leading on this work and EPSRC, as part of the UKRI family, will participate. Issues such as investment level, student numbers, and financial support such as stipend levels are all tightly interlinked. The research councils and other stakeholders will need to consider how to balance the competing demands within the new deal.

EPSRC funds students across all areas of its remit and there have been no significant changes in the proportion of students in each discipline (Theme) over the last 5 years. With the exception of Artificial Intelligence, which has benefitted from the targeted additional investment through NPIF, studentships classified into the more detailed research areas have changed in line with EPSRC's Balancing Capability strategies. Doctoral education continues to need to support the creative and innovative fundamental research community and respond to, and support, emerging strategic priority areas.

This means balancing stable long-term investments with a more dynamic framework of investment, ensuring all areas of research are moving forward and allowing new discoveries to occur. As stated in the People and Culture Strategy, a requirement on research organisations to continually compete for funding has an impact of increasing the burden of bureaucracy on researchers. Our current schemes offer a mixture of competitive funds, accessible to all Higher Education Institutions, and allocated funding(with assurance processes) based on the EPSRC research portfolio of research organisations. We need to continue to consider what mixture of opportunities will best serve the community, and the UK as a whole.

Recognising the contribution that postgraduate researchers make to the research and innovation system and as stated in the People and Culture strategy, the "constantly growing demand for R&D skills", it is important that EPSRC is able to support at least as many doctoral students as it currently does. The People and Culture Strategy also highlights the need to review the support for all postgraduate students, to ensure they are appropriately supported and study in a positive environment. As Government has "estimated the R&D sector will need at least an additional 150,000 [people] by 2030 to sustain the UK's target of 2.4% research activity" we may well need to increase the availability of studentships. All of this will require an increase in expenditure compared to current levels.

A need for more investment in collaborative doctoral education was highlighted across all the review engagement activities and doctoral projects are widely recognised as a good way for partners to build collaborations. While EPSRC is the largest single funder of EPS doctoral students, to reach the Government's ambitions, the whole R&I system needs more investment, from both public and private sources. EPSRC and its funding has a significant impact and influence on the funding landscape for EPS doctoral students. Currently, 20% of EPSRC doctoral students are co-funded by non-academic partners and 5% of EPS doctoral students are solely industrially sponsored. In addition to seeking increases to our own budget, EPSRC is in a position to encourage greater investment in UK R&D, through co-investment. Greater involvement of Small and Medium Enterprises in particular was often raised during review engagement activities, with benefits for students and the companies alike. Stimulating and supporting SMEs to be more involved in doctoral training would be highly beneficial. In addition, we should continue to promote co-investment in our research portfolio as a whole, supporting potential co-investors in understanding the different routes available to them to support R&D career pathways.

Recommendation 1: To stimulate economic growth, EPSRC should increase the number of students it supports and the professional development that they receive. EPSRC-funded doctoral students go onto careers in innovation and research in manufacturing, information and communication technologies and other scientific and technical careers in industry and academia. To become a global science superpower, the number of people with these skills must grow and EPSRC must lead by increasing the number of students it supports. EPSRC should bid for an uplift of investment in EPS for doctoral education from the spending review and other opportunities.

Recommendation 2: EPSRC should better demonstrate the value of a doctorate, its outcomes, and the destination of doctoral graduates, so that this is understood by all key stakeholders.

Recommendation 3: EPSRC should continue to provide thought leadership in doctoral education to the EPS community by investing in the highest quality doctoral education provision which supports a diverse range of career paths.

Recommendation 4: EPSRC should provide a stable long-term baseline of investment to support a creative and innovative fundamental research community (such as the current algorithmic DTP investment), alongside a more dynamic framework to respond to and support emerging strategic priorities (for example by investing in more frequent CDT competitions and including studentship investments alongside research investments in top priority strategic areas).

Recommendation 5: To effectively support the UK's increasing STEM capability, the system needs to grow. Recognising the high value placed on doctoral studentships by industry, EPSRC should engage with industry (both the current and new sectors) to encourage and enable increased industry funding and co-funding of doctoral students. These are effective ways of attracting industry investment into the R&D landscape.

Recommendation 6: EPSRC should showcase the ways small and medium enterprises can and do engage with doctoral students, to widen participation and enable overall growth in the system.

Recommendation 7: EPSRC should work with UKRI on doctoral student issues covered by the Government's People and Culture Strategy, ensuring that issues facing the EPS community are addressed. In particular, the New Deal for postgraduate research is expected to address areas such as the stipend level for doctoral students, the rights and conditions of doctoral studentships, financial sustainability of doctoral education investments, doctoral student recruitment policies, and the health and wellbeing of students.

Recommendation 8: The existing opportunity to employ graduates on UKRI grants does not replace our main route to doctoral education but could provide a valuable alternative career path. EPSRC/UKRI should explore this opportunity further particularly with reference to innovation and career mobility.

The doctoral experience

Doctoral education is undertaken by students for a variety of reasons, but the most common is having an interest in the subject (35%). Students were attracted to undertaking a doctorate for a variety of reasons:

- It provided them the time to be able to focus on research: to ask deeper questions and to investigate a topic fully or explore new ideas
- They would have the opportunity to engage in critical thinking and problem solving to come up with innovative solutions
- It would allow them to build networks with people with similar interests
- They would be able to undertake interdisciplinary research and collaborate with industry

We have already discussed the significant contribution that postgraduate researchers make to the research landscape and economy overall. The reasons that students enter doctoral education map well onto these contributions. When considering studentships as training investments, it can be easy to focus on the careers of individuals, post-graduation. It is important to remember that the studentships we support are research training, and that a lot of the students undertake a doctorate in order to do research, in a subject they are interested in. While we need to be considerate of the career routes available to students, it is important that research and the education provided by conducting research is recognised and valued by stakeholders, and that it remains front and centre in the doctoral experience.

The review confirms that students should develop skills in a number of ways. They should also consider developing some experience across a range of sector specific skills and be supported to do so. This is because so many students change their career aspirations over the course of their doctorate. It essential that students keep their options as open as possible while they decide their preferred route. Only then can students make an active choice of the career they wish to pursue rather than feeling bound to a path because of the skill set they have developed.

Across all EPS doctorates, the following skills were recognised as those that doctoral students develop during their education:

- Independence and resilience – These skills enable doctoral students to be proactive, take ownership of their work, and face and overcome challenges
- Analytical skills – Doctorates require high level analytical skills that are beneficial to a wide variety of roles
- Communication skills – The ability to explain highly complex information to a variety of audiences, which is necessary in both technical and non-technical roles
- Team working – Science is increasingly collaborative. Where doctoral graduates have experience of team working, this develops valuable skills as the majority of industry projects are team based.

There are a number of activities or experiences that many in research would consider to be standard parts of a doctoral experience, including presenting to a team or department, writing progress reports, writing papers, training others, and collaborating with colleagues in both academia and industry. For many, involvement in teaching undergraduates would also be standard practice. It is important that these kinds of activities are recognised for the skills they provide doctoral students, and the contributions these make to the skills outlined above, and more. Nonetheless, this review suggests that all students need to have access to additional training opportunities.

Students should have the opportunity to participate in additional activities beyond their research project as these develop significant and useful skills, enhance those they are developing through their research, or give them a different perspective on how they can be applied. In general, the majority of students participate in a wide variety of activities that allow them to develop a wide skill set. Most students were positive about the range of training and professional development available to them across a wide range of topics delivered through a central researcher development programme or locally through CDTs. However, the review found evidence of significant variation in the amount of training that is required and available to individual students.

Ensuring equal access for students is essential and requires a combination of increasing awareness and expectations, reducing barriers, and providing appropriate financial support. Given the importance of postgraduate researchers to the research and innovation system, the highest quality, value for money, experience should be available to them and this should be prioritised over the number of students that are supported.

There are several key barriers, identified by the community, to accessing different experiences. These barriers apply to multiple activities and can arise due to a wide variety of personal circumstances. While varied, the barriers often relate to the need for equal availability to opportunities regardless of the study location, research group size, or funding mechanism.

- Ability to participate in activities that are out of working hours
- Ability to travel
- Time being available
- Funds being available
- Availability of experience
- Knowledge of activity.

These barriers relate to the personal circumstances of students; the knowledge, experience, and attitudes of supervisors; and support and expectations of universities, partners, and EPSRC. Early in a doctorate, students should have active, informed discussions about the opportunities available (or that they should look out for) and what they might benefit from. This will allow the time and funding available, ways of supporting personal circumstances, or alternative opportunities, to be considered.

We need to recognise that career guidance, tailored for postgraduate researchers, is essential for these informed discussions so that students can understand the skills and activities that would prove useful to them. This was one activity that all stakeholders considered to be valuable, but not widely available. Before studentships begin, it is also important that EPSRC, universities and supervisors ensure that the time, funds, and support routes for experiences are actively considered during the allocation and project design stages.

We need to be careful to strike the right balance in the doctoral experience between the time used for activities that are valuable but additional to the research project, and the time dedicated to the research itself. The review showed that students have the most positive experiences when they have the flexibility to choose the activities that provide them with the skills that they deem useful. Too much time spent on non-research activity, particularly mandated time, could reduce the attractiveness of doctorates.

Recommendation 9: EPSRC should work with the sector to provide greater recognition and visibility of the wider skills developed alongside research skills during a doctorate to ensure the employability of all doctoral graduates.

Recommendation 10: All EPSRC funded students should have access to opportunities outside of their research project (e.g., conferences, placements, public engagement), irrespective of the funding route. EPSRC should be explicit within each scheme that funding should be made available for opportunities outside of the research project.

Recommendation 11: EPSRC should prioritise funding excellent doctoral experiences and access to opportunities over student numbers, while ensuring value for money.

Recommendation 12: EPSRC should assist those who deliver the EPSRC doctoral investments in developing and sharing good practice.

EPSRC studentships

Training Schemes

EPSRC provides studentship funding for between 3 and 4 years (full-time equivalent) which most stakeholders felt was long enough. Three quarters of EPSRC students submit a thesis which for almost all (98%) is a doctoral thesis. Over recent years, the funding duration of our DTP and ICASE schemes have increased, bringing study and funding durations more into line. For CDT students, there has been a reduction in the time taken to submit suggesting that projects are being better designed and managed to be achievable within the funded period.

There were mixed views in the community about whether all studentships should be the same length. While there is an advantage of simplicity, it would fail to cater to the individual needs of students with more bespoke or flexible approaches seen as desirable by a number of stakeholders, including students.

Encouraging greater co-investment also requires greater support for stakeholders, particularly non-academic partners. The ICASE scheme is well known and liked, but there is a lack of visibility of the opportunities to collaborate through the DTP and CDT schemes. As part of better promoting collaboration, the current flexibilities available on the DTP and CDT schemes needs to be both better advertised and better incentivised.

EPSRC's current training schemes are well regarded, and the proportion of our students supported under each scheme closely maps our expenditure on that scheme. While there are always improvements that can be made, most issues found as part of the review can either be resolved through adjustments to our existing schemes or arise from a lack of understanding of the flexibilities and support already available. Adjusting our approach where needed and explaining the opportunities more widely will enable more individuals and companies to be involved in EPSRC investments.

An aspect that requires more significant thought is part-time learning. It is already a requirement that EPSRC studentships are available on a part-time basis, but we need to work with stakeholders to understand the practical barriers. Despite these areas for improvement, it is unlikely that increasing the number of schemes we support would have a positive impact. Unless specific aspects of training are missing and unable to be accommodated through adjustments to the existing approaches, we should avoid increasing the complexity in the funding system.

Guidance and peer learning

The review points to a need to support students to better understand the support available to them from EPSRC funding, via their university. This includes provisions for sick pay, parental leave, disability support and support for people with caring responsibilities. As only a third of doctoral students are funded by EPSRC, there can be differing levels of support available for doctoral students within an institution. When this is compounded with a lack of visibility of who their funder is, and EPSRC's policies, it can result in students not receiving the support they require and are eligible for.

Students are confused by which parts of their experiences are influenced or mandated by EPSRC, and what falls under the purview of their university. The students asked for a clear definition of EPSRC's and the university's responsibilities, and more reassurance that EPSRC was monitoring university adherence to the policies. This included a request for guidance on EPSRC's existing policies and for us to support an increase in their understanding of the expectations we hold of organisations regarding the supervisory relationship, training, and professional development.

As students are not funded directly by EPSRC, their first port of call for support is, and should be, the support structure within the university they are registered with. Within organisations, students requested clearer signposting of what services they can access and how. This included a request for more routes for raising concerns or problems informally before having to report issues through formal complaint procedures. This related particularly to the supervisory relationship. While the majority of students were positive about their supervisory experiences, there was recognition that they are highly dependent on their supervisor and that there is a power imbalance within the relationship.

A specific experience that students requested was more access to networking opportunities and cohort activities with other students, both within and across organisations. Those involved in the student focus groups articulated clear benefits to hearing the different experiences of other students. Given EPSRC's position and the number of students it supports, EPSRC could be well placed to facilitate such cross-organisational opportunities and it could also provide the greater interaction the students requested with us as their funder. The review saw a similar request from companies who also wanted to network and learn from their peers and engage with students and academics. Peer support activities suggested included, alongside traditional networking, buddying schemes for smaller companies to partner with larger ones, training on how to provide placements and supervision, and opportunities for companies to advertise problems which students would then pitch solutions or research projects for.

Access to doctoral education

Geography

EPSRC supports students in every region of the UK, with the distribution of EPSRC funded students more or less identical to the distribution of EPS students across the UK. The proportion of EPSRC students also tracks EPS academics and EPSRC research funding by region. As students need access to state-of-the-art facilities and supervision by experts in their chosen field of study to get the best research education, it is not surprising that EPSRC student location is driven by the presence of EPS academics within a region. As the EPS academic population significantly correlates with the geographic spread of research organisations that are eligible for UKRI funding, the number of organisations in a region also influences student location. However, for those who are unable or do not wish to relocate, geography affects their ability to access doctoral opportunities.

As acknowledged by the Council for Science and Technology for Government Office for Science, the impact of R&D investment depends on several inter-connected factors, including the availability and access to a skilled workforce; social and connective infrastructure; and strong local leadership. The companies we engaged with as part of the review highlighted the importance of engaging with the Government's Build Back Better strategy and we should consider what role doctoral education has in the levelling up agenda. It is important that as part of these considerations we ensure that we do not diminish the success of the UK's existing outstanding research institutions and knowledge-based economy.

Over half of EPS doctoral students (54%) stay for employment in the region in which they studied. As research and innovation activity increases, we can assume a corresponding increase in demand for doctoral graduates. How each region responds will depend on their own unique circumstances. Different regions in the UK currently have different levels of student retention and graduate attraction. If demand for the skills that doctoral graduates have increases, they will need either strategies to encourage students to stay in the area or to attract graduates to move into the region, or both. Without such strategies, the impact of nationally increasing student numbers will be dampened in regions with low retention or less inward flow of graduates. It is also the case that if UK student numbers do not increase in line with job opportunities, the ability of a region to meet its needs will come at the cost of another region. It will be important for EPSRC to consider the interplay of student numbers and regional aspirations and strategies.

Equality, diversity, and inclusion

The EPS student population is not as diverse as the UK population and the EPSRC population within it is even less so.

The EPS doctoral population is significantly younger than the doctoral population overall and 90% of the doctoral students funded by EPSRC are under 30. While this may point to better funding opportunities enabling individuals to continue into a doctorate straight after an undergraduate, integrated masters or taught masters degree, we need to look carefully at the EPS disciplines to understand if our support is inadvertently creating barriers for lifelong learning. Similarly, the proportion of EPSRC students declaring a disability, or identifying as female, is lower compared to EPS first-degree undergraduates, and for disability, lower than the EPS population overall. While we have a high level of non-disclosure, or unknowns in our ethnicity data, we can see from the Advance HE reports that more could be done to encourage and support participation.

Across the protected characteristics, we need to understand the particular issues and barriers within the disciplines that we support and consider how we can encourage and support wider access to doctoral opportunities. These are likely to be complex and nuanced, needing different approaches for different subject areas and characteristics. Two areas that the review points at, in addition to this discipline specific understanding, is qualifications and part-time study. There is a significant difference between the most recent qualifications of EPSRC funded students and the wider population of doctoral students.

The impact that this has on the candidate pool and recruitment processes needs to be explored. One option, raised by stakeholders as part of this review, could be to consider the possibility of contextual offers for doctoral places as is now used for undergraduate offers. Given the breadth of impact, this should be considered as part of UKRI's ongoing EDI work. In relation to part-time study, the Advance HE reports make it clear that this study mode is particularly important to support older, disabled, and/or female students and, as already mentioned in this summary, understanding how to enable part-time study within our training approaches is essential.

Recommendation 13: It is essential that EPSRC continues to invest through a diverse range of flexible approaches so that we continue to support doctoral students' varied needs, backgrounds, and potential careers as well as the differing requirements of the research and innovation communities.

Recommendation 14: As EPSRC's current mechanisms are well regarded, new initiatives should only be introduced where there is a compelling case for an alternative approach.

Recommendation 15: EPSRC should work with all stakeholders to ensure the current flexibilities relating to both collaboration and supporting students are well known and used.

Recommendation 16: Doctoral education should be available to people following a variety of career paths. EPSRC should work with stakeholders to continue to improve access, diversity of entry points to doctoral education and tailored support for individuals.

Recommendation 17: EPSRC should understand detailed EDI issues in each of our research areas or sectors and work with our community and representative bodies to address them. EPSRC will continue to work within UKRI on broader EDI initiatives.

Recommendation 18: EPSRC should explore how doctoral training investments can support the levelling up agenda.

List of recommendations

Recommendation 1	To stimulate economic growth, EPSRC should increase the number of students it supports and the professional development that they receive. EPSRC-funded doctoral students go onto careers in innovation and research in manufacturing, information and communication technologies and other scientific and technical careers in industry and academia. To become a global science superpower, the number of people with these skills must grow and EPSRC must lead by increasing the number of students it supports. EPSRC should bid for an uplift of investment in EPS for doctoral education from the spending review and other opportunities.
Recommendation 2	EPSRC should better demonstrate the value of a doctorate, its outcomes, and the destination of doctoral graduates, so that this is understood by all key stakeholders.
Recommendation 3	EPSRC should continue to provide thought leadership in doctoral education to the EPS community by investing in the highest quality doctoral education provision which supports a diverse range of career paths.
Recommendation 4	EPSRC should provide a stable long-term baseline of investment to support a creative and innovative fundamental research community (such as the current algorithmic DTP investment), alongside a more dynamic framework to respond to and support emerging strategic priorities (for example by investing in more frequent CDT competitions and including studentship investments alongside research investments in top priority strategic areas).
Recommendation 5	To effectively support the UK's increasing STEM capability, the system as a whole needs to grow. Recognising the high value placed on doctoral studentships by industry, EPSRC should engage with industry (both the current and new sectors) to encourage and enable increased industry funding and co-funding of doctoral students. These are effective ways of attracting industry investment into the R&D landscape.
Recommendation 6	EPSRC should showcase the ways small and medium enterprises can and do engage with doctoral students, to widen participation and enable overall growth in the system.
Recommendation 7	EPSRC should work with UKRI on doctoral student issues covered by the Government's People and Culture Strategy expected to be published in summer 2021, ensuring that issues facing the EPS community are addressed. In particular, the New Deal for postgraduate research is expected to address areas such as the stipend level for doctoral students, the rights and conditions of doctoral studentships, financial sustainability of doctoral education investments, doctoral student recruitment policies, and the health and wellbeing of students.
Recommendation 8	The existing opportunity to employ graduates on UKRI grants does not replace our main route to doctoral education but could provide a valuable alternative career path. EPSRC/UKRI should explore this opportunity further particularly with reference to innovation and career mobility.

continued...

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Acknowledgements

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Thanks also go to the EPSRC team:
Shyeni Paul, Christina Turner, Karen Muncey, Christina Hurrell and Alison Wall

Queries should be addressed to students@epsrc.ukri.org

Annex 1: Data information

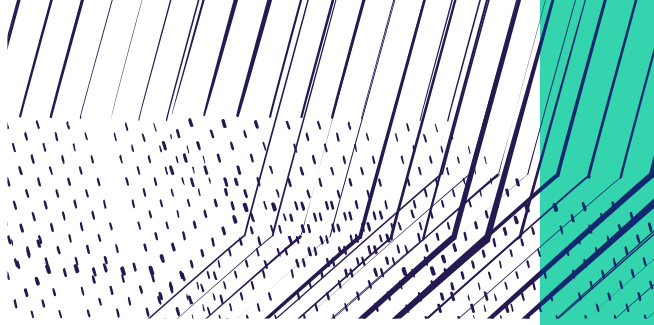
The EPSRC held data used within this report has been made publicly available for viewing in a Tableau site, available here.

Funding data for training grants, research grants and fellowships are gathered through returns to the Joint electronic Submissions (Je-S) system, which the research community uses to apply for UKRI funding.

Studentship data is provided by research organisations through the Je-S Studentships Detail Functionality. This data includes students personal information, project details and timeframes and collaborator details. Submission data is provided by research organisations through the annual submission survey.

HESA data is used to understand the wider postgraduate landscape in the UK.

EDI data for the wider student population and postgraduate population is taken from the AdvanceHE Equality in higher education: statistical reports which are publicly available here: Equality in higher education: statistical reports | Advance HE (advance-he.ac.uk)



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