ROYAL SOCIETY OF CHEMISTRY

Open for Business

A chemistry department perspective on university–business engagement

November 2016

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Foreword

At the Royal Society of Chemistry, we're committed to advancing excellence in the chemical sciences for the benefit of science and humanity.

We do that by connecting people across the chemical sciences and a key part of this is building bridges between academia and industry.

There is plenty of evidence that closer engagement between universities and businesses brings significant benefits – from increased support for research and faster commercialisation of new technologies, to better job prospects for students.

In the chemical sciences, universities and companies have traditionally had very strong links. But the precise nature and extent of these relationships has not been documented at the national level.

We wanted to understand what is happening on the ground and to share good practice across and beyond our community. So we decided to conduct a survey of chemistry departments in the UK and Ireland to capture in detail how they work with businesses to support their activities in research, enterprise and skills development.

We found that chemistry departments are very much 'open for business', with over a thousand collaborations reported by the 25 departments that took part. Even more impressive was the sheer range and diversity of engagement – from mentoring by alumni, to skills sharing with SMEs and major research collaborations with multinational companies.

In parallel with this report, we have created an online collection of up-to-date case studies of different types of university business collaboration at **rsc.li/ube**. Our aim is to help universities, businesses and policymakers take concrete steps to develop new collaborations, both with these real-world examples, and our survey results and recommendations.

We're proud of the innovative ways in which universities and businesses in the chemical sciences are already working together. The findings from this research will certainly inform our own programmes to connect people from universities and businesses.

And I hope that they will inspire everybody in the academic, business and policy community who wants to work together to keep the UK at the forefront of global research and innovation.

Robert Parker
Chief Executive

Executive summary

In this report we examine how university chemistry departments in the UK and Ireland are currently engaging with businesses to support their activities in research, enterprise and skills development. Our survey results show the scale and variety of interactions between chemistry departments and business. Combined with our 18 case studies of university to business connections at **rsc.li/ube**, we hope that this report will be a useful resource for individuals and departments who are working to expand or diversify their engagement with businesses.

We have also identified some barriers, which mirror those found in other reports on university to business interactions. We hope that our perspectives on these barriers, together with possible ways of overcoming them, will be useful for the many people in universities, companies and government who are committed to effective engagement between universities and businesses.

In Spring 2016, 25 chemistry departments who are represented in the Heads of Chemistry UK (HCUK) group responded to our survey about interactions with businesses between 2012 and 2015. We discussed the preliminary findings with HCUK in May 2016 and clarified some points based on feedback at that workshop.

Snapshot of the university–business engagement landscape in chemistry

University chemistry departments collaborate extensively with businesses in research activities, interacting with both SMEs and large companies from a variety of sectors.

There were over 1,000 research collaborations with companies, an average of at least 40 per department. The number of collaborations per department ranged from 5 to 192. Of these collaborations, 34% were with small and medium sized enterprises (SMEs).

A higher proportion of the collaborations with SMEs were on projects in applied rather than underpinning research. For large companies the opposite is true. The majority of collaborative research partnerships with SMEs were established within the last three years, whereas with large companies, the trend was towards longer-standing relationships.

University chemistry departments are highly engaged with businesses to support teaching and technical training, as well as the development of employability and enterprise skills.

All the departments in our survey work with companies from a variety of sectors to support teaching and technical training as well as the development of employability and enterprising skills. Of the companies, 31% were SMEs.

All of the departments engage with companies to provide industry placement opportunities for undergraduate students, postgraduate students or staff, with most providing industrial placement opportunities for more than one of these groups.

Nearly 80% of departments had company input to the development or delivery of subject-specific teaching or technical training for their students; 75% of departments worked with companies to enhance the enterprise skills of their students and / or staff.

Research collaboration with industry partners, as measured by one research engagement score, did not adversely affect the Grade Point Average of chemistry departments in the 2014 Research Excellence Framework (REF 2014).

Some academics perceive that collaborating with industry partners is damaging to an academic career path. In chemistry we had heard concerns that collaboration with industry could have a negative impact on performance in the REF. We created a research engagement score which is a weighted measure of the number of research collaborations a department has with businesses. Departments with higher research engagement scores in fact tended to have a higher ranking by Grade Point Average in REF 2014.

Personal connections, particularly alumni networks, play a key role in finding company partners for research collaboration and are also very important in the enterprise and skills development activities of chemistry departments.

Personal contacts are the most common way of finding company partners for research collaborations, although expanding personal networks of contacts in industry is challenging.

Alumni networks are by far the most common mechanism for finding company partners to support teaching, training and employability skills development. Alumni also play an important role in mentoring.

Barriers and opportunities

From a university chemistry department perspective, the top four barriers to research collaboration with businesses are: difficulty in identifying partners; access to funding; negotiations about contracts and IP; and pressures on academic time.

Our survey and case studies suggest many potential ways of overcoming these barriers, with opportunities for all of the stakeholders across the research and innovation community.

Opportunities for individual researchers and departments:

1. Explore a wider range of routes to finding research partners including using knowledge transfer networks and innovation centres as well as local company and alumni networks.
2. Senior academics facilitate introductions for colleagues at earlier stages in their career.
3. Explore a wider range of funding options for research collaboration with companies and for enterprise activities such as spinouts.
4. Experienced researchers support early career staff in developing successful applications for specific funding schemes.
5. Raise awareness about standardised IP templates such as the Lambert toolkit.
6. Link with institutional, regional and wider mentoring schemes .
7. Explore opportunities to engage alumni in mentoring students and staff as well as in industrial advisory boards.
8. Share examples of good practice in providing industrial placement opportunities for undergraduate and postgraduate students.
9. Develop a common framework of undergraduate skills requirements for industry.

Opportunities for companies and / or research and innovation supporters such as universities, TTOs, funders and learned societies:

1. Raise awareness of the current mechanisms available to find industry partners and the ways of accessing them.
2. Consider new or expanded schemes to facilitate initial links between people in universities and businesses.
3. Raise awareness of different funding schemes available to support university–business engagement.
4. Ensure that funding application processes are clear and that the time required to prepare a proposal is reasonable compared with the amount of funding available.
5. Review institutional IP arrangements and the role of TTOs in supporting research collaborations with industry.
6. Develop a common framework of undergraduate skills requirements for industry.
7. Consider how institutional alumni networks can support the development of links with departments in order to engage alumni in activities ranging from research and enterprise to technical and business skills development.
8. Increase the number of industrial placement opportunities for undergraduate and postgraduate students.

Introduction

Collaboration between universities and businesses brings benefits to academics, companies, students and the UK economy. There have been many reviews focussing on different aspects of university–business engagement since the *Lambert Review* in 2003 (1).

From a business perspective, changes in business models and the rate of progress in science and technology have led to an increased emphasis on establishing partnerships with academic researchers. Businesses also increasingly need to engage with universities to fulfil their future skills and technology requirements. In 2015 the Confederation of British Industry reported that 68% of businesses already have some type of links with universities and 35% of businesses are looking to extend their interactions still further (2).

For universities, engaging with companies opens new avenues for research collaboration and funding, as well as opportunities to commercialise academic research. It also gives access to data, equipment, expertise and networks. The value of such knowledge exchange activities to universities was over £4.2bn in 2014 / 15, 6% higher than the previous year (3). In the 2015 *Dowling Review* academics cited many other advantages to collaborating with companies such as: increasing employability and providing good job prospects; working on challenging, interesting and 'real-world' problems; and seeing the societal value of their research (4).

Universities and individual researchers also increasingly need to demonstrate the economic and societal impact of publicly funded research. In the UK, researchers applying for Research Councils UK funding must include a 'Pathways to Impact' statement in their proposal (5). The Research Excellence Framework (REF) is a system for assessing the quality of research in UK Higher Education institutions. In 2014 'impact of research' was included as an element in this assessment and is expected to be a significant component of the next REF assessment (6). The Engineering and Physical Sciences Research Council found that 44% of the 1,226 impact case studies submitted within its remit for the 2014 REF involved industrial collaboration (7).

From a student standpoint, the introduction of loans for undergraduates is one factor that has prompted a greater awareness of the need to connect academic learning with employability. This need can be addressed through training and experiences designed to enable students to acquire wider skills as part of their time at university.

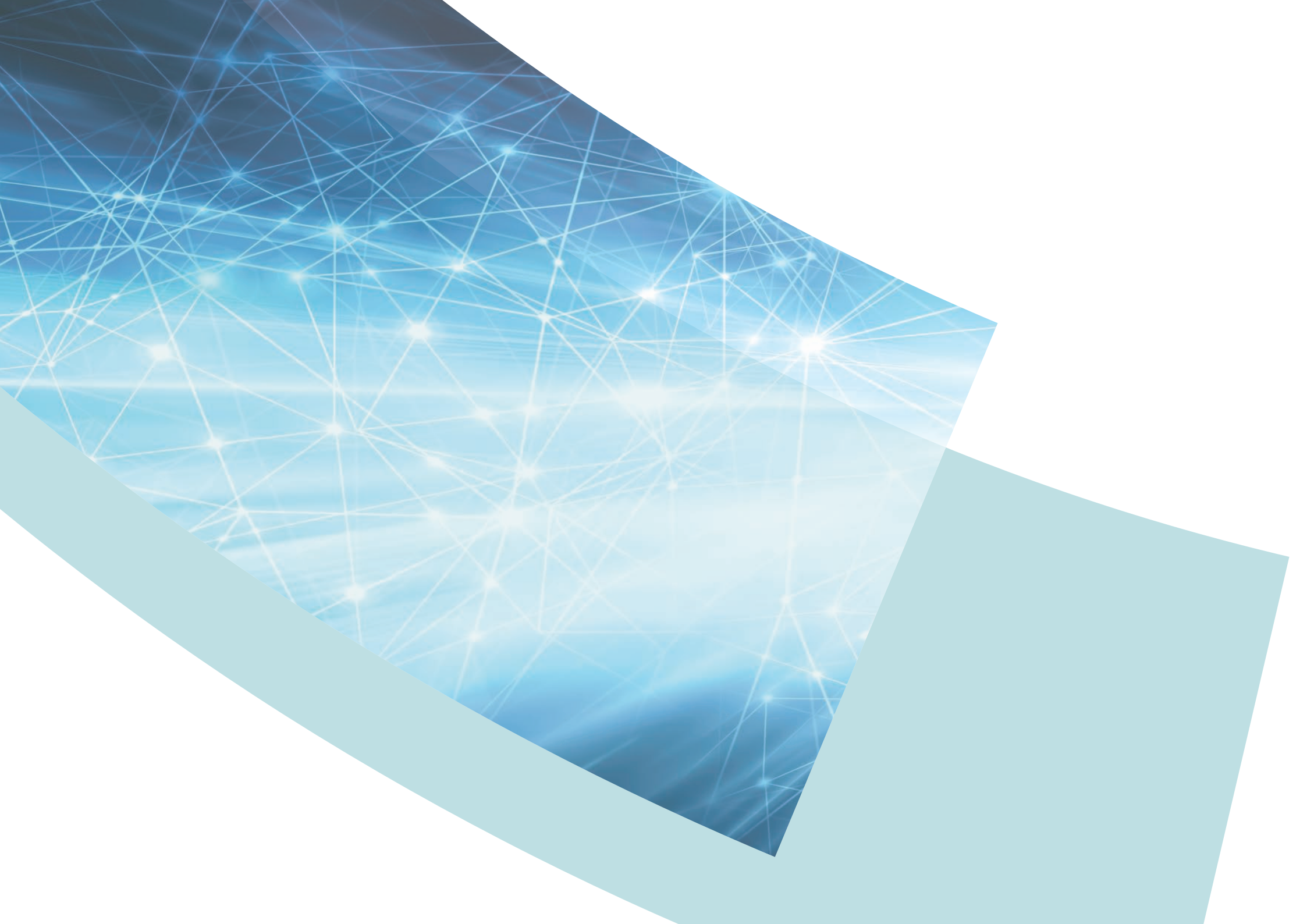
Putting all these perspectives together it is clear that there are many drivers for supporting effective university–business engagement. The science and technology innovation landscape is continuously evolving with increasing awareness of the importance and needs of SMEs, proposals to combine Research Councils UK and Innovate UK under the new UK Research and Innovation structure, and uncertainty about access to European funding and networks in light of the UK referendum on EU membership.

Against this backdrop, the Royal Society of Chemistry wanted to build a comprehensive picture of the current status of university–business engagement in chemistry. There is a long tradition of interaction between universities and companies in the chemical sciences and there are many examples of how departments and individuals approach this engagement in order to meet their specific needs, and to make the most of their relationships locally and beyond.

We wanted to take a contemporary snapshot of the specific ways in which chemistry departments engage with large companies and SMEs in research collaboration, entrepreneurial activities, and business awareness and skills development for staff and students. We wanted to understand how the barriers to university–business engagement in chemistry compare with those identified in the reviews by Dowling and others, as well as what chemists are doing to overcome these barriers.

We surveyed university chemistry departments about their activities, ranging from numbers and types of collaborations with businesses, to mechanisms for finding partners. In addition to the consolidated data presented in this report we also provided benchmark reports to participating departments so that they can compare their own activities with the wider landscape. We also identified case studies of current initiatives used by chemistry departments around the UK and Ireland to foster engagement with industry, which are available at **rsc.li/ube**. One of our goals in sharing this research is to enable individuals and chemistry departments to connect with one another and draw on these examples.

This report will inform priorities for future programmes by the Royal Society of Chemistry and Heads of Chemistry UK to strengthen university–business engagement in chemistry. We have found a vibrant landscape of interactions between chemistry departments and businesses, although some barriers remain. We hope that the overview of barriers and examples of solutions will be useful to the wider community of people, companies and organisations committed to building effective links between universities and businesses.



About our survey

Chemistry departments in our survey

25 chemistry departments in the UK and Ireland participated in our survey in the spring of 2016[1]. This corresponds to:

- 36% of the chemistry departments who are members of Heads of Chemistry UK (HCUK).
- A geographical distribution of departments within the UK and Ireland. See Figure 1.
- 54% of the UK and Ireland undergraduate chemistry student population.
- 59% of the UK and Ireland postgraduate chemistry student population.
- A range of department sizes. See Figure 2. While these distributions do not exactly mirror the UK / Ireland-wide distributions (there is a greater proportion of small departments across the UK and Ireland) the mix and coverage is representative.
- A variety of types of institution. See Table 1.

We asked departments who did not participate in our survey for feedback. The main reasons for not responding were not having the information to hand or not being in a position to allocate sufficient staff time to gather the data required by our survey in the time available.

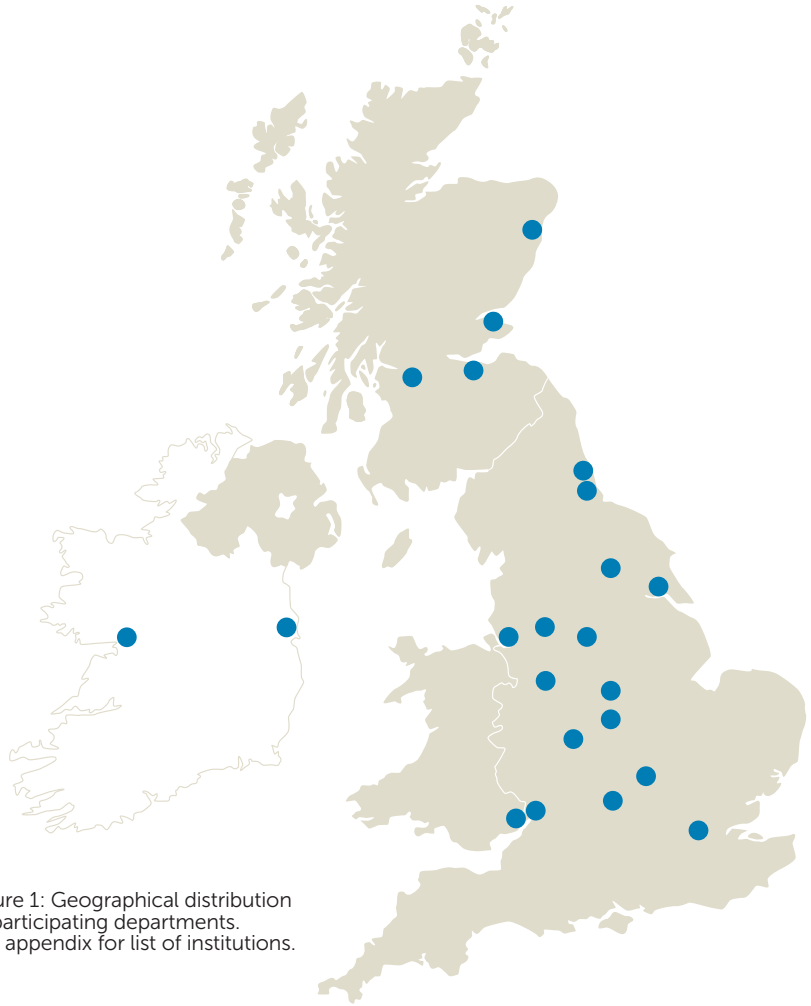


Figure 1: Geographical distribution of participating departments. See appendix for list of institutions.

Table 1: Proportion of departments in our survey that are in Russell Group universities and are involved with Centres for Doctoral Training.

	Russell Group	Centres for Doctoral Training
Participating departments	56%	60%
All UK and Ireland chemistry departments	29%	33%

[1] Not all of the departments that participated in the survey responded to every question. However, the data shown are representative. All questions had a response rate of at least 68% and specific data on the number of respondents for each question is available on request.

Types of university–business engagement

Our survey covered the three academic years from September 2012 to September 2015. We discussed the results at the HCUK 2016 spring conference and clarified some points based on feedback at that workshop.

Our survey had three sections reflecting the main types of activity chemistry departments engage with businesses to support:

a) **Research**: Types of companies involved in collaborative research, mechanisms for sourcing partners and funding, outputs and barriers.

b) **Enterprise**: Spinouts, funding mechanisms, and enterprise and business awareness training for staff and students.

c) **Employability**: Contributions by industrial partners to staff development, teaching and student employability skills.

The survey questions are available at **rsc.li/ube-survey-questions.**

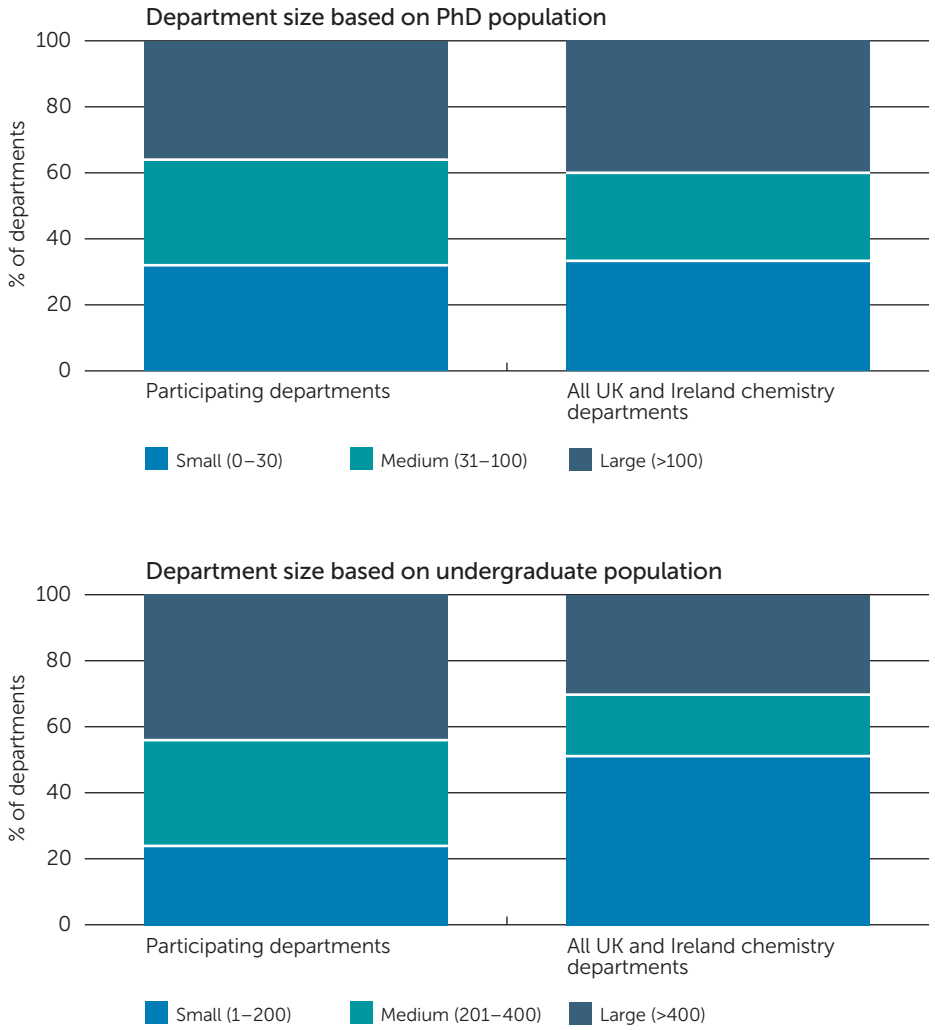


Figure 2: Sizes of participating departments compared with corresponding distribution for all UK and Ireland chemistry departments. The choice of small, medium and large boundaries was informed by discussion with Heads of Chemistry UK (HCUK). Source data: **Higher Education Statistics Agency student and staff records 2014–15**. Data for Irish universities came from department websites.

University–business engagement in research

Relationships based on trust and understanding underpin successful research collaboration between universities and businesses (4; 8; 9; 10; 11). Developing such relationships takes time and it is also a challenge to initiate them in the first place. According to the *Dowling Review* one of the top 10 barriers to collaboration with universities from a business perspective is that it is 'difficult to identify academic partners or where academic capability lies.' From a university perspective, one study across all faculties identified that the single biggest challenge to engagement with industry on research was the difficulty in finding suitable collaboration partners (12).

Mobility in both directions across the academia-industry boundary is one way of fostering open and trusting relationships between people. This mobility is important at all levels in universities – from students to professors – but lack of incentives, a perception that collaboration with industry is damaging to an academic career path, and low awareness of schemes can all act as barriers to mobility.

There are also people and organisations that act to broker new relationships and develop networks across disciplines and sectors. Well-networked individuals, or 'discipline hoppers' (4), can be very effective at building links across the interfaces between academia and industry. Knowledge Transfer Partnerships and Local Enterprise Partnerships also provide frameworks for creating links.

University Technology Transfer Offices (TTOs) and Research Collaboration Offices (RCOs) play a role in facilitating agreements and developing connections between universities and businesses (13). Intellectual Property (IP) arrangements are still cited as a barrier to developing research partnerships and in negotiations related to commercialisation of research outputs, although standard intellectual property (IP) templates such as the Lambert Toolkit can be useful. The *Dowling Review* also highlighted the importance of IP awareness and broader business training for PhD students (4).

Collaborative research projects between business and universities range from fundamental curiosity-driven research to applied programmes addressing a specific challenge. Applied research can sometimes fall into the gap between the remits of Research Councils and Innovate UK. However, there is a range of funding to support collaborative research, including Innovate UK's Higher Education Innovation Funding (HEIF), Research Councils UK (RCUK) Impact Acceleration Accounts and RCUK CASE studentships.

Snapshot of university–business engagement in chemistry research

The 25 chemistry departments participating in our survey told us about the types of companies with which they have research collaborations, with:

- More than 1,000 research collaborations with companies during 2012–2015.
- An average of about 40 collaborations per department.
- The number of collaborations for individual departments ranging from 5 to 192.
- Collaborations with companies of different sizes. See Table 2.
- Collaborations with companies in different sectors. See Figure 3.
- The majority of collaborative research partnerships with SMEs established within the last three years. For large companies the trend was towards longer-standing relationships.
- The balance between collaboration on underpinning and applied research different for SMEs and large companies. See Table 4. We described underpinning science as 'research to develop fundamental scientific understanding' and applied science as 'investigations to assess the scope and applications of underpinning science'.

Table 2: Breakdown of total number of research collaborations by company size.

Company size	Proportion of research collaborations
SME (<250 employees)	34%
Large (>250 employees)	56%
Consortium (>2 companies)	10%

Table 3: Proportion of research collaborations with SMEs and large companies that were established more (right column) or less (left column) than three years ago.

Company size	Proportion of collaborative partnerships established within the last three years	Proportion of collaborative partnerships established more than three years ago
SME	64%	36%
Large	41%	59%

Table 4: Proportion of research collaborations identified in our survey that focus on underpinning research or applied science.

Company size	Research collaboration type	
	Underpinning research	Applied research
SME	42%	58%
Large	63%	37%

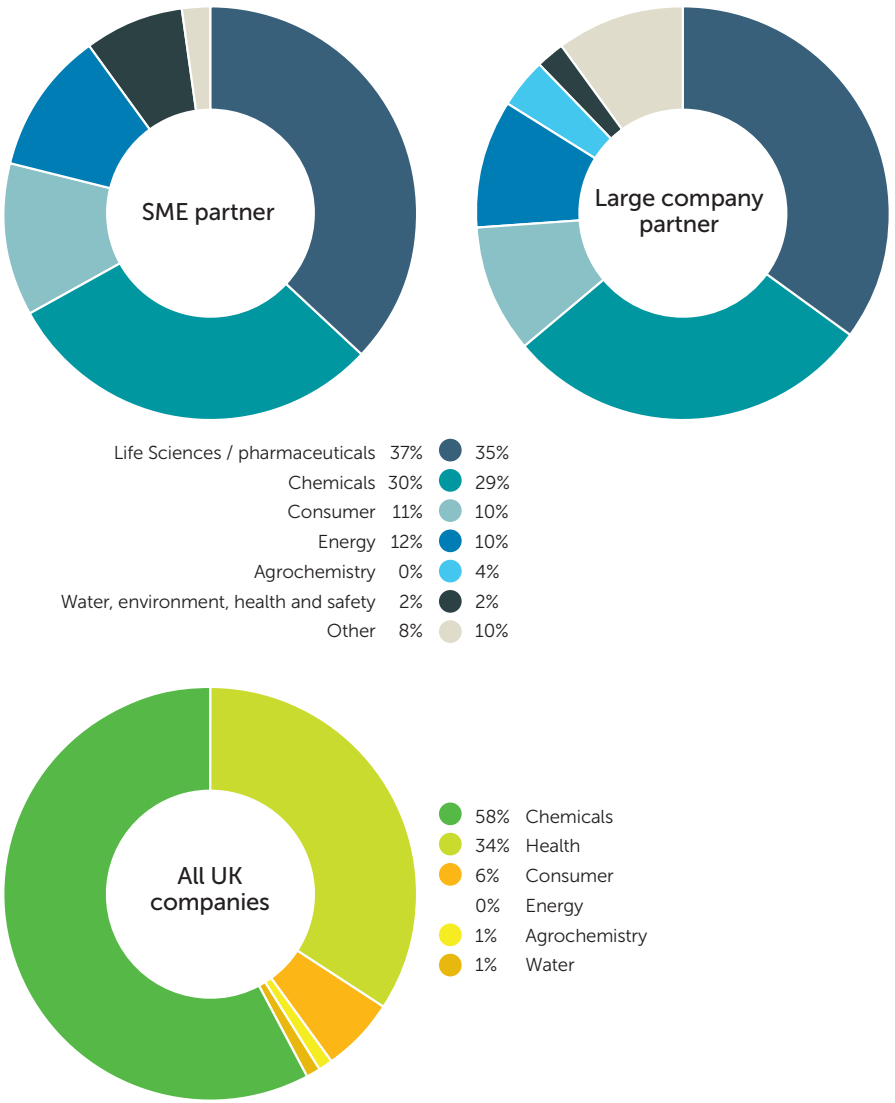


Figure 3: Breakdown of research collaborations by company sector for SME and large company partners (upper charts). Relative size of industry sectors in the UK based on employee numbers (30) shown for comparison (lower chart; percentages rounded to whole numbers).

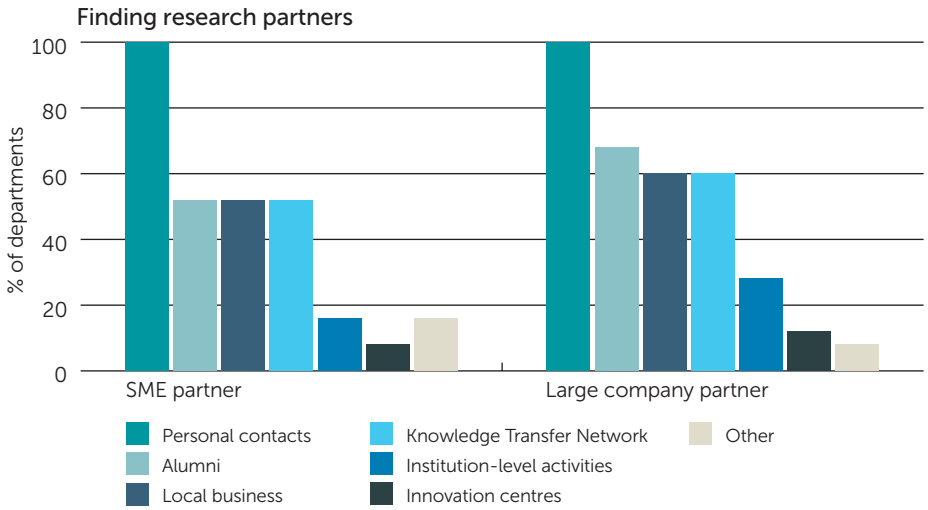


Figure 4: Mechanisms used by chemistry departments in our survey to find new collaborative partners in SMEs and large companies.

Barriers to and opportunities for successful university–business research collaboration

Participating departments identified the four top barriers to university business research collaborations in chemistry from a university chemistry department perspective:

i. Difficulty in finding suitable partners
ii. Lack of funding
iii. Intellectual property and contract negotiations
iv. Pressures on academic time

Barriers ii)–iv) were among the 10 obstacles to successful university to business research collaboration identified from a university perspective in the *Dowling Review* (4).

Finding suitable partners in industry

Individuals and departments use a variety of mechanisms to identify and develop partnerships with businesses. Personal contacts are a key way of finding new partners. Participants in the HCUK workshop reinforced the view that personal contacts are the most effective way of developing collaborations. They also said that expanding personal networks of contacts in industry networks is challenging. See Figure 4.

RECOMMENDATIONS AND OPPORTUNITIES – FINDING PARTNERS IN INDUSTRY

For departments and individual researchers:

• Explore the full range of mechanisms available to develop contacts with industry partners.

Case studies on the Knowledge Centre for Materials Chemistry (**rsc.li/ube-case-17**) and the Organic Materials Innovation Centre (**rsc.li/ube-case-3**) give examples of how knowledge transfer centres can be used to find industry partners.

A case study on the University of Nottingham's Chemistry Innovation Laboratory describes how they build links with SMEs in particular (**rsc.li/ube-case-16**).

A case study on how Aston University partners with consortia is available at **rsc.li/ube-case-18**. Researchers could also explore online brokerage tools such as Innovate UK's _connect (26) and the National Centre for Universities and Business's (NCUB) Konfer (27) as well as opportunities provided by events such as the RSC Emerging Technologies Competition (28) or more indirect connections through student placements in companies.

• Share contacts with businesses within departments; in particular explore ways in which senior academics can support colleagues at earlier stages in their career in developing their network of connections in companies.

For innovation supporters:

• Raise awareness of the different mechanisms available to find industry partners and the ways of accessing them.

Access to funding

Chemistry departments and businesses draw on a range of funding sources to support research collaboration. See Figure 5. Participants at the HCUK workshop suggested that senior academics would often be pleased to support colleagues at earlier stages in their career in developing contacts and that there are opportunities for people with experience of submitting successful funding proposals to share good practice with colleagues.

RECOMMENDATIONS AND OPPORTUNITIES – ACCESS TO FUNDING

For departments and individual researchers:

- **Explore the full range of funding sources available to support university to business research collaboration.**

  Case study: The Sheffield Science Gateway (SSG) is a project supported by the Higher Education Innovation Fund that allows industry to collaborate with the faculty of science at the University of Sheffield (**rsc.li/ube-case-14**).

- **Develop mechanisms to share best practice and advice in writing successful funding applications. This is likely to be most practical within departments or between peers.**

For innovation supporters:

- **Raise awareness of the different mechanisms available to fund university to business research collaborations.**
- **Ensure that application processes are clear and that the time required to prepare a funding proposal is reasonable compared with the amount of funding available.**

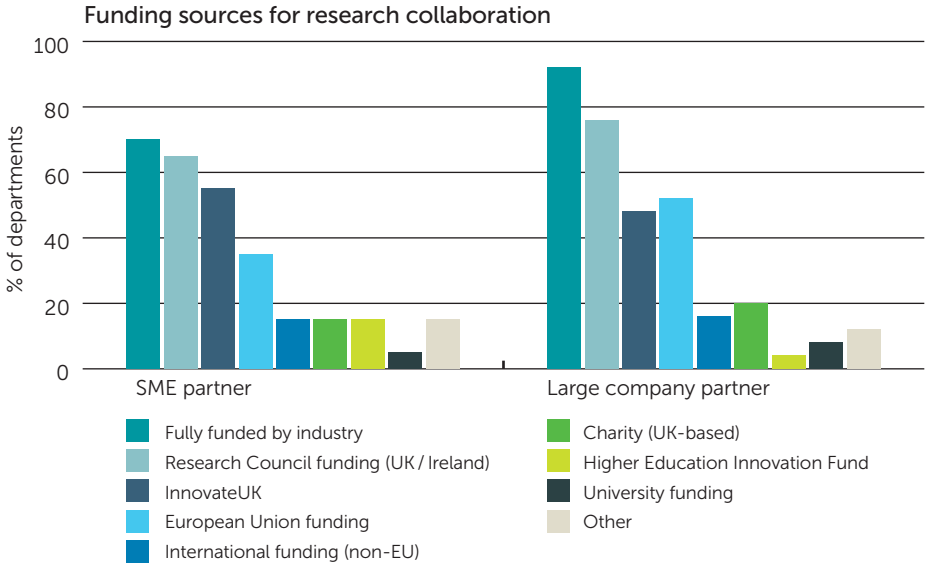


Figure 5: Sources of funding used to support university to business research collaborations in chemistry.

Intellectual property and contract negotiations

Our key findings are that:

- 50% of chemistry departments in our survey identified complex IP and contract negotiations as a barrier to research collaborations.
- Chemistry departments use a variety of IP templates. See Figure 6.
- Publications are the main output from research collaborations, followed by patents and licences. The breakdown of outputs from research collaborations was similar for partnerships with SMEs and with large companies. See Figure 7 and case study describing the University of Aberdeen's patents resulting from their work with TauRx Pharmaceuticals (**rsc.li/ube-case-1**).
- More than 80% of chemistry departments identified their Technology Transfer Offices (TTOs) as having a lead or partner role in the commercialisation of research collaboration outputs. See Table 5.
- 20% of chemistry departments in our survey have the equivalent of at least a 50%-time staff member dedicated to supporting department-level enterprise activities. See Table 6.

Participants in the HCUK workshop explained that in some cases individual academics are not aware of standardised resources like the Lambert Toolkit (14) and Easy-Access IP (15). Also, some universities prefer to use bespoke IP contracts rather than standard templates. Participants also said that TTOs can be perceived as a barrier when setting up collaborations with businesses. This can be because TTOs require contracts and IP agreements to be agreed before preliminary conversations with people in companies can take place at all, or because the terms of the IP contracts set by TTOs are unacceptable to the company partner.

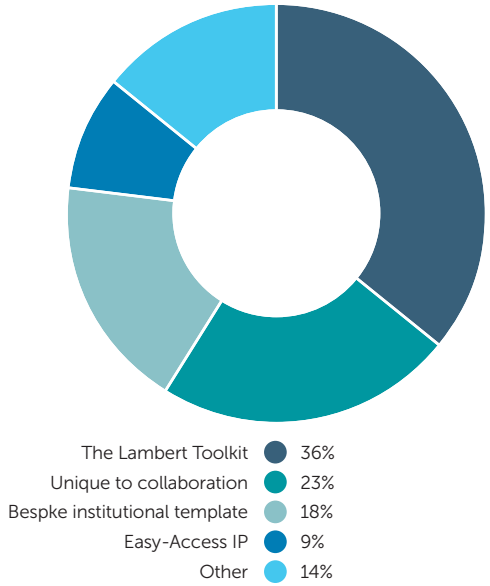


Figure 6: Primary intellectual property template used by chemistry departments for research collaborations.

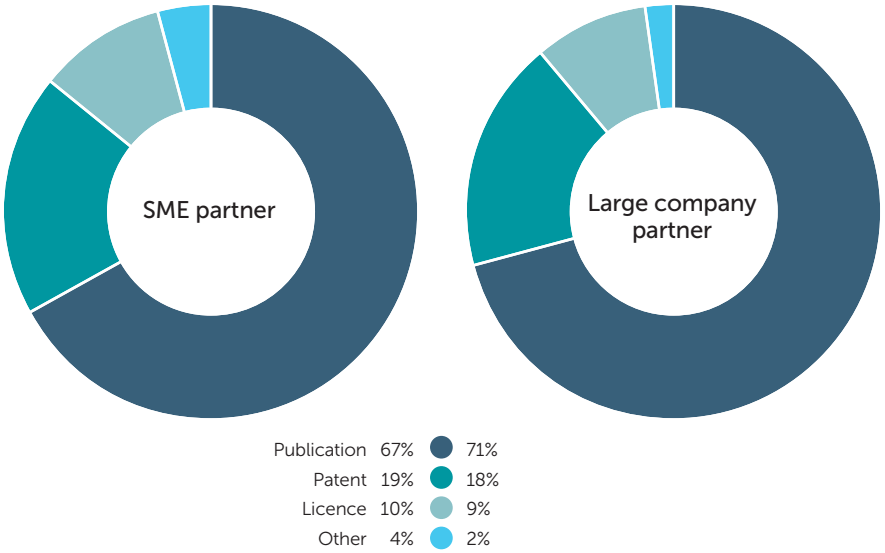


Figure 7: Percentage of partnerships leading to publications, patents or licences as primary output.

Table 5: Perceptions of chemistry departments in our survey regarding role of their university's Technology Transfer Office in supporting the commercialisation of research.

Role of Technology Transfer Office	Proportion of departments
Lead: leading role in facilitating commercialisation of research outputs	39%
Partner: key partner in facilitating commercialisation of research outputs	44%
Support: provides input to commercialisation of research outputs on request	17%

Table 6: Staff in the chemistry departments in our survey dedicated to supporting enterprise activities.

Role of Technology Transfer Office	Proportion of departments
Up to 25% full-time equivalent	74%
25–50% full-time equivalent	5%
Over 50% full-time equivalent	21%

RECOMMENDATIONS AND OPPORTUNITIES – IP ARRANGEMENTS

For departments and individual researchers:

- **Raise awareness of standardised IP templates and examples of good practice among research and research support staff.**

For institutions:

- **Review institutional IP arrangements and the role of TTOs in supporting research collaborations with industry to reduce the extent to which these can be a barrier to collaboration while at the same balancing with institutional interests.**

Research engagement score and the Research Excellence Framework

The *Dowling Review* (4) found that some universities perceive collaborating with industry partners as damaging to an academic career path. We had heard similar concerns from chemistry academics that this negative association would mean their departments would not submit the work of academics that collaborate with industry to the Research Excellence Framework (REF).

We created a research engagement score as one potential measure to explore the relationship between the extent to which a department collaborates with industry and its 2014 REF ranking by Grade Point Average (GPA) (16). See Figure 8.

We found that departments engaged in a larger number of research collaborations, as measured by this research engagement score, tended to have a higher ranking by GPA in the 2014 REF exercise [2].

Figure 8: Definition of research engagement score. We gave projects involving people exchange a higher weighting based on the perception at the HCUK workshop that this type of collaboration is most significant in terms of its investment and value.

[2] This finding is based on a smaller sample size (52%) than the rest of our results. Only 18 of the 25 chemistry departments participating in our survey submitted to REF 2014 and of those 18, only 13 had completed enough sections on research collaboration in our survey to be assigned a research engagement score.

Chemistry department spinout activity

23 chemistry departments completed this section of the survey:

- 17 out of these 23 chemistry departments spun out companies in the five academic years between September 2011 and September 2015.
- The number of new spinout companies per department during this time ranged from 1 to 5.
- Taken as a whole, chemistry departments used a variety of sources to fund the development of spinout companies.
- Different types of funding are used to support the science / technology and business aspects of spinning out a company. See Figure 9 and case study describing the University of Oxford's funding scheme to help researchers commercialise their work, including securing additional funding to spin out companies (**rsc.li/ube-case-13**).
- 25% of individual departments used three or more different sources of funding.
- No departments used banks or crowdsourcing to fund the business development aspects of spinout companies.

RECOMMENDATIONS AND OPPORTUNITIES – SPINOUTS

For departments and individual researchers:

• There may be an opportunity for chemistry departments to explore a greater variety of sources of funding to support spinout activity.

Case study: The Translational Research Office (TRO) at University College London supports academics to explore translational pathways for their research and explore multiple funding sources (**rsc.li/ube-case-2**).

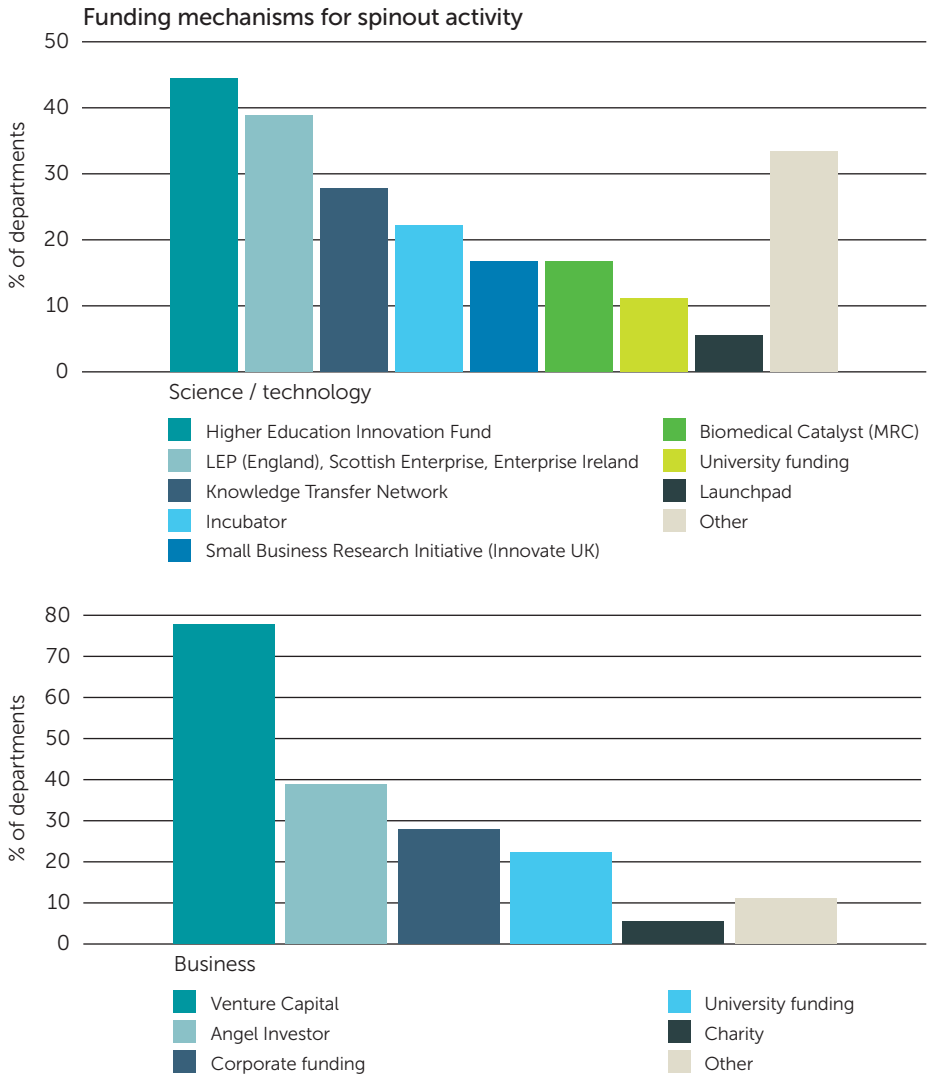


Figure 9: Funding mechanisms used by chemistry departments to support the science / technology and business aspects of spinning out companies.

University–business engagement in teaching, training and employability

Businesses contribute in many ways to university teaching, training and employability activities. Various reports have highlighted the value to students in all STEM disciplines of work placement programmes (8; 17; 18; 19). They are also a key mechanism that businesses across sectors use to address their skills requirements. Nearly two in three of all employers look for graduates with relevant work experience and over a third of all companies that engage with universities offer some form of work placement (2). Work-based learning schemes range from work tasters through to summer internships and one year sandwich placements (20).

One in four employers across all sectors is involved in developing higher education courses. This can include curriculum design and technical teaching as well as providing general advice on course content and delivery and is particularly prevalent in biological and physical sciences (21). The *Wakeham Review* suggests that more could be done to align student skills development in universities with the expectations and needs of employers (22).

Enterprise skills and business awareness

23 departments completed survey questions about contributions by industrial partners to the development of skills in enterprise and business awareness:

- 75% of departments worked with companies to enhance the enterprise skills of their students and / or staff. Figure 10 gives the breakdown of activities by type and level. Case studies on the Soft Matter and Functional Interfaces Centre for Doctoral Training at the University of Durham (**rsc.li/ube-case-5**) and the Medici Enterprise Training Programme at the University of Birmingham (**rsc.li/ube-case-6**) give examples of enterprise training for postdoctoral researchers and academic staff.
- 43% of departments worked with companies to deliver training courses, workshops or events for their academic staff.
- 17% of departments worked with industry experts to provide mentoring to their academic staff. Participants in the HCUK workshop said this type of mentorship was the most effective way of developing these skills for this group.
- Chemistry departments used several routes to find partner companies to support enterprise and business awareness skills development. See Figure 11.

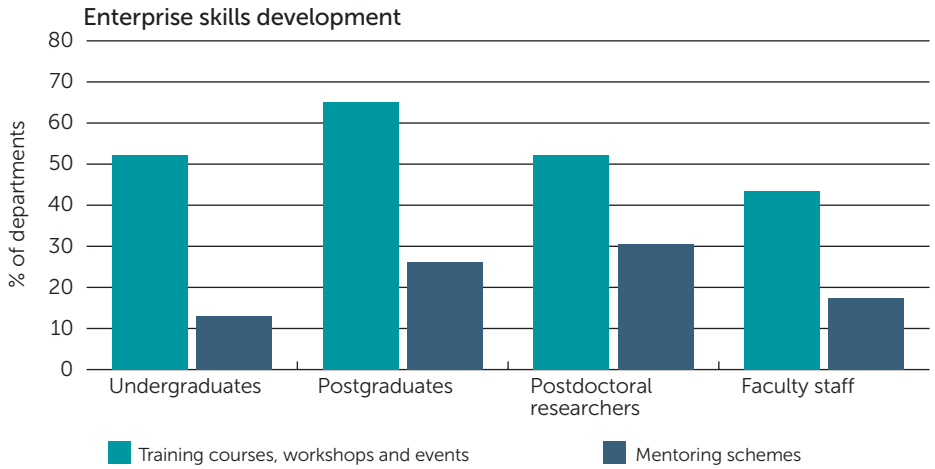


Figure 10: Percentage of chemistry departments that involve companies in enhancing enterprise skills development.

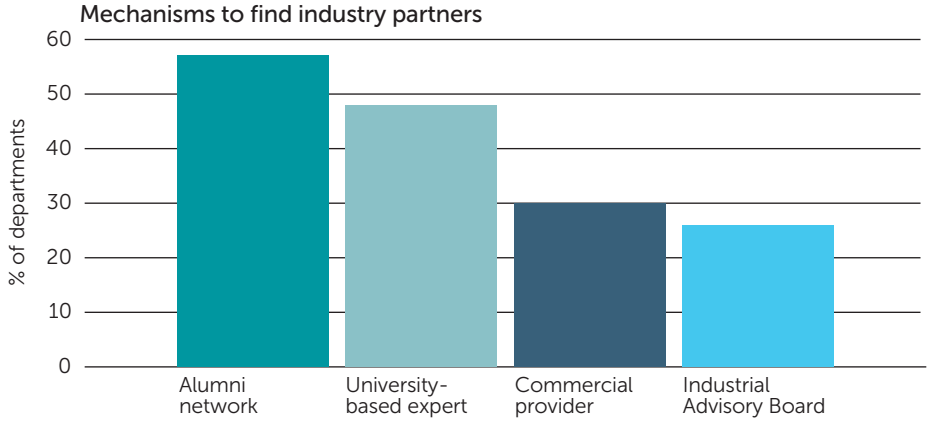


Figure 11: Mechanisms used by chemistry departments to identify partners to support enterprise skills development.

Participants in the HCUK workshop particularly valued alumni in providing a real-life perspective on business and enterprise. Some felt that their aims in working with alumni conflicted with those of the institution-level alumni departments, which they perceived to be focussed on seeking gifts and donations. See case study on the alumni network set up by the chemistry department at the University of Oxford for an example of building relationships with alumni (**rsc.li/ube-case-10**).

RECOMMENDATIONS AND OPPORTUNITIES – MENTORING AND ALUMNI

For departments and individual researchers:

• There is an opportunity for chemistry departments to establish or link with mentoring schemes to connect academics with people working in companies. Department-specific alumni networks could be a useful way of identifying potential mentors.

Examples are the Royal Society of Chemistry Mentoring Service (29) or the University of Nottingham's Business Fellowship Scheme (**rsc.li/ube-case-7**).

For institutions:

• There is an opportunity for institutions to review how institutional alumni relations can hinder or enable personal contributions by alumni to supporting enterprise activities within departments.

Teaching, technical training and employability

23 departments completed survey questions about contributions by industrial partners to teaching, technical training and the development of employability skills. Employability skills are defined as transferable skills needed by an individual beyond subject knowledge and include: communication skills, problem solving, time management, organisation and team-working (23).

We found that:

- Departments worked with more than 560 companies from a variety of sectors to support teaching, technical training and employability. See Figure 12.
- 31% of these companies are SMEs. Case study: The Royal Society of Chemistry's EnterprisePlus Industrial Placement scheme places undergraduate students with an SME for a year (**rsc.li/ube-case-12**). This scheme is highly competitive and oversubscribed.
- Departments use a variety of mechanisms to find suitable company partners to support teaching, training and the development of employability skills. See Figure 13.
- All the departments in our survey worked with companies to provide industrial placements for either their undergraduate or postgraduate students.
- Nearly 80% of departments work with companies on the development or delivery of subject-specific or technical training for either their undergraduate or postgraduate students. See Figure 14.
- Company involvement in formal mentorship or coaching schemes is lower than in other activities. See Figure 14.

Industrial placements are an effective way of developing undergraduate student employability skills (8; 17; 24). Participants in the HCUK workshop echoed this view about the value of industrial placements.

There was strong support from participants in the HCUK workshop for a clear and established framework of undergraduate skills requirements for industry. Case studies describe how the University of Reading embeds professional skills for chemists through its undergraduate degree course (**rsc.li/ube-case-8**) and how the University of Leeds works with an Industrial Advisory Board to design an undergraduate skills framework (**rsc.li/ube-case-9**).

HCUK highlighted CASE and industrial CASE PhD studentships as an important mechanism by which PhD students develop technical and employability skills. Another development has been the creation of Centres for Doctoral Training. In addition to direct or in-kind financial support from companies, these centres also provide a means by which PhD students have opportunities to work directly with researchers based in industry.

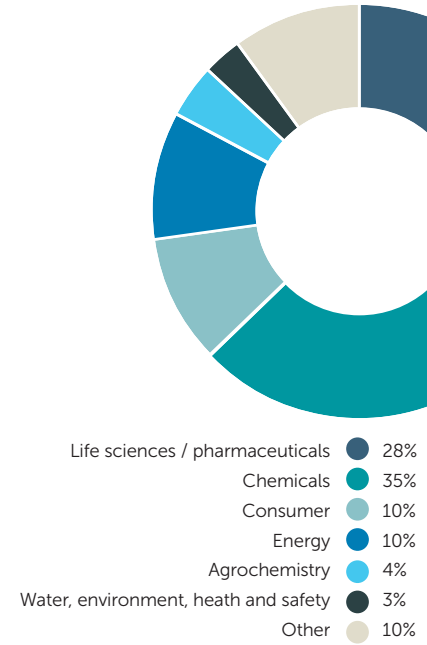


Figure 12: Breakdown of industrial sectors of companies supporting teaching, technical training and employability.

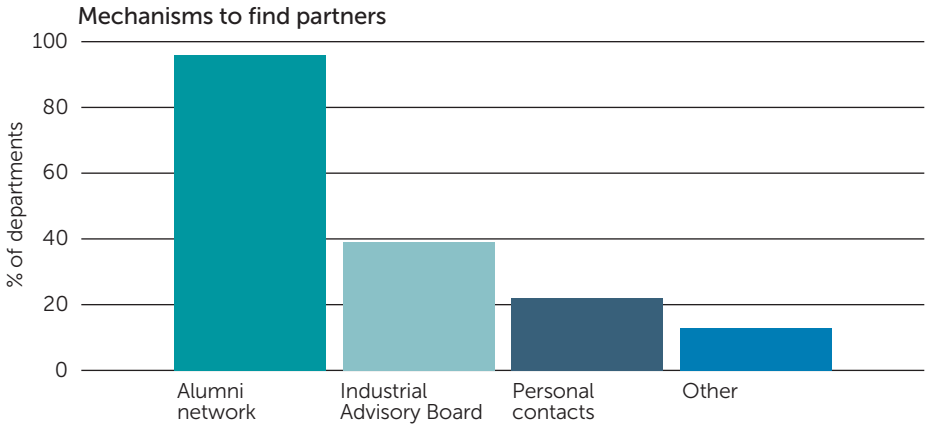


Figure 13: Mechanisms used by chemistry departments to find partner companies to support teaching, training and the development of employability skills.

Chemists benefit from having a way of recording skills they have developed, which they can present to future employers. Mechanisms already exist for this, such as the Royal Society of Chemistry's Undergraduate Skills Record (25). If a student does not do an industrial placement they can, with support from their supervisors, use the skills record to identify gaps in their experience and seek alternative opportunities to develop skills for a role in industry or elsewhere.

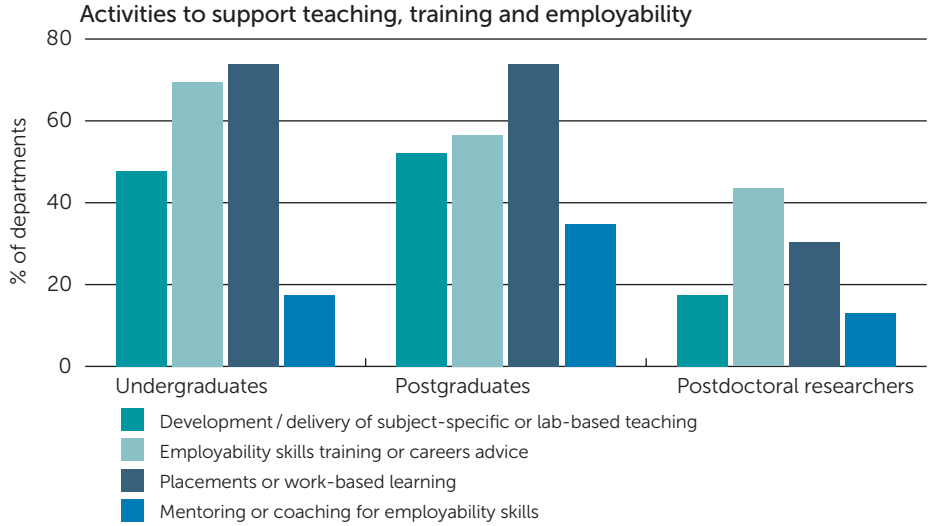


Figure 14: Activities undertaken with companies to support teaching, training and employability for undergraduates, postgraduates and postdoctoral researchers.

RECOMMENDATIONS AND OPPORTUNITIES – SKILLS AND INDUSTRIAL PLACEMENTS

For departments and individual researchers:

- **Departments and institutions may wish to consider developing a common framework of undergraduate skills requirements for industry.** There is the option of adopting or adapting existing skills frameworks such as that used for awarding Registered Scientist (RSci) status (**rsc.li/rsci**), or those in the case studies at **rsc.li/ube-case-8** and **rsc.li/ube-case-9**.
- **There is an opportunity to share good practice in student industrial placements.**

For universities, companies and funders:

- **There is an opportunity to increase the number of industrial placements for undergraduate and PhD students**. There are different factors that limit availability of industrial placements, including availability of funding and capacity of companies to host industrial placement students. It is also a challenge for chemistry departments and for companies to connect with one another in order to explore industrial placement opportunities.

Conclusions

University chemistry departments are engaged with large, medium and small businesses across all industrial sectors. The snapshot in our report shows a vibrant landscape with many different types of university to business interactions, ranging from collaboration on research and entrepreneurial activities to development of skills and experiences for students and staff.

These interactions are enabled in many different ways. A key theme is the importance of relationships between people: personal connections are the primary way of identifying new research collaborators and use of alumni networks extends across all activities involving business engagement including mentoring, advisory and training activities.

Our set of 18 case studies shows diverse examples of university–business engagement in chemistry. We hope these will be a rich source of ideas for individuals and departments in and beyond chemistry who are interested in expanding their interaction with businesses, as well as for companies and innovation supporters.

The barriers we identified to university–business collaboration in research are similar to those that have been found generally, most recently in the *Dowling Review*. These were: difficulty in sourcing partners, access to funding, IP arrangements and pressures on academic time. While there are some issues that will require review or action from external stakeholders, in each case we also found that there are opportunities for individuals and departments to explore a wider range of options.

Members of our Royal Society of Chemistry Divisions from universities and businesses run activities to discuss science and technology challenges and to connect PhD students with potential employers. Our Enterprise Plus Industrial Placement Scheme and our Emerging Technologies Competition are also key elements in our programme to support university–business engagement in chemistry.

Looking to the future, this report will inform the evolution of our programme to support the growth of connections and collaborations across the interfaces between university chemistry departments and businesses.

Appendix: survey respondents

Aston University	University of Birmingham
Cardiff University	University of Bristol
Durham University	University of Edinburgh
Imperial College London	University of Glasgow
Keele University	University of Hull
Liverpool John Moores University	University of Leicester
Manchester Metropolitan University	University of Manchester
National University of Ireland, Galway	University of Nottingham
Newcastle University	University of Oxford
Open University	University of Sheffield
Queen Mary University of London	University of St Andrews
Trinity College Dublin	University of York
University of Aberdeen	

Table 7: Chemistry departments in our survey. Departments completed the survey on the understanding that grouped data would be published but their specific contribution would remain anonymous.

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Heads of Chemistry UK (HCUK) is the body which represents the interests of departments engaged in chemical education, scholarship and research in universities and similar institutions throughout the United Kingdom and Ireland.

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