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Industrial Doctorates - Employer Engagement in Research and Skills Formation

Fumi Kitagawa

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Industrial Doctorates – Employer Engagement in Research and Skills Formation [1]

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Abstract

This paper examines forms of industrial involvement in doctoral education for the new competence building, workforce skills development and the formation of "hybrid spaces" between academic and industry through the mobility of talents. Knowledge exchange activities between university and industry have direct and indirect education implications for doctoral students and their research experiences. Nevertheless, there is little empirical research with regard to the educational impact of university-industry relationships or analysis of the implications for research training. The paper looks at the development of "industrial doctorate programmes" in the UK over the past decade in relation to the wider international debates surrounding the changing nature of doctorate degrees and forms of employer engagement. Empirically, the aim of this study is to understand the "learning experiences" and "strategies" of industrial doctorate students at EPSRC-funded Industrial Doctorate Centres (IDCs) while they conduct doctorate research within industrial contexts. The pilot survey conducted with 25 industrial doctorate students enrolled at EngD in Systems illustrates the institutional complexity of working within "hybrid spaces," managing different expectations, and co-producing knowledge with industry and academic partners, as well as acting as "change agents" within organisations.

Key words

Employer engagement; doctoral education; intermediate labour market; university-industry relationship; S&T human capital; mobility of talents

1. Introduction

It is argued that the competition for ideas, knowledge and skills defines the new economy (Drucker, 1993), where new models of organisation and employment are required to cope with rapid technological innovation and change (Lam, 2007). The increase in educated labour is considered to be "a power shift" where human and intellectual capital – individual expertise, knowledge and creativity – generate prosperity for individuals, companies and nations (Brown *et al*, 2008). Consequently, along with an increased expectation of the role of universities for innovation and economic development from research and commercialisation of the knowledge they generate, there is growing interest in the production of new forms of "high-skilled" workforce. Since the 1990s, countries around the world have been increasing "doctoral degree production" (Nerad, 2010), and there is a growing interest in new forms of doctoral education and research training in different national contexts (Harman, 2004; Enders, 2005; Nerad, 2010; Servage, 2009; Thrift, 2009).

Issues concerning doctorate education and research training are discussed from two different angles. On the one hand, the needs of the knowledge economy have increased the demand for doctoral-level research abilities in governments, research institutes and private industry alike; while on the other hand, doctoral education has been seen to have failed to meet the needs of industry and society, and has thus created "misalignments and inefficiencies in the employment market for graduates" (Servage, 2009, 765). Reforms in doctoral education, particularly the perceived need to make stronger links with industry and employers are an international and transnational phenomenon and pertinent, given the growth in doctoral students and their eventual destinations (Stephan *et al*, 2004; Lee *et al*, 2010). These are associated with a number of common issues surrounding doctoral training and education, such as low completion rates, and the mismatch between academic research and industry needs. Responses to these issues are found in the emergence of new types of coordination between science and technology, and new types of PhD labour market (Mangematin, 2000). Lanciano-Morandat and Nohara (2006) and Lam (2007) developed the concept of "an intermediate labour market" and "overlapping internal labour market" between academia and industry, interacting between the two spaces.

This paper examines forms of industrial involvement in doctoral education for the new competence building, workforce skills development, and the formation of "hybrid spaces" between academic and industry (Lanciano-Morandat and Nohara, 2006; Lam, 2007, 2010) through the mobility of talents. The broad underlying questions underlying this paper are as follows:

1. How can universities work better with employers to meet the needs of high-level, especially doctorate-level, skills and competence building?
2. What forms of skills and workforce development are possible through the mobility of talents between university and industry, and how can they be reflected in human resource management?
3. What funding and institutional mechanisms are needed to achieve circulation of knowledge and formation of competence and skills through the mobility of talents between university and industry?
4. How do doctoral students learn through such mobility experiences, and how would that be embedded within an industrial context?

The focus of this paper is industrial involvement in doctoral education as one type of “university-industry relationship” (Perkmann and Walsh, 2007) at different stages of employees’ career development. It takes different “human mobility” forms including short-term secondments, financial arrangements to fund doctoral students, and co-supervision of doctoral research projects between academia and industry. These forms of relationships are not so new; many have developed over the last decades. The mobility of scientists and researchers, including doctoral students, are conditioned by wider employment relationships and labour market and training mechanisms of each national system.

It is argued that the workforce needs to have “higher-level skills”, in order to compete in global markets. Employer engagement with higher education has been high in the UK government agenda in recent years. Combined with the demographic trend, it is argued that higher education and industry will be in increasing competition to recruit students or employees, respectively, and the employer engagement by higher education is considered to be one way to counter this trend (Dales and Arlett, 2008). The UK government and employers have a particular concern about “the supply and quality of graduates in science, technology, engineering and mathematics (STEM)”. In a consultation document on *Higher Education at Work* (DIUS, 2008), the government sets out aims for “more, and more employable, graduates” and is looking for ways to increase the level of STEM skills in the existing workforce(cited from Dales and Arlett, 2008). The Leitch review (2006) emphasised the need for greater numbers of employees obtaining higher-level skills and proposed that a proportion of programmes at higher education institutions could be funded by “demand-led processes". In 2006, the government requested the higher education sector (HEFCE, 2006): "....to lead radical changes in the provision of higher education in this country by incentivising and funding provision which is partly or wholly designed, funded or provided by employers."

The empirical focus of this paper is on a particular type of provision for employer engagement with higher education, related to specific "high-skill' research training provided at doctorate level. The paper looks at the development of "industrial doctorate programmes" in the UK over the past decade in relation to the wider international debates surrounding the changing nature of doctorate degrees and forms of employer engagement with roles played by research councils, industry associations, employers and universities.

The structure of the paper is as follows. Following this introduction, the Second Section provides a review of the background literature in two related fields: a) knowledge production and knowledge flows between academia and industry, especially through human mobility; and b) Science and Technology (S & T) human capital, labour market and researchers' careers. The paper introduces a conceptual framework drawing on recent literature on "hybrid spaces" (Lam, 2007; 2010) between academia and industry, learning and competence building (Lanciano-Morandat and Nohara, 2006). There are different career structures and incentives for academics and those who work in industry. For example, "entrepreneurial academics" or "linked scientists" are one type of people who move between the two spaces (Lam, 2007). Those doctoral students who pursue a career in industry may represent another type of mobility between "hybrid spaces." In the Third Section, the empirical context of this paper is presented by providing a chronological review of the development of the Engineering Doctorate/Industrial Doctorate Centres (IDCs) in the UK, and the recent policy debates. The Fourth Section presents empirical observations from a recent study examining strategies and learning processes of industrial doctorate students who move between the university and industry. The paper concludes by identifying different motivations, strategies and learning processes regarding employer engagement in doctorate education, in relation to the current policy agendas in the UK. Finally, further research agendas are identified.

2. Human mobility as university-industry relationships and development of Science & Technology human capital

2-1 University-Industry relationship and human mobility

Today, universities are encouraged by various policy and funding instruments to actively engage in the diffusion of research-based knowledge by multiple routes, including commercial channels− licensing patents, consulting, or implementing knowledge through spin-off companies, as well as more relationship-based knowledge transfer activities (Perkmann and Walsh, 2007)− collaborative research, commissioned research, consultancy, equipment sharing, advisory roles, joint supervision, joint publication and student placements. Thus, recent studies demonstrate a variety of university-industry “links” and “relationships” evolving between them and inter-linkages between different channels. D’ Este and Patel, for example, examining findings from a survey with the UK researchers in engineering and physical sciences. The sample of researchers was obtained from the records of principal investigators who had received research grants from the UK Engineering and Physical Sciences Research Council (EPSRC) in the period 1995–2003 (D’Este and Patel, 2007). They concluded that researchers use a wide variety of such channels, such as consultancy and contract research, joint research, training, meetings and conferences, and the “creation of new physical facilities” (e.g. “spin-off” companies).They found that a significant number of academics are engaged in several channels simultaneously, particularly in the applied sciences.

A comprehensive review is provided by Perkmann and Walsh (2007) of the academic-industry “relationship-based” mechanisms such as research partnerships and research services, in relation to other mechanisms related to “transfer” and “mobility.” These *typologies* of university-industry links coexist with different types of knowledge flows, such as scientific codified knowledge and informal social interactions.

Table 1 Typology of University-Industry linkages

Based on Perkmann and Walsh (2007)

Relationship Based	**Research partnerships**	Inter-organisational arrangements for pursuing collaborative R&D
	Research services	Activities commissioned by industrial clients including contract research and consulting
Mobility Based	**Academic entrepreneurship**	Development and commercial exploitation of technologies pursued by academic inventors through a company they (partly) own
	Human resource transfer	Multi-context learning mechanisms such as training of industry employees, postgraduate training in industry, graduate trainees and secondments to industry, adjunct faculty
Transfer Based	**Commercialization of property rights**	Transfer of university-generated IP (such as patents) to firms, e.g. via licensing

The focus of this paper, industry engagement with doctorate research training, falls between relationship-based and mobility-based university-industry links. By contrast, human mobility aims at transferring "generic skills," among graduates seeking work in industry, is part of a more infrastructural role of universities and is therefore not classified under the relationship category according to Perkmann and Walsh (2007). As Perkmann and Walsh argue:

> *"Relationships will often occur in conjunction with human mobility: for example, when companies sponsor Ph.D. studentships. In fact, in many cases, mobility can be intrinsic to relationships if it occurs within the context of specific collaborative projects."* (2007, p.263).

In the context of "open innovation," the links with high "relational involvement" are considered to be relevant to innovation, as they facilitate the building and maintenance of inter-organisational relationships over a prolonged period of time (Perkmann and Walsh, 2007, p.263). Because different industrial sectors have different intensities of R&D and interaction they have different preferences for 'relationship' mechanisms. Schartinger and his colleagues (2002) found that in Austria collaborative research is preferred to contract research in the chemicals, instruments, metals and automotive sectors; while the opposite is true for software development. By contrast, the service industry uses relationships mainly in the form of training and education. It would be interesting to investigate further how mobility creates different sets of "relationship" mechanisms in different industrial sectors.

2-2 Training, innovation and workforce development

Recent literature on skills and workforce development argues for "pro-innovation" organisational practices for innovation in work places. In terms of training, workforce development and employment relationship at a firm level, it is argued that there is an association between the "propensity of firms to innovate and the probability of them providing workplace training" (Toner, 2011, p.32).

> "Learning and interaction within organizations is at least as important for innovation as learning through interactions with external agents, and indicators for innovation need to capture how material and human resources are used and whether or not the work environment promotes the further development of the knowledge and skills of employees" (OECD, 2010, p. 11).

A recent report on skills and innovation commissioned by the OECD notes an increased interest on the "links between the propensity and intensity of innovation in firms and the different forms of innovation activity that firms and industries can implement and the adoption of specific work organisation patterns" (Toner, 2011, p.53). It is argued that the supply of vocational education and training (VET) skills is influential in determining not only what goods and services are produced in a national economy, but how they are produced. Firms' product market choices are constrained by the availability of necessary skills (Toner, 2011, p.35).

The literature on the "institutional foundations of national skill formation regimes" identifies three broad types of intermediate skills formation systems: "occupational," "internal" and "flexible" (Hall and Soskice, 2001). These types of labour market models are a set of "self-reinforcing institutions", that create "economic incentives and legal and social obligations" on workers and firms to "invest in particular forms of workforce training and on firms to adjust their production systems and products to these particular types and level of skill" (Toner, 2011, p.35). These labour market models may define the types of innovation and skills required in each system. For instance, the German VET system underpinned by national institutional mechanisms, suits the "occupational labour market model." In such a model, vocational skills are characterised by "deep competencies within established technologies" (Estevez-Abe *et al.*, 2001, p. 174), which are particularly "suited to incremental innovation and problem-solving but are inappropriate to a world where competition is dependent on rapid changes in basic innovation" (Lauder, 2001, p. 170).

It is argued that in the UK and the US, the education and training systems follows the innovation model based on "high level elite skills in science and technology" (Toner, 2011, p.50). These are particularly eminent in industries such as pharmaceuticals, chemicals, electronics, software, defence and aerospace indicated by, measures such as R&D intensity, trade performance and patenting activity shows the strength of this high level science base (Toner, 2011, p.50). The absence of labour market regulations on hiring and firing and high levels of job mobility, including "scientific, engineering and managerial elites", is well suited to these industries (Toner, 2011, p.50). High-level skills also underpin international competitiveness in financial services and creative industries such as advertising, publishing, design, entertainment and management consulting (Tether *et al*, 2005, p. 70). A high-level of labour mobility, especially amongst the "technical elites", is also a critical means of technology diffusion in industries where change in technology and markets is particularly rapid (Finegold, 1999, cited in Toner, 2011, p.50). Where there is a large pool of workers with advanced and highly portable skills, there is a reliant on flexibility characterised by "rapid product innovation strategies" and a "high responsiveness to new business opportunities" (Estevez-Abe *et al*, 2001, p.174).

2-3 S & T human capital and Intermediate labour market

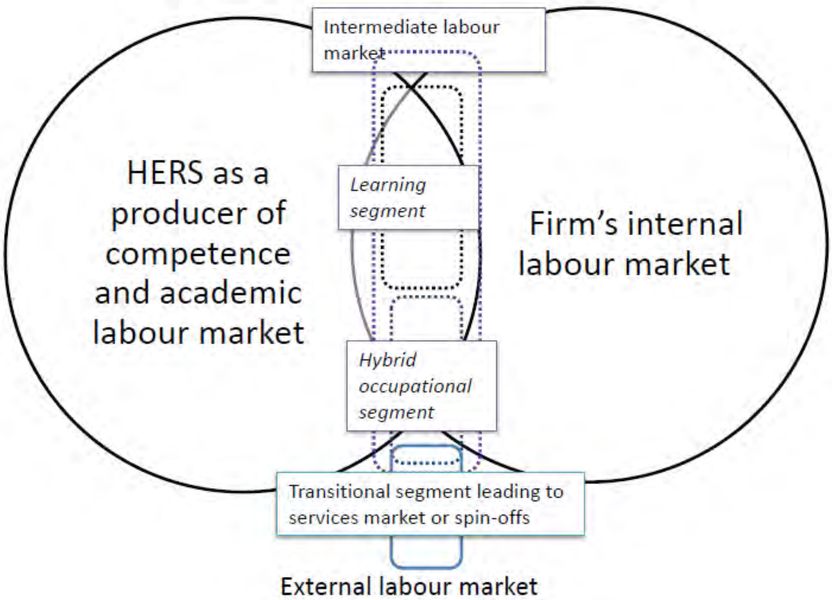
Bozeman *et al* (2001) defined Science and Technology (S & T) human capital as *the sum of scientists' and engineers' scientific and technical knowledge, work relevant skills and social ties and resources*. This paper focuses on such S & T human capital building mechanisms, and takes a view that industrial engagement in doctoral education is one type of university-industry relationship which enhances S & T human capital through increased interactions with external agents. Such relationships develop over years in different national policy contexts, within national innovation systems (Mowery and Sampat, 2005). The paper draws on and synthesizes the academic literature focusing on a) knowledge production and knowledge flows between academia and industry on the one hand; and b) S & T human capital, labour market and careers of researchers on the other. In other words, in order to understand the processes of learning and competence building, and knowledge production and innovation with employer engagement at the Industrial Doctorate Centres (IDCs), two inter-related issues embedded within the industry-university collaboration need to be unpacked: one is concerned with "the joint production of new knowledge with commercial applications," and the other is related to the "patterns of careers and incentives." These are underlined by “the divergent work norms and reward structures governing the two different knowledge production systems” (Lam, 2007, p.997).

Referring to the intersection between the two different knowledge production systems of industry and academia, significant “barriers” are identified (Bruneel *et al,* 2010). These are related to the nature and orientation of different types of knowledge (Harryson *et al*, 2008; Chiang, 2011). According to Harryson *et al* (2008) this is characterised as “a fundamental difference between corporate and academic research: scientific knowledge produced by companies is usually claimed to be short- and medium-term oriented, aiming at exploitation, whereas the strength of academic research is claimed to prevail in exploration, but seldom comes up with results ready for commercialisation” (Harryson *et al*, 2008, p.113). Rather than looking at these corporate and academic spheres of knowledge production systems as a dichotomy, a more interlinked perspective seems helpful. In innovation research, two “modes of learning and innovation” have been identified. One is based on “the production and use of codified scientific and technical knowledge” – the *Science, Technology and Innovation (STI) mode*, and the other is “an experienced-based mode of learning” based on *Doing, Using and Interacting* – the *DUI mode* (Jensen *et al*, 2007). It is argued that firms that use mixed strategies that combine organisational forms promoting learning with R&D efforts and co-operation with researchers as knowledge institutions are much more innovative than the rest. In other words, the firm that “combines a strong version of the STI-mode with a strong version of the DUI mode” excels in production innovation (Jensen *et al*, 2007, p.685). In this light, knowledge production systems within corporate and academic research spheres interact with each other and they are interdependent.

Recently, there is growing pressure on firms to “acquire and make effective use of knowledge that has been generated beyond their own boundaries” (Mason and Nohara, 2010, p.461) with the potential benefits to firms of recruiting experienced scientists and engineers who bring with them skills and knowledge gained in the other firms. Thus the new scientific labour market is characterised by the formation of competences on a collaborative basis between organisations, sometimes between academia and industry, through the creation of a joint “pool of human resources” (Lam, 2007, p. 1005). Authors have called such human capital as “the linked scientists” (Zucker *et al*, p. 2002), whose work roles and careers straddle the world of the university and the firm. However, little is known about “how the flow of knowledge across organizational boundaries is intertwined with careers and employment relationships" in relation to the systems of training and competence building at firm and national levels (Lam, 2007, p. 994). Furthermore, since personnel often possess tacit knowledge, it is interesting to look at "the role of the functions and the qualifications of R & D personnel in relation to activities developed in the framework of technical collaboration agreements" (Spithoven and Teirlinck, 2010). This leads to two questions. One is concerned with researchers' career, incentives and disincentives for mobility, and reward mechanisms as part of the firms innovation strategies; and the other concerns development of the skill set of researchers and the systems through which researchers are trained. Jacobson *et al* (2004), for example, identifies "the reward and incentive system" in academia as the main barrier for knowledge transfer (p. 248).

According to Lanciano-Morandat and Nohara (2006), human actors, such as researchers, post-docs, professors and doctoral students play a central role in the "structuring of the *hybrid space* that is emerging at the interface between academia and industry" (Lanciano-Morandat and Nohara, 2006, p. 280). Figure 1 is a schematic representation of the interlink between the two labour market systems, or an "intermediate labour market" between academia and industry. Doctoral students are seen as "linked scientists" whose competences are jointly produced by actors and stakeholders in both academic institutions and industrial organisations (e.g. academic supervisors, industrial supervisors, academic and industrial peers).

Figure 1. Intermediate labour market between academia and industry
Source: Lanciano-Morandat and Nohara, 2006



Arguably, the formation of competences is taking place increasingly on a collaborative basis between the two spheres, in a so-called "overlapping intermediate labour market" (Lam, 2007, p.1013). A growing share of scientists is being "jointly produced" by the higher education and research systems (HERS) and firms, which Lanciano-Morandat and Nohara (2006) call the "learning segment." The relationships between the two spheres give rise to networks and a circulation of researchers, which the authors call the "hybrid occupational" segment (p.282), or what is also called "network forms of organisations."

The empirical part of this paper illuminates the ways in which individuals strategically construct their knowledge spaces within the "internal labour market" with "learning" and "hybrid occupational" segments, and it highlights the challenges and constraints they face through the process.

3. Contextualising reforms in doctoral education: Engineering Doctorate (EngD) and Industrial Doctorate Centres (IDCs)

Mangematin (2001) points out the special nature of "doctoral manpower" – doctorate holders are trained to produce new knowledge and serve as an important channel for knowledge transfer from academia to industry if they enter industry after their doctoral education. In particular, over the past decade growing calls for "rethinking" contemporary approaches to doctoral education and research training have been made in different national contexts, including North America (Nyquist and Woodford, 2000; McAlpine and Norton, 2006; Nerad, 2008; 2009), the UK (The Roberts Review, 2002; Thrift, 2009) and Australia (Harman, 2004; Manathunga *et al*, 2009; Cumming, 2010). Different forms of doctoral education have been evolving over the years in different national settings (Clark, 1993). The condition under which doctoral students are trained and integrated into the labour market varies in each national context. Traditionally, obtaining a PhD has been regarded principally as a preparation for an academic career, while significant number of PhD holders work in industry or outside the "conventional S & E PhD occupations" (Lee *et al*, 2010), and the share of such doctorate holders varies (Enders, 2001; Lanciano-Morandat and Nohara, 2006). Universities are increasingly expected to produce doctoral graduates with the skills required by employers in various industrial as well as public and third sectors. However, this is paralleled with the "loss of exclusiveness as far as the role and centrality of higher education and the academic profession as the main source of new scientific knowledge and its dissemination" (Enders, 1999, p.73). There is also a growing need for universities to demonstrate the value of a doctoral education to individual students and prospective employers. Doctoral education and forms of research training are being shaped by a number of factors: the changing needs of society, and of research modes (Gibbons *et al*, 1994); the changing nature of knowledge, and of the academic profession and the university (Enders 1999; Geiger, 2004; Washburn, 2005), and growing university-industry relationships (D'Este and Patel, 2007; Beltramo et al., 2001). Stephen (2001) points out that technology transfer between university and industry have direct and indirect education implications for doctoral students and their research experiences. Nevertheless, there is little empirical research with regard to the educational impact of university-industry relationships and implications for research training (Chiang, 2011).

Some countries have developed national schemes to incentivise industrial engagement in doctorate training (Kitagawa, 2011). [3] This paper focuses on this UK Engineering Doctorate / Industrial Doctorate programme. In the UK, the Engineering Doctorate (EngD) programmes have been in existence since the early 1990s. The Engineering and Physical Sciences Research Council (EPSRC) has funded EngD Centres, which have recently been called Industrial Doctorate Centres (IDCs). The Engineering Doctorate Scheme, one of the UK's postgraduate degree schemes, was initially established by the Science and Engineering Research Council (SERC) in 1992, before the reorganisation of the research councils and the formation of the EPSRC in 1994. The aim of the Engineering Doctorate Scheme was to provide postgraduate engineers with "an intensive, broadly based, research programme incorporating a taught component, relevant to the needs of and undertaken through sponsorship with industry" (EPSRC, 2007). Distinguishing features of the scheme then was "its four-year duration," "higher stipend" than other doctorates, and a requirement for the students to spend a "significant amount of time on a project for their sponsoring

[3] For instance, in Denmark, an Industrial PhD programme has been established as "a three-year research project and research training programme with an industrial focus conducted jointly by a private company, an Industrial PhD student, and a university" (The Danish Agency for Science, Technology and Innovation, 2009). The student is employed by the company, which can be a public sector organization, and enrolled at the university. The programme is financed by the Danish Council for Technology and Innovation, and administered by The Danish Agency for Science, Technology and Innovation. In France, Industrial Agreements for Training Through Research (CIFRE) is a programme to develop "public-private research partnerships based on these jointly financed by firms and the National Association for Research and Technology (ANRT)". The CIFRE programme not only gives firms access to cutting-edge public research, but also helps the students to get a foothold in the firm in terms of their future job prospects. See Giret, J.-François, and Recotillet, 2004.

organisation." Those students enrolled on EngD degree are called "Research Engineers (REs)", rather than "research students" The programme is seen as a route to achieve "fast-track" progression to senior management positions in industry (Barnes and Neailey, 2011).

The chronological development of the programme is described below, and summarized in Box 1.

Box 1

1992 First 5 Engineering Doctorate Centres
1997 First Review; Another 5 Engineering Doctorate Centres
2001 Call for Engineering Doctorate Centres
2006 Call for Engineering Doctorate Centres
2008 New Centres for Doctoral Training (CDTs) – 45 Centres
2009 Industrial Doctorate Centres (IDCs) – 19 Centres

The Engineering Doctorate Scheme was launched with five Engineering Doctorate Centres in 1992, and the first review was conducted in 1997. Another five Centres were established after the first review. In 2001 and 2006, following calls by EPSRC for development in "particular areas of identified national need," further Engineering Doctorate Centres were created, sometimes as partnerships between several universities. Several earlier centres came to the end of their five-year funding period, while others received continuing funding. In 2008 EPSRC opened new Centres for Doctoral Training (CDTs). CDTs provide a four-year doctoral training programme to a significant number of PhD students organised into cohorts. CDTs are partly similar to EngD as they provide four-year doctorate programmes with taught courses rather than the three-year research-only degree. Each centre targets a specific area of research, while also emphasizing transferable skills training. Initially the focus of CDTs was interdisciplinary research in strategic areas. While the relevance to industry and transferable skills is an important element of the training, CDTs do not require students to spend time with industry. The £289 million was invested in 45 CDTs. This has resulted in a significant change in the landscape of engineering doctorate programmes in terms of the areas of programmes, training portfolio, and balance between support for career stages and research-based programmes (EPSRC, 2010).

Industrial Doctorate Centres (IDCs) were created in 2009 as a subset of EPSRC's Centres for Doctoral Training (CDTs). IDCs are considered to be "an evolution of the Engineering Doctorates Centres (EngD) scheme." These "user-oriented" centres provide the same training environment and features as CDTs whilst also incorporating a strong industrial focus. As part of substantial expansion of the CDT scheme, in 2009 EPSRC decided both to "expand the scope of the previous EngD scheme (to cover the entire remit of EPSRC) and to seek to refresh the portfolio of Centres being supported (to allow new priority areas to be identified and supported – in energy, for example)." Thus, the cohort of 19 IDCs represents "a mixture of new centres and continuations (albeit in an evolved form) of a number of EngD centres."[4] One of the new IDCs established in 2009 provides non-Engineering degrees; therefore its degree is not called EngD (e.g. in the case of University of Oxford, it is called DPhil, like other doctorate degrees). In 2010, a new call was opened inviting applications for EngD Centres in the area of manufacturing engineering, with a specific remit for the materials, mechanical and medical engineering programmes.

IDCs are unique, as doctorate students spend a significant part of their programme within the industry. The IDC consists of three different "stakeholders": the university research centre, the industrial research group, and an individual industrial doctorate student, with different aims and purposes. Students carry out research projects in line with the needs of industry, with rigorous academic quality at doctoral level. Table 2 is a schematic representation of the IDC's stakeholders and their respective agendas.

Table 2. IDC as a compound of three different stakeholders with different agendas

IDC		
University - Academic knowledge - Transferable skills - Pressure for employer engagement	**Research Engineer** - Individual career aspiration - Research progress - Career progress - Life opportunities	**Firm** - Industrial problem and R&D needs - Developing employees with high research skills - Gaining knowledge and skills from external organisation

[4] EPSRC Industrial Doctorate Centres http://www.epsrc.ac.uk/funding/students/coll/Pages/idc.aspx accessed 7 October 2010.

In the case of Industrial Doctorate Centres (IDCs), the doctoral students are enrolled not in PhDs, but in Engineering Doctorates (EngD), and are often called Research Engineers (REs). In most cases they are not pursuing academic careers. IDCs are designed to create "hybrid spaces" for doctoral students to be placed in both industry and academic institutions, conducting research which is of relevance to the industry's needs. Some of the REs are employed by the company, and they are sponsored by their own employers to complete the EngD degree. Others start EngD degrees, work as REs at the firms, and often get employed after the programme. It is possible for them to pursue academic careers afterwards, although this is rare. For them, the doctorate degree (EngD) is seen as an academic as well as a vocational qualification.

Industrial Doctorates can be seen as an evolution of the doctoral programme to meet new labor market conditions, as well as a response to "multiplication of the links" between the academic sector and the industrial R & D sector (Beltramo *et al*, 2001). Firms need to solve industrial problems and need "state of the art" scientific knowledge for their R & D needs. Firms also need to develop employees with highly developed research and analytical skills. Individual REs look for career progress, and aspire to progress in research with industrial relevance. There are some financial incentives for firms to participate in IDCs as it is relatively cheaper to have doctoral students supported by EPSRC. In order to ensure these agendas are shared, IDC management committees typically consist of a mixture of academics and industrialists who have some projects with the university. They try to optimise training opportunities for doctorate students under the IDCs.

4. Empirical observations at the IDC in Systems as a case study : research methods and initial findings

4-1 Aims

The strategy this paper employs to investigate research aim (Research Question 1, see p.4), is to draw on evidence gathered from a study looking at the recent development of Industrial Doctoral Centres (IDCs) funded by the EPSRC. The objectives of the empirical study are:

- To identify strategies for industrial actors involved in the IDCs as a form of "employer engagement" to meet high-level doctorate training and skills formation;
- To identify strategies for academic staff developing the IDCs, and industrial partners working with the students; and

- To identify "learning processes and strategies" for individual industrial doctorate students enrolled at the IDCs.

This study thus helps to shed significant light on the overarching research questions identified earlier (Research Questions 2, 3 and 4, see p.4). The research was conducted through a mixed qualitative methodology: interviewing academic staff; participating in workshops with industrial doctorate students, and in a focus-group meeting; and by carrying out a survey of industrial doctorate students asking about their experiences of "learning and skills formation" both at the university and in industrial settings. This is exploratory research, and methodologically there are a number of weaknesses. [5]

In this paper, some of the findings from the study conducted at one of the IDCs as a pilot case study are presented, and emerging issues identified through wider interviews are discussed. The aim of the pilot study was to illustrate "learning experiences" and "strategies" of individual doctoral students who worked between the two knowledge production systems and who moved across two spaces through their career building, namely academia and industry. The main purpose of this paper is to develop a conceptual framework to capture learning experiences of both individuals and organisations through the IDC, based on a small number of empirical observations.

4-2 Contexts of the pilot study

The IDC in Systems was originally established in 2006 as EngD in Systems between Universities of Bristol and Bath, with £3.4 million funding from the EPSRC. A brief institutional context and development of the IDC in Systems is summarised below.[6] In the first three years, 31 EngD projects were established, across the full range of disciplines,

[5] An initial pilot study at one of the IDCs was conducted between May 2010 and January 2011. The pilot study was conducted at the IDC in Systems, in collaboration with the research and management team at the Systems Centre at the University of Bristol. The project took a mixed method qualitative research strategy including : attending a student focus group meeting and a workshop as an observer, interviewing academic staff, the IDC centre manager, a secondary documentary analysis and web-based analysis of the IDC and sponsoring firms. These provided contextual information about the IDC in Systems. In order to gain systematic data sets on REs' attitudes and perceptions, an on-line survey with REs who were enrolled on the programme was developed in collaboration with the research and management team of the IDC in systems. The survey targeting the REs was launched on 24 August, and by 15 October, twenty-five responses were collected out of the targeted fifty students (excluding the first year intake in October 2010). Interviews with other IDCs Centre managers or the Directors were conducted by telephone between August and September 2010. The on-line survey was circulated to students at four of the IDCs through the Centre managers or the Directors, which led to a small number of responses.

[6] http://www.bris.ac.uk/eng-systems-centre/idc/about-idc/ accessed 30 September 2010

sponsored by more than 20 different companies. In April 2009 the Centre was awarded a further £5.3 million from EPSRC to establish a new Industrial Doctorate Centre (IDC) in Systems. The first year (2009-2010) of the IDC has brought on board a further 18 REs – the highest rate of recruitment across all IDCs in the UK (IDC in Systems, 2010).

The Engineering in Doctorate in Systems is for those who aspire to (IDC in Systems, 2010):

- Develop the knowledge and skills to become a leader in Systems
- Acquire excellent career prospects
- Join an international research network in Systems
- Gain experience of using the latest Systems techniques in industry sponsored research projects.

The taught component is delivered collaboratively by the University of Bristol and the University of Bath. Research Engineers (REs) are registered at either university, and they take the same taught courses in the first year, while on average, they spend more than 70 percent of their time working at their companies. As of October 2010, the number of EngDs was 62: 80% were "stipend REs" who were receiving a grant of £15,000 a year from EPSRC, and 20% were "employed REs" sponsored by their companies. The fee for the EngD degree (£7,400 a year) was covered by the EPSRC.

The first cohort of EngD students started in 2006 under the Engineering Doctorate Centre in Systems. As of the end of 2010, when this study was conducted, the first cohort students were in their final year, and were due to complete their dissertation towards the end of 2010 and early 2011. One had already graduated in the summer of 2010.

There were 37 industry companies sponsoring the programme having stipend or employed REs, and there were a few firms that had both stipend and employed REs. Eleven companies sponsored more than one RE. The nature of the industry partners was diverse. One of the characteristics of the IDC in Systems is that the industry stakeholders cover a broad spectrum which is not "sector" specific, unlike many of the other IDCs. The industry sectors represented include: nuclear, electronics, construction, service operation, renewable energy, built environment, defence, aero industry, and high tech manufacturing. The research themes REs were engaged in at the companies were identified as: "product/technology development"

41%; “sustainability” 21%; “decision support” 13%; and process development/organisational change 25% (IDC in Systems, 2010). The industrial sponsors varied in terms of size and experience. There were large firms that took several REs while there were also small and medium sized firms (SMEs) that worked on a particular project with an RE. The view of one senior manager of a firm pro-actively engaged in the IDC, supporting strategic directions of the centre and benefiting from it was expressed as follows:

> *“We hoped that in addition to furthering his [RE’s] professional education, we would meet other systems thinkers in other organisations, and identify opportunities to work together in new ways.”* (IDC in Systems, 2010).

Given the diversity of the firms and the sectors, it would be important to understand the different needs and motivations of the firms as well as the issues and constraints they faced through working with the IDC.

4-3 Results from surveys with REs

The main empirical observation is based on 25 REs’ responses (Figure A in Annex) to the survey, conducted between August and October 2010. Some of the results of the survey are presented in Figures in Annex. The following section gives an overview of the qualitative empirical observations that highlight these points. Where appropriate, comments from the REs are quoted to highlight the diversity and complexity of their experiences, especially in terms of perceived challenges and “barriers” to knowledge exchanges across organisational boundaries. Understanding the perceived barriers to university-industry collaboration from point of view of individuals is important because it uncovers the problems and challenges that have emerged in the processes of mobility experience and knowledge exchange. Qualitative study of personal experiences of REs illustrates such processes.

In terms of prior experiences, the majority of the respondents answered that they had had industrial experience and academic experiences with a wide range of ‘transferable skills’ (Figure B, C). Seven out of twenty-five respondents had been “employed REs,” employed by the same company prior to enrolment on the EngD, which meant they were supported by their current employer to engage in the EngD, and had already been embedded in their industrial organisational contexts prior to the start. Another nine “stipend” REs had had experience of working at other companies – therefore they had had a variety of industrial backgrounds. One respondent commented that he/she had been working in industry almost 20 years prior to starting the EngD. The remainder of the respondents were "stipend" REs who had come more or less straight from their post-graduate studies, but they answered that they had had internships or other placement experiences within industry. In terms of academic experience, the multiple answers showed that many of the EngD students had had a wide range of provision such as management and leadership training, communication skills training and courses on entrepreneurship – the type of provision generically called "transferable skills," along with having studied academic courses related to the EngD.

The relationship between gaining academic knowledge and applying the knowledge to industrial problem-solving seemed to be a synergetic and dialectical process, as the following comments illuminate:

> *"I benefit immensely from academic knowledge that I apply directly to my everyday work experience."*

> *"It's [being an RE] unique in that I am solving a real industry problem that hasn't been solved before, and the results could be applied across the industry. If you are full time employed and not an RE, it is difficult to see and to solve problems in the organisation, but as an RE, you see the organisation with a third eye from an academic point of view, and you are better placed to see and solve problems (only if the managers can listen!)"*

There were comments from the respondents regarding the contexts of acquiring and practicing "management and leadership skills." The following two comments highlight different perceptions of "industrial needs" and the level of individual autonomy and possibility to change organisational practices:

> *"I got more of this [leadership and management skills] than I expected. It's a good thing. It probably came from the freedom of the working environment and the opportunity to organise things off my own back. and in collaboration with the other REs."*

> *"The skills and basic knowledge [on management and leadership] are probably there, but no opportunity to practice, and the company doesn't seem to want any more leaders, just well-trained followers..."*

Academic staff at the IDC in Systems had responded to the needs of the students, and taught programmes have been modified to reflect students' feedback. Given the fact that management and leadership skills are the areas of focus of the IDC in Systems, it would be particularly interesting to investigate further the ways in which EngD students see the changes in their skills and knowledge in management and leadership through the taught component of the programme, and in relation to their working and research experiences at the industry partners.

Another set of questions asked individual EngD students about their strategies in carrying out research projects between academia and industry. "Which of the following factors do you think influence your strategies to carry out your research?" Individual and direct relationships with industrial and academic supervisors strongly influenced students' research strategies. In particular, EngD students perceived the influence of the industrial supervisor as being greater than the academic one. The following comment from one of the respondents highlighted the issues concerning the influence of the industrial supervisor and broader organisational context:

> *"Industrial supervisor was not made aware of the reason why senior management decided to go for the EngD. Also industrial supervisor is more focused on meeting short term objectives; he does not appreciate the length and benefits of research. He just needs to be educated on this."*

There were diverse perceptions about the extent of influence of other relational factors such as the "existing collaboration between the company and the University" and the "relationship with peers at the IDC." These may be areas where the IDC could be proactive – how they create collaborative environments with industry partners; and how to make individual REs create collaborative relationships which might benefit their industrial and academic achievements.

In response to the open question about the main challenges of being an RE, several comments pointed to the different needs between academia and the business world and the difficulty of balancing and managing these between two supervisors:

> *"Applying academic theory in a business setting is difficult. You have to show immediate financial return or the company is not interested."*
>
> *"Hard to keep academic and industrial needs balanced. Being able to fully express the problem as it keeps changing as the company changes".*
> *"Deciding what to prioritise, balancing the needs of the different supervisors, not getting stuck in a place where it's hard to make progress"*

Sharing the value of research within the company was generally seen as challenge:

> *"Nobody is able to really understand the research you do, even your supervisors (unlike PhD). Makes you feel very alone, but also develops strong skills in resilience and independence."*

> *"Staying focussed on achieving an EngD award at the end of four years while being based in a company which has no one else with the same aims and therefore the focus of the work is very different in nature".*

Being an RE gave certain independence and autonomy in conducting research within an organisational setting; whether or not the firm is ready to listen to the research results was another matter:

> *"Freedom of thought and ability to change direction of research aims and objectives. Implementation of findings is a different matter..."*

And to quote one of the REs again, being an RE was unique as it provided an outside perspective, but whether or not the company responded to that perspective was not so straightforward (emphasis added):

> *"If you are full time employed and not an RE, it is difficult to see and to solve problems in the organisation, but as an RE, you see the organisation with a third eye from an academic point of view, and you are better placed to see and solve problems* ***(only if the managers can listen!)****"*

Several answers pointed out the difficulty of implementing the findings of research within the organisational culture:

> *"The main challenge is the organisational behaviour and culture is not, in my opinion, consistent with the research that I am carrying out: members of the board (and a lot of others in the company) do not want the changes that my research suggests we need."*

In terms of the perceived 'impact' of their work to the company, 'new ideas, tools, products, process' was the top answer followed by 'collaboration with the university' and 'expanded client base' (Figure D). In terms of the changes within the organisation, it seems that REs, in particular "stipend REs," could see "radical innovation" in terms of changes in organisations, whereas employed REs may be better positioned to induce an “incremental” innovation process within the workplace. However, this point needs further study to prove by clarifying the organisational contexts they work. If combined with their career strategies, such processes of organisational changes may lead to new leadership and innovation in workplace.

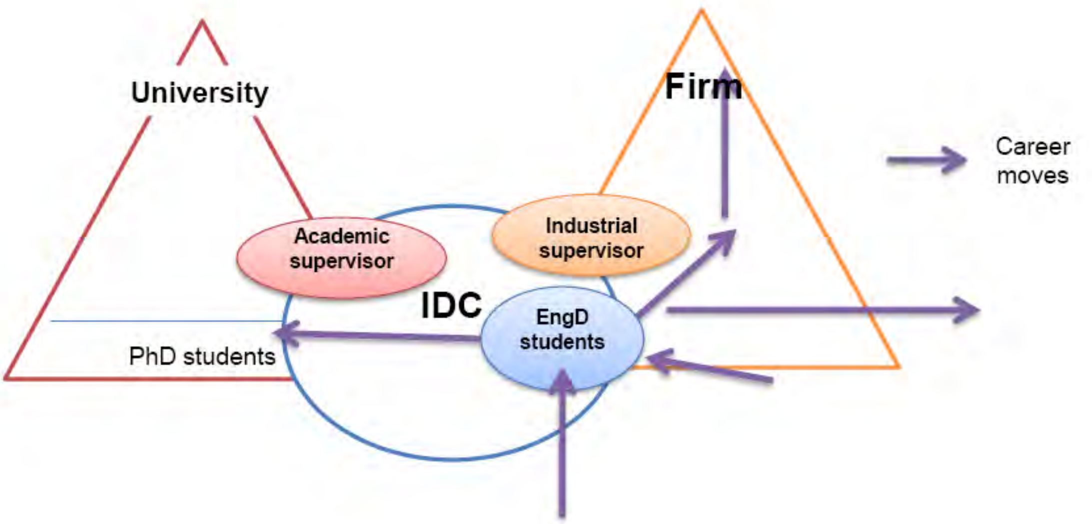
To the questions “What is your plan after the EngD?” eighteen answered that they want to stay at the same company where they worked on EngD research (Figure E). Out of seven employed REs that had worked at the same company prior to the EngD programme, six answered that they would stay. Many REs on stipends also expressed their expectation to stay at the company where they worked on their project. In terms of career strategies, it should be noted that there were differences between those who were on “stipends” and conducting research as EngD engineers at industrial partner companies, and those who had been employed at the company prior to the enrolment on the EngD programme. The differences between those REs employed by the firms and those on stipends were highlighted in the survey comments; and one of the IDC senior academics pointed out the issue: those who had been employed were more embedded in their organisational contexts and obviously under higher pressure to meet the company needs at the work place.

5. Discussion: issues concerning IDCs and employer engagement for doctoral training

The results of the survey with EngD students at IDC in Systems highlight some of the issues concerning employer engagement for doctoral research training and the complexity of the organisational contexts EngD students are embedded in. Some of the comments quoted above highlight the complex nature of learning, power and identity within a workplace and throughout different stages of human capital development. Individual REs act as agents of knowledge exchange and competence building between the university and the firm. Furthermore, they sometimes act as agents of organisational change within the firm. One of the issues which arises from analysis of the survey concerns organisational change and the organisational structure of the EngD programme. An industrial doctoral student/RE stands in the middle of two worlds: the university and the firm.

The career directions of industrial doctorate students are diverse, as schematically presented in Figure 2. Their career pathways cross over not only academic-university boundaries, but sometimes also boundaries within the firms. In other words, REs work in different knowledge production systems, or “communities of practice” (Wenger, 1998). They translate knowledge not only *between university and industry*, but also face the challenge of translating different types of knowledge *within the firm* where they work with limited freedom and autonomy. The constraints are amplified, especially when they are not in a senior position. A senior academic staff at the IDC pointed out that whilst the firm’s top level management appreciates having an RE, the day-to-day manager, the industrial supervisor, may not necessarily share this strategic view. This resonates well with one of the comments from an RE in the survey, as shown above. An agreement is made at the top level between the university and the firm; however the strategic objectives of the employer engagement in doctoral training is not necessarily reflected in the work environment and research project where the RE is embedded; and also the context of the work requirement changes rapidly. Alternatively, when the RE’s research project is bottom-up in nature based on the existing industry-academic the collaboration, there is less tension and short term problem may be solved, but the project may not benefit the long term strategic goal of the company. It seems that REs, in particular “stipend REs,” could see “radical innovation” in terms of strategic changes in organisations, whereas employed REs may be better positioned to induce an “incremental” innovation process within the workplace. If combined with their career strategies, these may lead to new leadership and innovation in organisational change.

Figure 2. Possible career directions for Engineering Doctoral graduates



The survey with the REs at the IDC in Systems illustrates the institutional complexity of working within "hybrid spaces," managing different expectations and solving industrial problems with academic inputs and support, as well as acting as "change agents" within organisations. One of the industrial doctorate students described the challenge of being an RE:

> *"to gain a compromise between what the different stakeholders want from the project, i.e. me, my company, my industrial supervisor, the University."*

As already mentioned, there is a difference in terms of *autonomy* and *embeddedness* between EngD students who are on a stipend and those who have been employed by the same company prior to the EngD enrolment. Furthermore, the career perspectives for "linked scientists" in industry are not so straightforward. There are a number of perceived "barriers" between university and academia. In general, it is assumed that these barriers "hinder effective knowledge exchange". However, there is no evidence on "how the perceived barriers shape subsequent collaborations" (Bruneel *et a*., 2010) or how individuals may overcome such barriers. We do not know how these perceived barriers affect individual career strategies and decision making processes.

The findings from the IDC in Systems may not be generalisable because of the nature of their programme – unlike some of the other IDCs funded by the EPSRC, EngD in Systems has a broad spectrum of different types of industrial partners including nuclear, aerospace, high-tech manufacturing, construction, defence, and the service industry. Therefore individual REs tend to have a diverse range of sector experience. Some IDCs focus on specific industrial sectors, for instance, on life sciences, or nuclear engineering, or photonic technologies. EngD in Systems has another unique character as it takes a broad "systems approach" to problem-solving, encompassing engineering and social sciences; and staff at the IDC in Systems emphasise their strong focus on organisational management and leadership elements in the programme. Whether or not these programme characteristics and the diversity of industry sectors have effects on REs' perceptions and experiences needs to be investigated by conducting a comparative study with other IDCs.

6. Concluding remarks

The examination of the model of IDCs and findings from the industrial doctorate students' learning experiences raises a number of questions about mobility of high skilled scientists and engineers, their skills and competence formation, and inter-organisational knowledge exchanges, in particular, between academia and industry. The recent literature emphasises the potential benefits to firms to gain knowledge and skills from scientific "external labour market" (Mason and Nohara, 2010) – this is often combined with "mobility-based" and "relationship-based" university-industry linkages (Perkmann and Walsh, 2007) and the formation of competences on a collaborative basis between academia and industry, characterised by the creation of a joint "pool of human resources" and the emergence of "linked scientists" (Lam, 2007).

One of the IDC interviewees, a senior academic manager, illuminates this point within the context of the IDC:

> "*One of the best ways of achieving a good connection between two research groups, be they two academic, or an academic and an industrial one – is to have a person who is located in both, and these students fulfil that role.*"

Industrial doctorate students who work within "hybrid spaces" of academia and industry can be seen as a new type of "linked scientist" likely to pursue an industrial career rather than an academic one, though not exclusively. They are expected to become future managers/leaders of their organisations with agents of change with new scientific knowledge production as well as developing management and leadership skills. However, what this study highlights is the sometimes contradicting nature of the mobility, skill formation and career development in the hybrid spaces.

Career development and workforce skill enhancement could provide long-term incentives and sources of workplace innovation (OECD, 2010). Lepak and Snell (1999, p.41) talked about a "hybrid mode of employment relationship that blends internalization and externalization" by developing partnerships with external organisations to create joint human capital (cited from Lam, 2007, p. 999). IDCs exemplify new spaces where "the joint production of new knowledge with commercial applications" occurs, and these spaces function as "learning segments" as part of the intermediate labour market between academia and industry (Lanciano-Morandat and Nohara, 2006). However, "hybrid occupational" segments as part of the intermediate labor market are somewhat limited. There are a number of challenges related to "patterns of careers and incentives," and the recognition of those who are engaged in such mobility. Industrial doctorate students working in this hybrid space do not have a clear career structure either within their current firm or throughout other firms for the long term, in highly flexible labour market mechanisms. As Lam (2007, p.997) points out, these challenges are underlined by "the divergent work norms and reward structures" governing the two different knowledge production systems between academia and industry. Further, their career perspectives and strategies are conditioned by many contingent factors within the firms, including their investment in scientific and technical human capital, and internal power structures. The strategic objectives of the employer engagement need to be shared at the appropriate level of hierarchy within the partner organisations, with a mutually agreed time scale.

This paper contributes to the current policy discussions on industrial engagement in higher education. Whether or not industry engagement with doctoral programmes can be "scaled-up" to a sustainable level in the long term remains to be seen, and it would depend on the funding arrangements of the future higher education sector in the UK. At the institutional level, universities need to manage and balance different missions and activities: teaching, research, and engagement with industry and society. Industrial engagement with doctoral provision gives rise to interesting questions regarding the relationship between these activities. In the UK context, universities are facing different sets of policy expectations and agendas: the two recent policy agendas of "skills, learning and employer engagement" on the one hand, and “industry links and knowledge transfer,” on the other, represented by the Leitch review (2006) and the Lambert Review (2003) respectively, highlighted the industrial engagement activities as part of the mission of universities.

The accumulation of experience of the IDCs would be of value to the development of a similar kind of future provision in terms of linking scientific research training with human resource management and skill development at the workplace at firm levels. In doctoral education, one of the biggest issues concerns incentives and constraints for employer engagement. Under the IDC, there are some financial incentives for firms to have REs. Once the relationship between the IDC and the firm is established, and there is trust between the two parties, the IDC model could represent a virtuous cycle between the university, the RE and the firm. Through these experiences both industrial and academic supervisors need to learn how to work together, because without learning, organisational changes and also culture change happening at both sides, the employer engagement in doctoral education would not lead to a hybrid space of learning.

Whether the EngDs or the IDCs provide new forms of doctoral training and new career pathways for non-academic doctorates remains a big question to be investigated further. Throughout its history, the number of EngD degree holders is already high and has an established credibility in engineering. The recent new development of Centres for Doctoral Training (CDTs) and new Industrial Doctorate Centres (IDCs) is still in its early days, and it is too soon to determine the specific impact of these. It would be interesting to compare other forms of PhD and industry-related PhDs, such as the CASE studentship, and new provision such as the CDTs and IDCs and the career trajectories of those doctorate holders in the long term. Another interesting comparative perspective would be to look at research training at doctorate level in different national systems involving innovation and competence building (see Mason and Nohara, 2010). Countries such as the United States and the UK have developed highly deregulated labor markets combined with a number of university-industry links, whereas other countries have had more “hierarchical research systems” (Lam, 2007, p.1014), often with a greater role played by public research institutes. The careers and training mechanisms for scientists and R&D personnel need to be investigated in broader and more diverse institutional landscapes from a comparative perspective. Such perspectives would open up debates concerning the convergence and divergence between different national systems.

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Annex

Figure A Year of the EngD programmes the respondents are registered

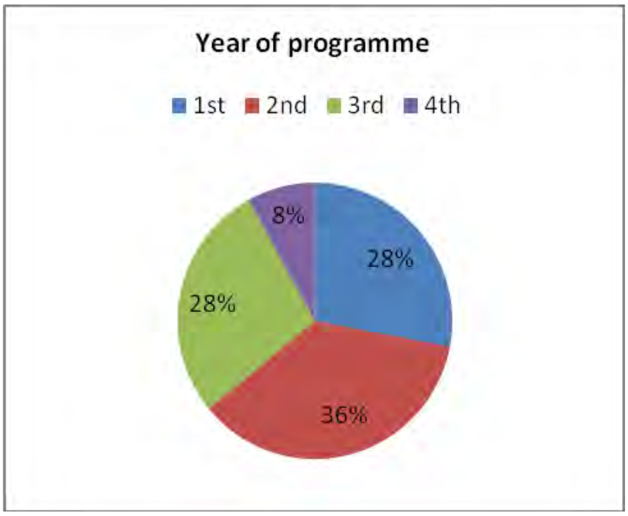


Figure B Prior Industrial Experiences

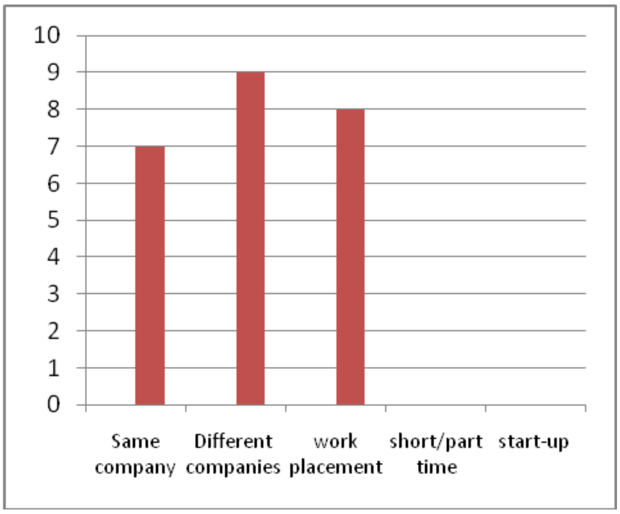


Figure C Prior Academic and training Experiences

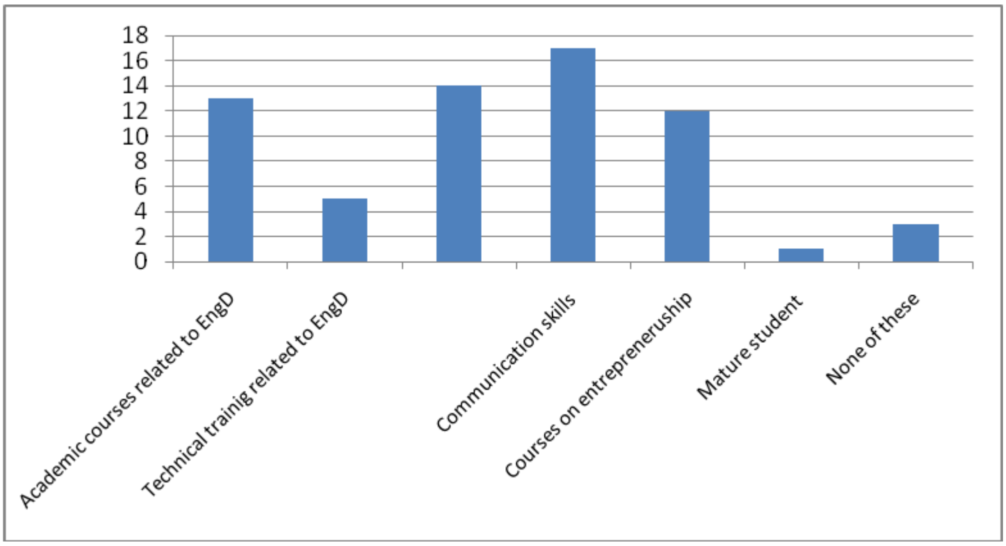


Figure D Perceived Impacts through EngD to the company

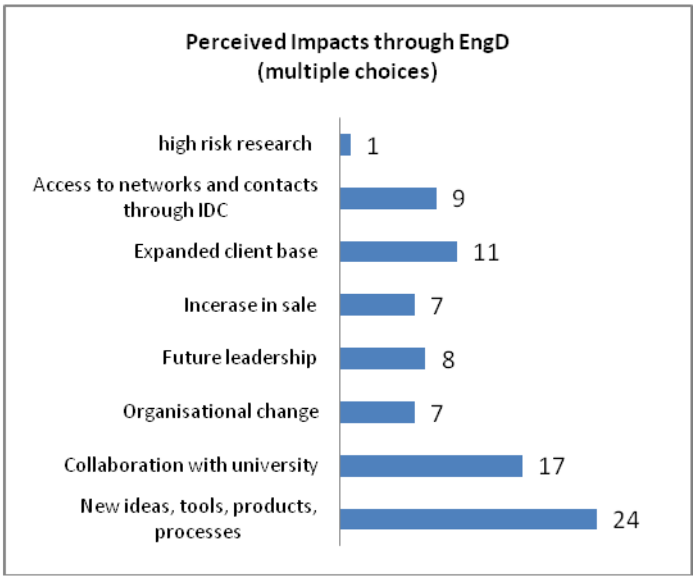
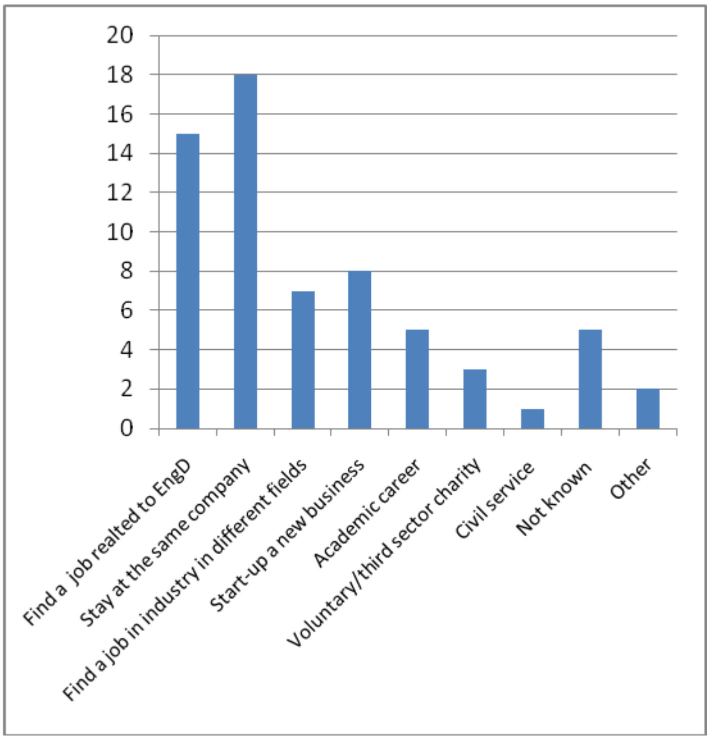


Figure E Future Plans of EngD students (multiple choices)



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