

# **Capturing Research Value in Commercial Design Outputs**

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## ABSTRACT

Effective university-industry collaboration has become a major focus for governments in recent years. Universities are increasingly expected to play a greater role in the innovation system and evidence their contribution to economic development. At the same time, the growth in research quality assessment exercises makes it imperative that all opportunities to discover excellent research with the university context are uncovered. This research was conducted at a commercial design consultancy based within an academic institution, PDR (International Centre of Design and Research). The interaction between applied research and commercial consultancy within PDR led to a recognition of research potentially existing within commercially designed output. The Research questions posed within this PhD thesis are:

**Research Question 1:** How best to recognize where commercial outputs can be characterized as research?

**Research Question 2:** Where a research characterization is met, how best to recognize and describe the research quality?

The aim of this research is to identify whether research value exists within commercial design outputs produced in an academic context and how the quality of this research could be assessed.

This thesis adopts grounded action research inquiry using semi-structured interviews to explore the barriers to, and drivers of, reconciling commercial design activities with research quality in design.

The thesis uncovers opportunities to capture value beyond the commercial impact, which university-industry collaboration projects are initiated for. The research led to the identification of a knowledge creation spiral resulting from the knowledge and technology transfer activities taking place within the commercial design projects in a university-industry context. In some instances, this new knowledge can be of excellent research quality if it meets the necessary research criteria.

A discovered barrier to the identification of research quality within in commercial outputs was the lack of granular data on the projects thus demonstrating appropriate rigour. It was concluded that there is a need to build a documentation framework to capture the needed information and assess the research potential of commercial design projects from the outset, in order to capture the exchanged and created knowledge. A prototype of a

documentation process was developed and tested with two of PDR's lead designers. The documentation process barriers are limited to technical issues, and its implementation could assist in learning and development, as well as generating new knowledge of research quality.

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## ACRONYMS

REF	Research Excellence Framework
PDR	International Centre for Design and Research
CMET	Cardiff Metropolitan University
UCD	User Centered Design
NPD	New Product Development
PRI	Private Research Institution
HEI	Higher Education Institution
HCR	Human-centered Research
UoA	Unit of Assessment

# 1 INTRODUCTION

An increasing drive towards a knowledge-driven economy and the need to use research to address socio-economic challenges and drive innovation has led to an increase of commercially-focused industry-university collaborations. The twin pressures on universities of demonstrating this engagement with industry, whilst also achieving high-quality academic research outputs, gives rise to the challenge of identifying where there is the potential for academic research in commercially-driven projects, and developing mechanisms to evaluate the quality of this research and its academic and industrial impact.

This thesis explores this challenge in the context of PDR, a design and research consultancy based at Cardiff Metropolitan University (CMET). PDR conducts a large number of commercial design projects every year and is also expected to contribute to the research mission of CMET. Within the introduction, the emergence of a knowledge-based economy in the UK and its influences on university-industry collaboration is explored. Challenges that Wales, with its historically strong manufacturing economy, faces in transitioning to such an economy are identified. Next, the role of design in the knowledge economy is briefly considered. The continued importance of demonstrating research excellence in universities is addressed. The development strategy for Cardiff Metropolitan University is discussed in this context. Finally, the International Centre for Design and Research (PDR) is introduced and discussed as a potential key contributor to Cardiff Metropolitan University's research and enterprise missions, and to the wider knowledge economy.

## 1.1 THE KNOWLEDGE ECONOMY AND INDUSTRY-UNIVERSITY COLLABORATIONS IN THE UK

Since the mid-1970's the UK has undergone a period of rapid de-industrialisation. In the period from 1981 – 2011, the UK's manufacturing sector shrunk by almost two-thirds. This represents the most significant de-industrialisation of any developed economy during that period (Chakraborty, 2011).

As the economic contribution from manufacturing – the long-time cornerstone of the UK economy – fell, politicians increasingly began to look towards other sources of revenue, and particularly knowledge-based service industries. In 1993, the UK Government's White Paper *'Realising our potential: A strategy for science, engineering and technology'* identified the crucial role that universities could play in developing a knowledge-based economy for the UK (HMSO, 1993). OECD (1996) defines knowledge-based economies as "economies, which are directly based on the production, distribution, and use of knowledge and information... [as] reflected in the trend towards growth in high-technology investments, high-technology industries, more highly-skilled labour and associated productivity gains"(p. 7). The strategy proposed to support effective collaborations and knowledge exchange between universities and industries, offering public funding for applied research to support the development of more sophisticated productions and services, and espoused a more complex relationship between universities and industries where industries relied more heavily on the knowledge developed by universities (HMSO, 1993). The White Paper was followed by multiple independent reviews addressing these industry-university collaborations and how they could be supported with the right policies for better engagement and reduced complexities, facilitating intellectual property negotiations, support spin-offs, and focus on the employability of graduates in a way that meets the market's needs (Dowling, 2015; Lambert, 2003; Leitch, 2006; Wilson, 2012). As such, UK universities are viewed as being fundamental to the continued growth of the knowledge economy. Policies, strategic partnerships, and long-term relationships between industry and universities -including knowledge transfer programs, spin-offs, graduate mobility, university-based consultancies etcetera have become an important measure of universities' research excellence criteria, and require attention and investment (Wilson, 2012). Further, the UK's Industrial Strategy (BEIS, 2017) proposes a Knowledge Exchange Framework, which will sit alongside existing assessment exercises for teaching and research at universities and is intended to "benchmark how well universities are doing at fostering knowledge sharing and research commercialisation" (BEIS, 2017: 79).

However, the most recent OECD report (2019) indicates that the situation has not drastically changed as a result of these policies. Whilst the total contributions of universities and research institutions remain modest in terms of patenting and translating

valuable knowledge into innovation in the OECD countries, the number of patenting applications show that universities' contributions to innovation is growing faster than the industries' (OECD, 2019). In the 2019 World University Rankings<sup>1</sup> none of the top twenty best-performing HEIs in terms of industry income (representing knowledge transfer and collaborations with industry) are from the UK. On the contrary, the majority are European universities including HEIs in Germany and the Netherlands (Times Higher Education, 2019).

### **1.1.1 THE KNOWLEDGE-ECONOMY AND UNIVERSITY-INDUSTRY COLLABORATION IN WALES**

Due to its heavy reliance on manufacturing and primary sector activities such as mining and farming; the Welsh economy was particularly vulnerable to the UK's pivot away from these sectors towards a predominantly service-based economy. After devolution in 1999, the Welsh Government was given powers to set a development strategy for an economy that was struggling and imbalanced, with a lagging research base unable to support the knowledge economy (Ball, 2008; Braczyk et al., 1998, Jones- Evans, 2002; Pugh, 2017; Morgan et al. 2000).

Nevertheless, in 2002, '*A Winning Wales*', the national economic development strategy of the Welsh Government was released. The strategy set out a goal "to raise the standard of living and the opportunities available to the people of Wales through the development of a modern, knowledge-based economy" (Welsh Assembly Government, 2002, p.20). Welsh universities were identified as key to this development, with the strategy setting a goal to "increase existing collaboration between universities and colleges and companies in Wales" (Welsh Assembly Government, 2002, p. 9). This drive for productive collaboration has been articulated in multiple economic development and innovation policies since this time (Pugh, 2017; Welsh Assembly Government, 2014). There has also been significant progress since Devolution; in 2017, The Science for Wales report (Welsh

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<sup>1</sup> The World Universities Rankings relies on a transparent set of indicators to calculate its ranking scores including volume (research productivity), income and reputation surveys for the research power scores and data such as the income earned from industry as an indicator for knowledge transfer.

Assembly Government, 2017) highlighted the Welsh universities' value and contribution to the Welsh economy, bringing almost half of all expenditures on research and development in Wales. However, Wales still does not fully enjoy the economic benefit of the exploitation of this knowledge (Welsh Assembly Government, 2014; 2019). There remains a need to further exploit this strength and turn original knowledge into economic gain (Welsh Assembly Government, 2014). Policies and strategies have been implemented to improve this collaboration, initiating schemes such as Ser Cymru I and II (Welsh Assembly Government, 2018). These schemes aim to help universities target investments, develop infrastructure, attract talent and prepare businesses for long-term relationships (Business Wales, 2013; Welsh Assembly Government, 2014; 2017; 2019). However, Wales continues to struggle under this heavy pressure to achieve optimal collaborations. Understanding the socio-economic context of the related country is essential for ensuring synergy between policies, better management of the interactions, the industry's activities, and the research mission to improve the performance of one field without negatively impacting the performance of the others (OECD, 2019; Pugh, 2017). The weaknesses in implementing created knowledge and the deficiency of targeted support offered to industry (the receiving end of the knowledge), has negatively affected Wales' ability to achieve successful collaborations (Pugh, 2017). Meanwhile, increasing competition in the Higher Education sector means that Welsh universities must perform well across all assessment platforms, including industrial engagement, to gain a competitive advantage over local rivals, as well as national Higher Education Institutions.

## 1.2 DESIGN IN THE KNOWLEDGE ECONOMY

It is pertinent here to consider the role that design plays in the knowledge economy. Much of the language within policy documents places heavy emphasis on the science and technology research to support knowledge-based industries; thereby adopting a classical view of technological innovation. However, there is increased acknowledgement of the non-technological drivers of innovation, including design (European Commission, 2010; Whicher and Walters, 2017). Indeed, Hutton (2010, p.5) argues that design is "at the core of the knowledge economy, and one of the coping stones of an innovation system". Knowledge creation in the design of high technology products and complex services translates the technical and market knowledge held by companies into the products and

services that satisfy customer needs. Far from the traditional view of design as a purely aesthetic activity, design is a knowledge-intensive activity and a fundamental driver of innovation (European Commission, 2013; Verganti, 2009). The European Commission's Action Plan for Design-Driven Innovation identifies the importance of design in an innovation ecosystem for bringing new ideas to market, and further identifies the research value of design in facilitating multidisciplinary collaboration and managing complex and 'wicked' problems (European Commission, 2013)

As such, design has an important part to play in the development of an effective knowledge economy, not only in the development of products and services, but also in catalysing knowledge production for complex and cross-cutting scenarios.

### 1.3 UK UNIVERSITIES AND RESEARCH EXCELLENCE

That universities can contribute to the knowledge economy is a direct result of their knowledge generation activities or research (Leydesdorff. & Etzkowitz, 1996; Martinelli, Meyer & von Tunzelmann, 2007). Academic research is supported by public funding, and the allocation of this funding has not always been transparent (Times Higher Education, 2013). Reduction in the infrastructure support money for universities under the Thatcher Government increased the need for greater transparency in funding allocation (The Telegraph, 2013; Times Higher Education, 2013). The first formal assessment of research quality in UK universities took place in 1986; there have been subsequent exercises in 1989, 1992, 1996, 2001, 2008 and 2014. The next assessment, against the 'Research Excellence Framework' (REF) takes place in 2021. In this thesis, research quality is understood as research that meets the originality, rigour and significance standards, which will be further explored in the literature- section 2.5.2.

The REF and its assessment criteria are discussed in detail in Chapter 2 but briefly, universities are assessed on the quality of their research outputs on a scale of 1\* (nationally recognised) to 4\* (world-leading); the impact of the research beyond academia; and the institutional environment that supports research (REF, 2019). Initially, research assessment exercises in the UK were focused on the assessment of traditional research outputs. In the context of this thesis a 'traditional research output' will be



understood as: the product of a research process delivered in a written form, explicitly identifying the aim, objectives, methodology, data and results (e.g. journal papers, publication, chapter in a book, etc.). More recently non-traditional outputs – understood as items or artifacts (tangible or intangible) resulting from a research process implicitly embedded in the object (such as designs, art work, productions, exhibitions, audio-visuals, policy documents, legal cases, maps and translations of major academic works) (Thelwall & Kousha, 2015) - and embodying research value, have emerged as potentially submissible outputs. In this thesis, an outputs' research value will be understood as outputs that meet the Research Excellence Framework (REF)'s definition of research "a process of investigation leading to new insights, effectively shared." (REF, 2019 a, p. 90). Understanding how to identify and communicate research quality in non-traditional outputs has therefore become increasingly important within higher education and research institutions striving to demonstrate research quality and attract more funding.

According to the 2019 World University Rankings British HEIs are performing well in research compared to other European countries: six out of the top 10 highest scores for research (based on volume, income and reputation) in the EU belong to British universities (Times Higher Education, 2019). However, as discussed in Section 1.1., this has not resulted in correspondingly high levels of industrial impact (OECD, 2019)

### **1.3.1 WELSH UNIVERSITIES AND RESEARCH EXCELLENCE**

Meanwhile, universities in Wales performed above the UK national average in REF 2014, with 77% of submitted research achieving 3\* (internationally-leading) and 4\* ratings (Times Higher Education, 2014). In addition, the impact of research conducted in Wales was the greatest of all the home nations (Wales Online, 2014). However, this regional achievement belies the fact that the high-quality research is focused in a small number of research-intensive universities (Pugh, 2017). Wales is home to only eight of the 154 HEIs submitted in REF 2014.

Cardiff University was the highest-performing HEI in Wales, ranked 17<sup>th</sup> in terms of research power<sup>2</sup>. The next three highest universities, Swansea, Aberystwyth and Bangor were ranked at 40<sup>th</sup>, 49<sup>th</sup> and 55<sup>th</sup> respectively. Of the post-92 universities<sup>3</sup> the University of South Wales performed the best, with a ranking of 94<sup>th</sup>. None of the remaining Welsh universities featured in the top 100 (The Guardian, 2014). The lack of research-intensive universities in Wales has also impacted on the capacity for achieving effective knowledge transfer between the university and industry sectors (Pugh, 2017).

#### 1.4 CARDIFF METROPOLITAN UNIVERSITY

The previous sections have outlined the context in which Cardiff Metropolitan University (CMET) operates. A post-1992 institution ranking 112th in terms of research power in REF 2014, CMET is one of four universities situated in the Cardiff region, with the highest performing ‘old’ and ‘new’ universities in REF terms as near neighbors. CMET focuses on the delivery of applied academic subjects and consists of five academic schools (Education and Social Policy, Management, Sport and Health Sciences, Technologies, and Art and Design) and a Design and Innovation Research institute (PDR). The strong representation of art and design is reflective of CMET’s history; its foundation can be traced back to 1865, when the School of Art opened in the Old Free Library in Cardiff (Cardiff Metropolitan University, 2017).

CMET, has a strong internal drive to prove that it is able to not only compete, but to excel, in the reformed Welsh HE landscape. The most recent iteration of the University’s strategy plan reveals an ambition for “significant growth in the volume, quality, value and impact of research and innovation”, and specifically to double research income compared to the 2015/16 period by 2022/23. There is also a clear commitment to contribute to

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<sup>2</sup> The Research Fortnight power rankings are intended to reflect the levels of funding that will be awarded to universities based on their performance in the REF. An explanation of how the power rankings are calculated can be found at: <https://www.telegraph.co.uk/education/universityeducation/11299261/League-tables-the-top-universities-for-research.html>

<sup>3</sup> Post-1992, or ‘new’ universities are former polytechnics or central institutions in the UK that became universities either in 1992 under the Further and Higher Education Act (1992), or subsequently without Royal assent.

industry through knowledge exchange and provision of practice-focused education for its graduates (Cardiff Metropolitan University, 2017), building on its focus on applied disciplines and strong relationships with allied industries through the adoption of an “entrepreneurial university” strategy (Etzkowitz *et al* 2000), in which research activities and education provision are informed by, and inform, industry.

## 1.5 THE INTERNATIONAL CENTRE FOR DESIGN AND RESEARCH (PDR)

PDR was established in 1994 with a mission to focus on external engagement around product design through knowledge exchange programs, academic research and design consulting activity. As such, it aims to make a significant contribution to the development of CMET as an entrepreneurial university. As part of the Welsh Government’s Centres of Excellence for Technology and Industrial Collaboration, in its early years, PDR had a specific mission to support the translation of knowledge associated with design and development activities to SMEs, largely facilitated through government-funded design support programmes and Knowledge Transfer Partnerships (KTPs). Between 1995 and 2006, PDR successfully completed 22 KTPs; and in the period March 2002 and April 2003 alone worked with 169 Welsh SMEs (Millward, Byrne & Lewis, 2006; Millward & Lewis, 2005). PDR’s mission was reflected in its staffing; a team of academic staff with research interests in the management of product design and technology, and a team of skilled design professionals predominantly serving Welsh manufacturing SMEs.

In recent years, PDR’s core activities have diversified. Changes in the HEI funding landscape, the emergence of design as a driver for business innovation and the increased outsourcing of design services by larger businesses has seen PDR’s role as a provider of knowledge-intensive design services on a commercial basis broaden. While PDR still works with local SMEs, the client base has internationalised, including a number of global MNEs. Abecassis-Moedas *et al.* (2012) describe PDR’s internationalisation mode as process-based creative KIBS; it offers an end-to-end New Product Development (NPD) process, allowing clients to access services at any point from the ‘fuzzy-front end’ of product innovation to pre-launch product, placing particular emphasis on the benefits of user-centred design for clients. Between 2014 and 2019, PDR’s design team undertook 458 commercial projects. The projects ranged in time and complexity from simple Computer Aided Design (CAD) manipulations to large-scale, knowledge-intensive projects.

Fulfilling the projects required innovative approaches to user research, concept development, mechanical engineering, design for manufacture, rapid prototyping, user testing, in-house low-volume production, and management of the handover for full-scale production. Some of the knowledge required to undertake the work was readily accessible, based on the experience and training of the designers, and in those cases, did not differ from the work conducted by a traditional design agency. In other cases, the work required larger teams working with complex new problems that necessitated rigorous investigative commercial research for the creation of innovative solutions, and was enabled by access to academic research facilities and methods. For the purpose of this research, 'commercial research' conducted by PDR is understood as the transactional research that takes place independently within the consultancy; between designers or designers and researchers. The results of this research are then either presented to the client or used for the development of an output (tangible or intangible).

The description of PDR's operations described above presents as two teams with separate missions around either design practice, or design knowledge creation. The 'separation' of design and research activity in PDR may be seen as problematic. However, PDR operates in the space between a knowledge-intensive business service (KIBS) and a university department. This gives rise to complex processes of knowledge flows both within and beyond PDR, which have the potential to support both high quality products and services and high quality research. Therefore, it is reasonable to assume a likelihood that significant and novel research exists in some of these commercial projects.

As discussed in Section 1.2 there is increasing acknowledgement of design's role in the knowledge economy. The rise of the industry's engagement in participatory, user-centered, services, sustainable, socially-responsible and innovation management design has led to the need for new research and design processes skills in the design community (Rodgers & Yee, 2016). The range of activities that might be conducted by PDR's researchers and practitioners as part of university-industry collaborations has expanded (for example, policy design, service design, and business solutions using user centered design). These activities are underpinned by the creation of new knowledge, the application of knowledge to solve problems and create products, and the associated impact on environment and stakeholders through the application of the knowledge

transfer activities (including commercial clients, businesses, SMEs, medicine, governmental stakeholders, other research institution and universities).

PDR's enterprise activity continues to grow in terms of volume and quality and is internationally recognised (as evidenced through the award of a number of major industry prizes). However, the knowledge creation that accompanies the tangible (or intangible in the case of service design) outputs of PDRs staff extends far beyond what is currently being exploited as a knowledge asset and remains largely invisible at university level (PDR Strategic Plan, 2017). At the same time, PDR faces the same pressure as other university departments across CMET to evidence their contribution to research. Whilst the quality of PDR's contribution to REF 2014 (in partnership with the University of South Wales and the University of Wales Trinity Saint David, where 50% of submitted outputs were rated as 4\* and 50% as 3\*) was substantially improved in comparison to the previous research assessment exercise (RAE 2008, where 10% were rated as 4\* and 60% as 3\*), the full potential of PDR's contribution to the university's 'entrepreneurial university' strategy could be increased significantly by capturing the research value and quality in the commercial outputs. Achieving better REF results by increasing the number of impactful, world-leading and internationally excellent research and case studies (produced independently or as part of a commercial output) could result from existing industrial collaborations. However, in many cases, while PDR's work has potential research value, the complex and non-traditional nature of the outputs makes it unclear to both producers and reviewers as to whether it meets the quality threshold for REF eligibility. As it stands, the high number of commercial projects conducted by PDR does not have a correspondingly high level of associated quality research outputs.

This thesis therefore sets out to establish whether it is possible to identify and communicate the research quality that is held within some of PDRs commercial outputs and develop processes that can facilitate this.

## 1.6 AIM AND OBJECTIVES OF THIS THESIS

The aim of this research is to explore ways of identifying where research value might exist within commercial projects and artifacts, and to try and identify approaches to assess the

quality of discovered research and communicate the resulting knowledge. Disseminating research from commercial designs produced in academic contexts will also contribute to the improvement of communication and knowledge sharing across academic and commercial disciplines.

The objectives of this thesis will address the aim through:

- Undertaking a review of the academic literature around the evolution of the role of universities, commercial design and its links to knowledge creation, and academic research;
- Better understanding the barriers and drivers of research-industry collaborations in a university context, and the elements contributing to success of these relationships;
- Investigating the potential presence of Research Value in the context of non-traditional outputs
- Creating a set of criteria for the recognition of Research Quality within commercial design outputs holding research value;
- Observing and engaging with design practitioners to investigate potential practical solutions that could be integrated into their daily activities, to capture Research Quality.

This research aims to address a gap in knowledge around identifying and qualifying any research value that might exist in commercial projects and commercially designed artifacts.

## 2 LITERATURE REVIEW

The evolution of the university's role in industry indicates a potential need for further investigation of this relationship's outputs, to better understand the impact and benefit of these collaborations and their created value. The aim of this chapter is to present and investigate the existing literature surrounding the university-industry collaboration, the commercial aspect of these collaborations in research production, and the role of design within a university-industry collaboration. The literature will set the grounds to assist in carrying out this research and investigating the impact of commercial design on the concept of knowledge creation and its potential research value.

To better understand the literature, and develop the research questions for further investigation, the literature has been laid out under the following subjects:

- The University's role and its evolution: Triple Helix
- Knowledge exchange and creation
- Commercial outputs and knowledge creation
- Research quality assessment

### 2.1 THE ENTREPRENEURIAL UNIVERSITY

The latter part of the twentieth century has seen universities in the UK evolve from their traditional roles as academic 'ivory towers' practicing basic research and education to fulfill a more socio-economic role, incorporating applied research, preparing the future generations for the job market and taking part in driving industrial innovation associated with the development of a knowledge economy (Bush, 1945; Cohen et al. 2002; Goldstein 2010; Leydesdorff and Etzkowitz, 2001; OECD, 2019; O'Reilly, Robbins and Scanlan, 2019; Pavitt 1991; Salter and Martin 2001; UK Government, 1993;). According to Etzkowitz (2013), this entrepreneurial role of an academic institution develops through three phases:

- In Phase 1, the academic institution works on its own strategic priorities, aiming at achieving them through public funding, tuition fees or other private forms of income
- In Phase 2, academic institutions begin to actively commercialize their intellectual property

- In Phase 3, the academic institution adopts a proactive role within its socio-economic environment through improving innovation, usually in collaboration with the government and industry through transferring knowledge and capabilities.

Once Phase 3 has been achieved, the university meets Ektowitz's definition of an 'entrepreneurial university' - a university undertaking enterprise activity "with the objective of improving regional or national economic performance, as well as the university's financial advantage and that of its faculty" (Etzkowitz et al., 2000 p. 313).

As outlined in Chapter 1, government-led policies in the UK have promoted the development of entrepreneurial universities (Dooley and Kirk, 2007; Dowling, 2015; Jacobsson, 2002; OECD, 2019; UK Government, 1993). Entrepreneurial universities are built on a complex relationship between three key entities: university, industry and government. For this collaboration to succeed, there is a need to fully understand the potential skills, the breadth of knowledge, and the research power and socio-economic context of all stakeholders (Lambert, 2003; OECD, 2019; Wilson, 2012,), and to develop strategies to manage them accordingly (Fisher and Atkinson-Grosjean, 2002).

### **2.1.1 DRIVERS TO COLLABORATION**

The increasing reliance on research in industry is growing; companies are decreasing their spending on early stage research and relying on universities to do that work for them, due to the universities' high level of scientific expertise and access to technology (Bettis and Hitt, 1995; Wright et al., 2008). In turn, faced with lower financial research support from governments due to academic institutions' competition over funding, a situation even more prevalent in lagging regions such as Wales, universities have become more receptive to collaborations with the industry (Hagen, 2002). The accessibility to funding and resources (EU funding, commercial funding, innovation foundation investments (NESTA)) and the commercialization of research findings have increased researchers' income (Brundenius, Lundvall, and Sutz, 2009; Etzkowitz and Leydesdorff, 2000; Guimon and Agapitova, 2013; Leydesdorff and Etzkowitz, 1998) and further bridged the gap between academic and industrial research (Clark, 1998; Etzkowitz, 2003).



Furthermore, this collaboration supports researchers by giving them better access to empirical data in industry, while at the same time enhancing the industry's reputation and giving businesses access to a pool of skilled workers, the universities' technology and knowledge, and risk reduction by sharing R&D costs and reducing uncertainty (Tidd, Bessant and Pavitt, 2005; Zucker & Darby, 1996).

### **2.1.2 BARRIERS TO COLLABORATION**

The concentration and unequal distribution of universities and hubs of industries in specific central areas, such as the south of Wales (Cardiff and Swansea to certain extent) (Welsh Government, 2017), gives some regions more advantage than others. These advantages are due to the effect of the geographic proximity on the success of collaboration and increase of innovation (OECD, 2019).

Tensions between practitioners looking for relevance in research and academics searching for rigour (Avenier and Parmentier Cajaiba, 2012; Bartunek and Rynes 2014) have also shaped further barriers for collaborations. Pressure on academics to deliver impactful outcomes is increasing, and practitioners feeling that they are not taken into consideration when it comes to academic research, increase those tensions (Bartunek, Rynes, & Ireland, 2006; Trank, 2013).

Some collaborations that involve commercial outputs can face difficulties such as commercial sensitivity of sharing information with the public, limiting the ability to successfully translate them into academic outputs. This could potentially affect academics' willingness to engage in such projects, given that they see limited positive impact on their academic career (beyond the extra funding). Furthermore, the lack of clarity regarding the extent to which the benefits of these collaborations justify the risks and costs, and the overlooking of some intangible benefits of the university-industry collaborations such as their impact on teaching (Ankrah and AL-Tabbaa, 2015) are all under-researched barriers, which can affect university-industry collaborations.

According to Ankrah & Al-Tabbaa (2015), other barriers that affect collaborations and their outputs include:

- The IP and non-disclosure agreements

- The mismatch between the research expectations of universities and the firms' expectations of fast commercial results (Correa et al., 2013)
- The need of industry for timely IP rights and difficulties in negotiating common grounds

## 2.2 THE TRIPLE HELIX AS A MODEL FOR THE ENTREPRENEURIAL UNIVERSITY

The idea of creating technology and new knowledge and translating it to entrepreneurial endeavors drove policymakers and governments to believe that there are possibilities to engineer these university-industry relationships and their resulting entrepreneurship (Brännback et al., 2008). This translates to an understanding that if governments and policymakers get involved and support these collaborations in a top-down manner, this will increase the production of technology and innovation (Brännback et al., 2001, Henry et al., 2003), driving many countries to develop innovation systems, the main one being the Triple helix (Etzkowitz and Leyesdorff, 2000). The Triple Helix “provides a model for integrating governmental institutions, universities and industries to boost innovative activities and technology development” (Brännback et al., 2008, p. 263), which has been well publicized since, and became a base for many countries' innovation systems (the Swedish VINNOVA and the Finnish Tekes).

Since then, multiple theories and models have been suggested as a twist to the Triple Helix model: the double helix (Brännback et al., 2008), Quadruple Helix (Carayannis and Campbell, 2009). For the purpose of this thesis, the triple helix model will be used to describe the relationship between government, industry, and academia.

Etkowitz (2002) describes the triple helix as “a spiral model on innovation that captures multiple reciprocal relationships at different points in the process of knowledge capitalization... [and] denotes the university-industry-government relationship as one of relatively equal, yet interdependent, institutional spheres which overlap and take the role of the other” (p.2). In the triple helix model, firms collaborate with government and universities to create joint ventures in order to achieve common strategic missions (Leydesdorff and Etzkowitz, 1998; Leydesdorff and Etzgowitz, 2001). The last decade has witnessed major developments in the relationship between universities and industry and

an increase in the number of research collaborations (Barrett, Austin, & McCarthy, 2000; Powers, 2003; Gertner, Roberts, & Charles, 2011).

### **2.2.1 INDUSTRY-UNIVERSITY COLLABORATIONS WITHIN THE TRIPLE HELIX**

All HEIs, irrespective of the extent to which they are research-intensive, are engaged in knowledge creation and exchange activities and thus act as spaces to stimulate interactions between different stakeholders in the innovation process (Cohen et al., 2002; D'Este and Patel, 2007; Hughes and Kitson, 2012; Lester, 2005; Perkmann et al., 2013). In some instances, they may also take on the role traditionally assigned to industry, helping in the development of new firms through business incubation provision (Leydesdorff and Etzkowitz, 2001). Meanwhile, businesses have traditionally been seen as the 'recipients' of knowledge created within universities; however, in recent years, industry has become a far more active partner in the collaborative development of knowledge, and in some situations takes on role of the university in offering training and research (Leydesdorff and Etkowitz, 2001).

Knowledge exchange can be described as the process of turning basic research into new technologies through 'transferring, converting and commercializing' that knowledge (Siegel, Veugelers, and Wright 2007). O'Reilly et al. (2019) describe knowledge exchange as being composed of "activities involving engaging with the wider entrepreneurial ecosystem" (p.246). This takes the form of a number of "soft" and "hard" activities (Philpott et al. 2011): development of entrepreneurial graduates; formal knowledge transfer schemes such as Knowledge Transfer Partnerships (KTPs); exchange of academic and industrial staff; conferences; publicly funded collaborative research; consulting; licensing agreements for intellectual property generated within the university; business incubation activities; and creation of spin-out companies (Audretsch 2007; Bartunek and Rynes, 2014; D'este and Perkmann, 2011; Philpott et al. 2011; O'Reilly, Robbins and Scanlan, 2019; Van den Belt and Rip, 1987). Productive knowledge exchange between university and industry embeds the necessary skills in existing and future practitioners and drives long-term engagement between practitioners and academics (Bartunek and Rynes 2014).

Furthermore, universities and industry engage in technology transfer activities, whereby both stakeholders invest their available skills and technologies in developing relevant outputs that could serve the universities' entrepreneurial agenda (through patenting and spin-offs) as well as the industry's services and products (through consulting services acquired from HEIs) to deliver to the markets' needs (Daghfous, 2004; Guerrero and Urbano, 2012). The dynamics of knowledge and technology exchange and their relation to knowledge creation will be further explored in section 2.3.

The capacity for knowledge exchange and technology transfer between industry and university is directly and indirectly affected by the size of the HEI (Howells et al., 2008). While smaller HEIs might need to partner with other research providers to be able to initiate such activities, larger HEIs are able to internalize a wider range of knowledge creation and exchange activities (Ulrichsen, 2018). Meanwhile, the socio-economic context in which the university operates also influences the potential for collaboration. In less economically developed areas, industrial partners might struggle to engage in knowledge exchange activities due to the level of the firm's capacity to absorb new knowledge for multiple reasons:

- The dependence of knowledge absorption on the already existing technology and knowledge in that specific firm (Cohen and Levinthal, 1990)
- The impact of international trade laws on the cost of trade and consequently the cost of technology adoption by firms
- The organization staff's know-how and their understanding of both the academic and business environments to act as gatekeepers for the firm's absorption of new knowledge and technology (Cohen and Levinthal, 1989; Zahra and George, 2002)
- The differences in culture, language and financial constraints when it comes to IP negotiations (Abreu et al., 2008)
- The ability of local firms to take-up new technology and apply it (Lester, 2005)
- The existing policies and their level of support to the receiving end of the technology transfer (mostly firms) (Pugh, 2017, OECD, 2019).

### **2.2.2 THE ROLE OF GOVERNMENT IN THE TRIPLE HELIX**

The rise of the knowledge economy heightened the entrepreneurial role of universities and its role in creating impact on the wider socio-economic context as understood in the

Triple Helix model. The model positions universities in relation to industry and government to make a national and regional impact on economy, society, environmental issues, as well as [the university's] financial advantage through patenting and commercialization (Zawdie, 2010).

Theoretically, the government's role encompasses:

- Setting the industry's economic role while simultaneously trying to be less involved in its activities (Etzkowitz and Leydesdorff, 1997).
- Developing the necessary policies and assessment frameworks to manage funding and incentivize impactful and wealth-generating university-industry collaborations (Etzkowitz and Leydesdorff, 1997; Lach and Schankerman, 2008; D'este and Perkmann, 2011).
- Contributing to favorable market conditions for the commercialization of the outputs of collaborations by making changes in the regulatory environment (Leydesdorff and Etzkowitz 2001, Etzkowitz and Zhou, 2017).
- Benefiting from universities and research institutions for policy development and design (Etzkowitz and Leydesdorff, 1997).

How this is achieved in practice depends on the nature of the majority of HEIs within the government's sphere of influence (private or public). In Western Europe for example, where governments have historically been the main source of funding, governments can exert more influence over universities and the type of research they conduct (Etzkowitz and Zhou, 2017).

Within the triple helix model, the government is traditionally positioned as the facilitator of university – industry relationships. The government's role however has been criticized for the lack of focus on early stages of these collaborations by raising awareness through the education system, the need to focus on more secure funding and access to it, and implementing programs screening and evaluations (Henry et al. 2003).

### **2.2.3 CRITICISM OF THE TRIPLE HELIX MODEL**

Brannback et al (2008) have criticized the Triple Helix for its top-down approach to managing policy making and entrepreneurial activity. They propose an alternative bottom-up approach that includes entrepreneurs and innovators in decision-making (the

Double Helix). Furthermore, other researchers have argued that the Triple Helix is highly reliant on some pre-requisites that characterize western contexts, such as knowledge being a driver for economic growth, intellectual property being protected by law, and the existence of a market oriented and supportive state (Cai, 2013; Cai, Pugh and Lui, 2015, Williams and Woodson 2012).

The policies driven by the Triple Helix and the governments' increasing push for collaboration that lead to high socio-economic practical impact have also led to a wave of criticism. Some commentators fear that understudied incentives and policies pushing university-industry collaborations could jeopardize universities and academics' research autonomy (Krinsky 2003; OECD, 2019; Slaughter and Leslie 1997). Some have raised questions on how this move could lead towards less academic freedom (Blumenthal et al., 1986), low academic productivity for researchers (Agrawal and Henderson, 2002), and less open knowledge diffusion (Nelson, 2009; Rosell and Agrawal, 2006).

On the other hand, proponents of this supportive relationship recognized these risks and concerns, but argued that the new adopted role of universities does not interfere with the generation of scientific knowledge as long as policies take into consideration the researchers' motivation to engage in technology transfer or commercial activity (D'este & Perkmann, 2011). Furthermore if governments consider the type of engagement (research, opportunity or commercialization- driven consulting) when it comes to incentivizing collaborations (Perkmann & Walsh, 2008), and more effort is invested in capturing the knowledge created through these collaborations (Hermans and Castiaux, 2006), the position of university as a knowledge creator can remain at the core of its role. Meanwhile, some gaps in the triple helix model can be the result of not taking into consideration the differences between two or more of the triple helix' three poles. The difficulties in university-industry collaborations have been linked to discrepancies between industry and HEIs' definition of success (Barnes, Pashby and Gibbons, 2002).

For instance, from an industry point of view, the relevance of collaborations with universities is not the output and knowledge, but rather the impact of that knowledge on the performance of the company. In a survey done on 106 projects in 25 multinational companies, roughly 50% of the projects led to "major outcomes (i.e. produced new ideas or solutions to problems, developed new methods of analysis or generated new

intellectual property of potential benefit for the company)”; however, only 20% of these projects led to impact on the performance of the companies (Greitze et al., 2010, p. 84).

How success is identified can impact the objectives of any collaboration and how to assess whether objectives have been met. There are current attempts to measure the performance of these collaborations through evaluating knowledge exchange activities (Research England, 2019), the focus is on universities’ knowledge and available physical assets (Ulrichsen, 2018), the number of commercialized innovation, revenue and publications (Stankevičienė, Kraujalienė and Vaiciukevičiūtė, 2017; Vining and Lips, 2015), and the correlation between available knowledge and the ability to commercialize it (Lockett and Wright, 2005). This represents a very difficult challenge. For instance, measuring the success of collaborations through patenting and commercialization is less relevant for fields such as social and behavioral sciences, as opposed to biosciences or engineering (Fini et al., 2010). As such other ways of evaluating the impact of these collaborations need to be investigated.

## **2.3 KNOWLEDGE CREATION AND EXCHANGE**

Knowledge exchanged between university and industry may take the form of knowledge newly generated through research activities (knowledge creation), or the transfer of knowledge, experience or technology existing in one partner to the other (knowledge transfer and technology transfer) (Ulrichsen, 2018). It is essential to realize the potential of each type of collaborative activity.

### **2.3.1 KNOWLEDGE AND TECHNOLOGY EXCHANGE**

The creation of new knowledge is highly dependent on the transfer of existing knowledge (Alipour; Idris and Karimi, 2011; Nonaka & Takeuchi, 1995; Sverlinger, 2000). Universities can enhance industrial innovation through the transfer of both knowledge and technology (Cohen and Levinthal, 2000; Ikeda and Marshall, 2016; Schulz, 2003). Ismail, Hamzah and Bebenroth (2018) argue that the two processes (technology and knowledge transfer) have so much in common that it is not a straightforward process to completely differentiate them, and indeed, most academic papers either use the terms

interchangeably (Štrach and Everett, 2006; Kidanemariam, 2014) or use one of the terms to describe activities relating to both (Abdul Wahab et al., 2012; Ismail et al., 2016; Wehn and Montalvo, 2018).

Ismail, Hamzah and Bebenroth (2018) have attempted to define some key characteristics of technology and knowledge transfer. According to their analysis, technology transfer is more geared towards practicality, and involves both tangible and intangible knowledge (also known as explicit and tacit knowledge) turned into a practical or viable product presented in Intellectual Property (IP). It is usually adopted and transferred through incubators, science parks, consultancies and research collaborations (Ismail, Hamzah and Bebenroth, 2018).

On the other hand, knowledge transfer is more tacit, intangible and conceptual. Knowledge transfer takes place through conferences, teaching, workshops, KTPs, worker mobility and student industrial training (Ismail, Hamzah and Bebenroth, 2018).

As a consultancy, PDR formally performs technology transfer activities (according to the above definition), however; the nature and context of PDR dictate the manifestation of knowledge transfer interactions. Since PDR hosts KTPs, engagement with clients, designers and researchers' interactions, researchers attending conferences, etcetera, the occurrence of knowledge transfer activities is inevitable. Therefore for the purpose of this research and since the main context of this thesis is PDR, the following literature will be on knowledge creation resulting from both technology and knowledge transfer within more commercially oriented university-industry collaborations (i.e. consulting services, spin-outs, patenting).

#### *2.3.1.1 Productive Knowledge and Technology Exchange*

Whilst maintaining a long-term relationship based on continuous knowledge-sharing is critical for the success of some relationships between industry and academia, both stakeholders face practical and research-related difficulties within this relationship.

The clash between the academics' need for rigour and the practitioners' search for relevance has been a tension between the two (Avenier and Parmentier Cajaiba, 2012; Bartunek, Rynes 2014). The lack of incentives for practitioners to engage in academic



research and the way academics can sometimes be inclined to dismiss practitioners' "voice" and experience when it comes to theorizing practice issues (Bartunek, Rynes 2014) can be a cause to many practitioners' disinterest or being distant from engaging in academic research.

Furthermore, many practitioners working in industry lack the skills and fundamental understanding of academic research inquiries and methods skills, and do not have experience in conducting, reporting, and sometimes understanding academically reported research (Marcos & Denyer, 2012; Wasserman & Kram, 2009). Such issues are often faced within industry-academia collaborations across sectors (Dirks, 2005; Rynes, Colbert and Brown, 2002). Therefore it is important to prepare future practitioners with a thorough grounding in methodology (Robson and McCartan, 2016). Similarly, engaging future researchers in practice assists in their understanding of the value of industry and practical knowledge in developing relevant and applicable research. Hence the importance of teaching and work based learning in preparing future professionals and researchers to these industry-universities interactions.

The presence of researchers and designers under one roof makes such issues more prevalent in PDR than other purely commercial or academic contexts. PDR's existence within an academic institution highlights the potential role of teaching in the knowledge and technology exchange process.

With the increasing focus on research-led innovation, imbedding this reflective process within the learning experience during the university years is essential. Choosing teachers who have in-depth research knowledge (PhD students/graduates and researchers), and have had extensive industry experience and access to real life case-studies constitutes a potent learning strategy to transfer the research experience to students (McLoughlin & Lee, 2008).

On the other hand, understanding the industry's needs and learning about its activities is as crucial for the development of insightful and industry-aware researchers.

There are also suggestions of extending knowledge transfer partnerships (KTP) as a mode for learning in undergraduate studies (Harris et al., 2013). KTPs can play a useful role in engaging the different stakeholders and offering the space for researchers and practitioners to engage in each other's contexts.

Relevant research and real life experience, combined with the ability and skills to reflect on and learn from the existing processes (Boud, Keogh, and Walker, 1985; Johns, 2000)

are crucial for the transfer of knowledge that meets the needs of today's knowledge-based industries, and to facilitate future interactions between researchers and practitioners.

### **2.3.2 KNOWLEDGE CREATION**

The transition from the 'ivory tower' to the entrepreneurial university has also led to changes of ways in which universities generate new understanding, which Gibbons *et al.* (1994) have described as a shift from Mode 1 to Mode 2 knowledge production.

Mode 1 knowledge production is typically exogenous (i.e. curiosity-driven), generated according to disciplinary norms isolated or semi-isolated from its external context, and leads to 'traditional research outputs'. The product of such research process is delivered in a written form, explicitly identifying the knowledge contained within them in terms of the research aim, objectives, methodology, data and results (e.g. journal papers, publication, chapter in a book, etc.).

A more endogenous form of research characterizes Mode 2 knowledge creation. Mode 2 is a complex, multidisciplinary process, which is built more in the context of application or use, accessible beyond academia, and highly-engaged with industry, and society and its environment (European Commission, 2010; Gibbons *et al.*, 1994; Nowotny *et al.*, 2001; Stokes, 1997). Mode 2 knowledge creation has supported the emergence of new disciplines, methodologies and ways of thinking (European Commission, 2010). This more applied approach often acts as a precursor for the development and production of a service or product (R&D) and so typically results in non-traditional research outputs.

In practice, activity in universities spans the continuum from curiosity-driven to practice-based and user-led knowledge creation; there is growing overlap between Mode 1 and Mode 2 processes (Goldense, 2014). Further, the boundaries are blurring between stakeholders in the knowledge creation process, leading to fundamental research being conducted in the context of application both outside and within universities (European Commission, 2010).

#### **2.3.2.1**      *Tacit knowledge*

The new span of knowledge creation in the context of university-industry collaborations has extended knowledge beyond research activity. Multidisciplinary collaborations and involvement of professionals, researchers, and entrepreneurs, involve interactions between different people carrying different types of knowledge.

Knowledge that can be translated into explicit 'data' is only a fraction of people's knowledge. As Polanyi (1966) expresses it "We can know more than we can tell" (p.4), classifying human knowledge into two categories: explicit knowledge and tacit. While explicit knowledge is codified and can be transmitted using formal language, tacit knowledge is more personal, imbedded, and harder to transfer or communicate (Polanyi, 1966; Ropke, 1998; Nonaka & Takeuchi, 1995; Argote & Ingram, 2000).

While technical knowledge is well sought for, tacit knowledge remains a point of differentiation attracting collaborations between university and industry. Technical knowledge can be explicitly available, while tacit knowledge accumulated through experience and trial and error cannot be duplicated, and it contributes to an organization's differentiation adding to its competitive advantage.

The accessibility and ability to build on knowledge created in past experiences is likely to help in improving performance (Garud and Nayyar, 1994, Tsey, 2019). Tacit knowledge is scripted and can be similar to cognitive models or frameworks people implement when they find themselves in a certain situation (Sternberg, 1994; Nonaka, 1991). Tacit knowledge becomes so rooted in the person's cognitive behavior that it appears completely instinctive and natural (Ravetz, 1971) and cannot be linked to articulable knowledge.

Scholars have recognized the value of tacit knowledge and studied the possibilities of transferring and 'externalizing' it (Nonaka, 1994). Tacit knowledge is essential for the creation of new knowledge, through transmitting and combining it with other organization members' explicit and tacit knowledge (Nonaka, 1994; von Hippel 1994). While models such as the hypertext organization has been created to "externalize" tacit and accumulate explicit knowledge through communicating and digitally organizing information (Nonaka, 1997), this method was faced with criticism arguing that it is based on mechanization and simplification of thinking and human mind (Virtanen, 2011; Weick, 1995), and that simply accumulating and sharing acquired explicit and tacit knowledge will not help the organization adapt to changes and create new and innovative ways of dealing with issues

(Weick, 1995).

Since the hypertext organization was developed prior to the high push for entrepreneurial university, this mechanism for knowledge creation was developed within organizations operating independently. The understanding of such mechanisms (accumulating and re-processing knowledge) within entrepreneurial universities can be different. Knowledge that has been co-created within an ecosystem formed of industry, universities, entrepreneurs, and government needs to be re-absorbed by the university to inform further knowledge creation (OECD, 2002). Nonaka and Takeuchi's (1995) four-mode model of knowledge creation explains how such knowledge exchange takes place within an organization. Transferring tacit knowledge through training and experience (socialization), explicit knowledge created from explicit knowledge through organizing, merging and re-processing (combination), and explicit to tacit through learning (internalizing), and tacit to explicit when internal goals and rules are articulated explicitly (externalizing). This model can also exist within an inter-organizational context, and could therefore be explored in the context of entrepreneurial universities. Research on externalizing knowledge from collaborations using Nonaka and Takeuchi's (1995) four-mode model of knowledge creation has been conducted (Hermans and Castiaux, 2006); however, it only covered its application on university-industry collaborative research. More research on creating new knowledge from existing knowledge (explicit and tacit) within a commercial ecosystem involving more stakeholders is thus needed.

#### *2.3.2.2 Creating knowledge through Knowledge and technology transfer activities*

Although the success of university-industry collaborations has been heavily studied and assessed through measuring number of patents, spin-outs and revenue, the way knowledge is created and exchanged during these collaborations and as part of the daily activities of a university-industry collaboration is not heavily researched (Agrawal 2001; Debackere 2000; Hermans and Castiaux, 2006). In an attempt to understand how knowledge is created and the ways it flows in collaborative research projects, Hermans and Castiaux (2006) applied the hypertext organization (Nonaka & Takeuchi, 1995) in an inter-organizational setting. Based on their research, Hermans and Castiaux (2006) detailed the different ways knowledge flows and is created in an inter-organizational context:

### ***Socialization***

The first stages of interaction in a partnership start with informal exchange of information between individuals from all the participating partners to build credibility and trust. The exchange of experience knowledge can support ways to go forward with the research activities. The exchange of each partner's tacit knowledge and capabilities will eventually lead to the specification of roles of partners and an informal and initial agreements of the collaboration's aims (Hermans and Castiaux; 2006).

### ***Externalization***

The 'socialization' phase and the informal delegation of responsibilities are now formalized. Externalization is the process of agreeing on a concept and explicitly specifying roles for the collaborations in a contract; the results of which will be later translated into publications, reports or even artifacts. A socialization mode that fails to create and share common perspective can affect this stage. Strict formalizations and contracts can however hamper the possibilities of sharing results due to confidentiality or intellectual property.

### ***Combination***

Combination takes place when "existing know-how" and technology is shared between partners to act upon formalized agreements, and crystalize the tacit and explicit knowledge along with newly developed and converted knowledge. It involves sharing existing and discovered information through a variety of medium (meetings, re-iterative processes, workshops, discussions...). This new information is then shared and transformed into publications or artifacts and shared with other partners and organizations.

### ***Internalization***

Internalization process is the culmination of the collaborative process, and the exploitation of knowledge, confirming the benefit for both partners: academics' access to industrial data and industrial partners exploiting academic outcomes.

These results are then justified by the peer review of the resulting outputs or the efficiency of the exploited new knowledge within the organization. The benefits reaped

go beyond the created knowledge and cover the trust and long-term relationships and repeat collaborations between partners.

These four stages illustrate how knowledge is shared and justified by multiple stakeholders. Individual explicit and tacit knowledge is enlarged to become organizational knowledge, and knowledge shared with industry and the academic community.

Although this analysis presents a valuable attempt to capture how knowledge is transferred and created within university-industry collaborations, it is only limited collaborative research projects. Furthermore this application was an initial attempt and that has not been studied further or followed up with expansion on other types of collaborations. As such, it simplifies the barriers that can affect more commercial collaborations and how they hamper the interaction, i.e. the differences in skills and the stakeholders' ability to engage in each other's processes, differences in 'languages', the academic versus commercial priorities, commercial sensitivity in shared outcomes. Moreover, this description does not consider the exchange and accumulation of knowledge taking place all the way throughout a collaborative process and the amount of lost knowledge that could not be communicated due to time and cost limitations in more commercial collaborations. An attempt to translate this understanding of knowledge flow into methods, which help to effectively capture knowledge in a university- industry commercial context, can help in better exploiting the value of these collaborations.

### **2.3.3 COLLABORATIVE ACTIVITIES AND COMMERCIALIZATION**

As part of their entrepreneurial role, universities are constantly attempting to translate their knowledge into applicable insight, and use available skills and resources to directly contribute to industry. Technology transfer mediums range between the university's direct commercialization of its knowledge through patenting, all the way to spin-outs, consultancies, and start-ups (Ankrah and AL-Tabbaa, 2015).

According to Perkmann and Walsh (2007) the range of collaboration activities range between high intensity (Relationships between partners), medium intensity (mobility activities) and low intensity (transfer) as follows:

- Research consortia: these are research partnerships arrangements between organizations. They are considered high intensity relationships between partners.

- Consulting (contract research, quality control, prototyping and testing): It is considered high intensity relationships and research activities, usually commissioned by industry partners to university researchers. The aim of these collaborations differ depending on the type of consulting services; research or commercially focused, or both.
- Technology Parks and Incubators: businesses from the industry use technology, labs and equipment located within universities. These types of collaborations are considered high intensity and usually lead to long-term relationships between universities and the relative industries.
- Spin-outs or partly-owned companies: are formed when academic inventors develop and commercialize their technologies and innovations, through companies shared with other industry partners or independent spin outs developed by the university. This type of academic entrepreneurship is considered medium intensity mobility of knowledge and technology and does not have the aim of developing research outputs.
- KTPs, training programs and exchange of research and industry staff: is a form of human resources transfer and training developed through medium intensity mobility partnerships. These activities assist in transferring knowledge and skills between industries and universities while enhancing stakeholders' skills and knowledge development
- Patenting and licensing are forms of commercialization of the university's intellectual property developed by its researchers. A low intensity form of technology transfer, generating revenue and reach.
- Conferences, meetings and social networking are informal interactions between stakeholders that could potentially lead to future high intensity relationships.

In a large-scale survey of UK universities, D'Este and Perkmann (2011) found that commercialization is at the bottom of the motivation reasons of researchers engaging with industry. In fact, the researchers' main reasons to engage in these forms of collaborations were: improving research and teaching through learning from an application context (Ankrah et al., 2013; Arza, 2010), accessing fields to test and apply their research (Lee, 2000), and supporting their academic research activities through learning, or access to funds and other resources (D'Este and Perkmann, 2011). Research

done around collaboration in the UK has shown that researchers with less industry collaboration publish less than those who are more involved with industry (Banal et al., 2008). Academic productivity and collaboration are positively related, and led by different motivations (Bekkers and Bodas-Freitas, 2008; Gulbrandsen and Smeby, 2005; Haeussler and Colyvas, 2011); collaboration leads to new ideas for new and relevant research (Lee, 2000, Welsh et al., 2008). Meanwhile research collaborations, such as joint research and contract research, are more sought after by academics due to these activities' alignment with academic productivity, as opposed to commercialization projects, such as spin-outs, startups, or patents collaborations (Perkmann et al., 2013). Furthermore, Perkmann and Walsh (2009) argued that the motivation to engage with industry depends on the channel of engagement. While collaborative modes such as joint research, contract research, and consulting, are motivated by more creative research-related objectives; classic technology transfer methods i.e., spin-out companies and patenting are motivated by commercialization. The more commercial the channels of interaction between universities and industry are, the less likely they are to lead to academic research since the data resulting from some interactions are not novel enough to lead to academic research (Perkmann and Walsh, 2009). However, these interactions still offer other indirect benefits such as access to research funding, new research problems, or learning about industrial problems (Perkmann and Walsh, 2009), which outweighs the lack of academic research outputs.

#### *2.3.3.1 Commercial and Research Consultancies*

Industry-university type of relationships could take different forms (Perkmann and Walsh, 2007) as listed in the previous section. Although consulting activities are one of the prevalent university-industry collaborations (whether done by individual university staff or through a consultancy type of structure), their range of activities can vary between purely research oriented, practicing knowledge transfer to produce commercial outputs, or a combination of both. This section is going to focus on consulting type of university-industry collaborations, which fits within PDR's commercial activity pattern.

Consulting stands somewhere in between both commercial work as well as research interest. Franco and Haase (2015) argued that consulting is more commercialization-led.



Others believe that consulting assists academics to gain an income, while still being led by their learning motivation to connect with industry and learn about real industry problems (Louis et al., 1989 and Lee, 1996, as cited in D'este & Perkmann, 2011, and Parkman et al., 2013). Research on Spanish universities has shown that the correlation between consulting activity and number of publications is field dependent: negative in fields of natural sciences and engineering and positive in humanities and social sciences (Rentocchini et al. 2014). The difference in correlation between consulting activity and academic productivity based on the field could be due to the diversity of activities taking place in each consulting context.

While there is a focus in the literature on the different types of technology and knowledge transfer activities such as spin-outs (Jacob et al., 2003; Pirnay et al., 2003; Etzkowitz, 2003, Etzkowitz, 2013;) and patenting (Guená and Nesta, 2006; Grimaldi et al., 2011), less attention is given to consulting (Cohen et al., 2002; Klofsten and Jones-Evans, 2000; Philpott et al., 2011) and contracted research (Cohen et al., 2002; Levy et al., 2009). The difference in motivation between consultancies and other forms of collaboration, and the diversity of commercial and research activities taking place in a consultancy context require further academic attention. Furthermore, university-industry collaboration studies are focused on hard sciences, engineering and business studies consulting, and less about commercial consulting.

There is a slight differentiation when it comes to the type of consulting motivation and its effect on academic research production: opportunity driven, commercialization-driven and research-driven consulting. The three types of consultancy collaborations are represented in Table 2.1 below, along with their impact on academic productivity and shifting away from basic research (Perkmann & Walsh, 2008).

While consulting relationships generally do not have a negative impact on research generation; however, the scale of the firms seeking opportunity-driven type of consulting (usually SMEs) and the breadth of this relationship (i.e. shorter period of time and smaller budget) are factors that can affect academic productivity (Perkmann & Walsh, 2008). Meanwhile, it has been shown that academic productivity is positively correlated with long-term collaborations (García et al., 2019). Therefore, the nature of collaborations conducted and fostered by PDR; aiming towards retaining international and large-scale organizations and clients, fit well within the long-term interaction within which research production strives. Although in their research Perkmann & Walsh (2008) focus on science

and engineering, the context of PDR's new product design and development involves similar if not same type of activities

	Shift away from basic research	Impact on academic productivity	Contribution	Benefiting firms
Opportunity-driven	No	-	Problem-solving, hired expert labour	Small technology-based firms
Commercialization-driven	No	0	Enabling and accelerating development	Licensees (up-start technology companies and existing companies)
Research-driven	No	+	'Windows' on new technologies, strategic advice	Large, science and technology-intensive firms

Table 2.1 Impact of The Three Types Of Academic Consulting Perkmann & Walsh (2008), P.1887

Building long-term relationships based on trust, and managing a continuous relationship based on interaction and exchange of knowledge and technology between the two stakeholders can contribute to the success of the collaboration (Dyer and Singh, 1998; Garcia et al., 2019; Gibbons and Henderson, 2012; Wit de Vries et al., 2018). The long-term continuous collaboration allows the alignment between the firms' values and activities with the academics, which then develops trust and analogies (Nonaka and Konno, 1998; Paulraj et al., 2008) allowing more specific knowledge creation. Managing a long relationship provides the stakeholders (industry and university) time to develop a clearer understanding of each other's offerings and missions, the objectives they are aiming for, and the fields they operate in. On the other hand, short-term knowledge acquisition and interactions are not worth the attempts to align values and practices due to the high costs of such high-maintenance interactions (Szulanski et al., 2004). Therefore the potential of short-term relationships leading to outputs that satisfy both stakeholders (more publications by academics) is less likely.

## 2.4 DESIGN CONSULTANCIES

The nature of commercial consultancies as a university-industry collaboration differs in motivation and processes from other types of collaboration. The more recent role of design in innovation and problem solving highlights the importance of design within university-industry collaboration. As such, a commercial design consultancy such as PDR plays a role in new knowledge and value creation within a university context.

Today's designer is not only responsible for a single aspect of the design process. Designers exist in a more complex environment; they are expected to identify problems, figure out the required solutions, set goals, develop sets of actions, and lead teams to achieve these solutions, analyze, synthesize and generalize (Friedman, 2000). Similarly, researchers need to have a significant knowledge base on the fields and industries they are likely to interact with, in order to study, develop, and create technologies relevant to those fields (Klevatorick et al, 1995).

By understanding experiences, and knowing the existing literature and the principles designers can add to that cumulative background through their immediate experiences, but cannot learn or substitute with only raw practical work results. Experience and skills alone is not enough to manage and improve processes, methods, and competitive advantage: Theory is the source of the question, and experience will help in answering it (Deming, 1986 in Friedman, 2000). As such, using technical skills, existing knowledge, and experience is crucial to generating new knowledge and potentially new theory. Many designers are employed on the basis of their professional reputation and continue to practice both academic research and commercial work, to maintain that reputation and to remain abreast of developments in commercial design (Rust, Mottram & Till, 2007). Meanwhile, designers undertaking professional practice within universities have been experiencing tensions between the need to evidence their contribution to industry and the need to prove their contribution to the research quality of the university (Kuys et al., 2014).

With the rise of collaborations between industry and universities and entrepreneurial university, multidisciplinary knowledge has become more and more important (Poggenpohl, 2015). To facilitate this cross-functional communication and inter-

dependency, there is a need for a systematic approach to the use of design in a more holistic way within the university-industry collaboration, in order to create value and new knowledge.

Poggenpohl (2015) argues that designers, who are focused on creating something new and on what comes next, ignore the fact that the past is the base of development. Krippendorff (2007) suggest that scientists are interested in what is observable and already exists, while designers focus on the unobservable and will exist in the future. Activities taking place within consultancies in a university context are at the center of this collaboration; merging both design research and its application. The successful application of any mix theoretical or practical design research methods relies on the designers' experience and intuition (Hare et al., 2018). Researchers are drawn into the design process to benefit it by offering their knowledge to answer specific questions and at the same time explore some benefits from their observations to feed into their research and teaching interests. If well exploited, the applied exchanged and accumulated knowledge can potentially be the source of new knowledge.

#### **2.4.1 KNOWLEDGE CREATION IN DESIGN**

Design research is a relatively new field, emerging in the second half of the 20<sup>th</sup> Century. Blessing and Chakrabati (2009) have defined three stages in the development of design research: experiential, intellectual, and empirical.

Experiential (up to late 1950s): during which, the design processes experiences and the resulting outputs were described by designers by focusing on one technical domain without any theoretical framework;

Intellectual (between the 1960s – 1980): more methodological ways of addressing the design issues were proposed in an effort to create more systematic grounds for the design industry;

Empirical phase (starting in the 1980s): collecting data in practice to understand the effect of the developed theory (methods and tools) on the design process.

Today the need to study the design field's relation to other areas of industry and research is increasing with the increase of industry-university collaborations. The collaboration between design and other disciplines (service sectors, policy, business solutions...)

requires further understanding of the design discipline and its relation to the other fields. As stated by the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine (2005), interdisciplinary collaborations are becoming an increasingly critical aspect of research. The complex socio-economic issues and need to solve questions beyond the borders of one single discipline, requires technologies from different industries and of a broader impact. Interactions between industry and researchers are needed in order to better weigh the needs of the industry and translate them into appropriate and practical solutions through rigorous research (Shah & Hazelrigg 1996). Meanwhile, the role of design as a driver for innovation is also becoming more recognized (Verganti, 2009). Norman (2013) highlights the importance of multidisciplinary collaboration in saving time and cost in solving problems. Progressive design organizations and consultancies are increasingly relying on the multidisciplinary collaboration and design as a holistic process including teams from multiple industries (Veryzer and Mozota, 2005). Limiting research and practice to one industry can thus increase the risk of limiting the nature of the output to the specifics of this field, which in turn would affect the breadth of the output's impact (Friedman, 2000).

This design research environment combined with the increasing industry-university collaborations lead to more design-driven research. Norman and Verganti (2014) have distinguished between the four types of design research along two dimensions: consideration of practicality and interpretation of meaning (Figure 2.1)

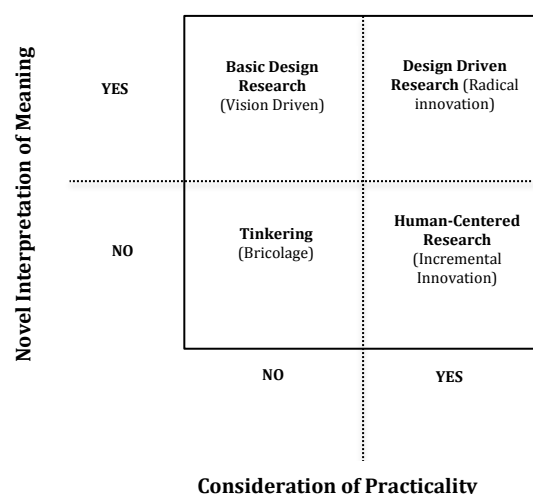


Figure 2.1 Design Research Quadrangle. Adapted from Norman and Verganti (2014)

Basic design research: similarly to other fields' basic research, basic design research does not have any practical objectives and is purely aiming at exploring a new understanding and meanings.

Design-driven research: as an applied type of research, the aim of design-driven research is to explore new understandings of how people behave and why they use certain products, and apply these insights to new technologies and products. Design-driven research usually leads to radical innovations.

Human-centered research (HCR) is linked to incremental innovations and does not lead to new technologies. Instead HCR aims at understanding users' interaction with a certain technology and assigned meanings to develop products that satisfy these meanings and insights. According to Norman and Verganti (2014) due to the incremental nature of this research, human centered research rarely leads to entirely new categories and rather improves the value of an existing one.

Tinkering is the process of exploring an existing product without any specific aim to enhance meaning or practicality. In some cases and usually by complete coincidence, the process of tinkering can lead to great insights for new products.

Although separated in definition, these four types of design research are often linked. One particular emerging pattern is basic curiosity-driven research that leads to design driven research; looking for a link between the new meaning and a potential practical implications, followed by improvements and enhancements of products through HCR (Norman and Verganti, 2014).

While Norman and Verganti (2014) argue that traditional HDC tools (interviewing users, observing) are only linked to incremental innovation, they do on the other hand link tinkering to accidental radical innovation. However, there is no mention of the HCR type of activity and its potential link to creating new and unprecedented knowledge or innovations. Meanwhile, it is argued that the interactive nature of some HCR tools, and the combination of HCR methods can lead to strategic solutions or 'big ideas' (Sanders and Stappers, 2012; Van der BijlBrouwer and Dorst, 2017). The existing element of experimenting and "learning by making" within the HCR process; specifically in using co-

design in generative stages as well as throughout the process, can uncover some hidden tacit ideas or needs that lead to more radical solutions (Sanders & Stappers, 2012; Van der BijlBrouwer and Dorst, 2017) (e.g. users interacting with products and exhibiting a new informing behavior, or users participating in the ideation process, learning by making). This implies that if applied in an environment with the necessary in-depth research capacity and the skills required for a combination of multiple tools; HCD could in fact lead to potential strategic results, even though it was previously argued to be serving only incremental innovation.

Similarly, Hermans and Castiaux, (2016) approach commercial R&D processes from an innovation/understanding axis perspective. In their research, they classify the types of university-industry R&D collaboration based on their objectives, resulting in three types of projects: 1) Exploration, seeking innovation and new understandings, which could be compared to design-driven research (Norman and Verganti, 2014); 2) Discover projects: which aims at new understandings and discoveries without the innovation purpose, equally as meaning driven as basic design research identified by Norman and Verganti (2014); and 3) Exploitation projects: based on existing knowledge in industry and universities, exploitation projects seek the implementation of this knowledge in order to obtain new products or technologies that could be commercially exploited (Hermans and Castiaux, 2016). In terms of seeking meaning versus understanding, exploitation projects could identify with HCR as described by Norman and Verganti (2014). In this context, however, exploitation projects are one type of the typical knowledge exchange and transfer activities that take place within a commercial R&D projects (including design projects), and are not solely limited to HCR. Figure 2.2 below represents these 3 types of collaborative projects along two dimensions: quest for understanding and innovation:

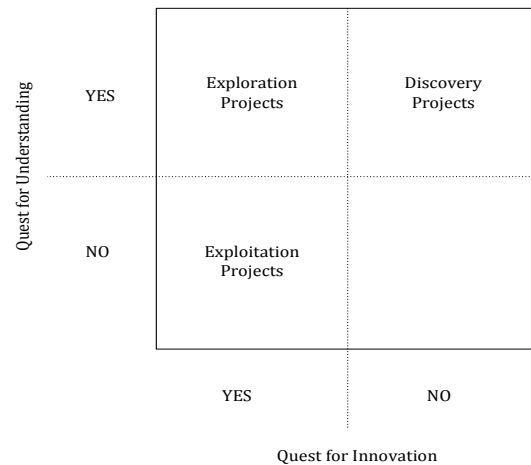


Figure 2.2 Nature of R&D projects based on the objectives, adapted from Hermans and Castiaux (2016)

Although three separated types of projects have been identified, the multiple stakeholders' involvement and nature of these collaborations lead in some cases to shifts in the objectives and needs of the project. These shifts can therefore lead to an overlap between the different types of projects, and realization of new objectives i.e. the need for new understandings in what started as an exploitation project, which requires the knowledge and skills of other stakeholders (Hermans and Castiaux, 2016).

#### 2.4.2 KNOWLEDGE EXCHANGE IN DESIGN

As a design consultancy, PDR is responsible for producing a variety of commercial outputs in collaboration with clients from industry. PDR's main points of contact with industry are through UCD research studies, New Product Development (NPD), service design, and surgical and prosthetics design.

As the department responsible for around 76% of PDR's commercial projects for the years 2014 – 2018, NPD is considered the main commercial outputs producer in PDR. The consideration of the knowledge value of NPD's outputs' in the context of university-industry collaborations and their potential research value are thus of high importance to the mission of PDR as part of an entrepreneurial university.



#### 2.4.2.1 *New Product Development*

NPD is a design process of transfer and implementation of existing technology and knowledge, as well as new insights emerging from R&D, industrial design, marketing research, UCD research, engineering and manufacturing, to create usable and impactful outputs (Marsh and Stock, 2003; Veryzer and Mozota 2005).

NPD is a process of interaction between multiple components resulting in a product (artifact or service). The aim is to manage the interaction between the components, and their transfer to the best possible level of practice. Although it does not mean the organization is ultimately ahead of its competitors, or that every product fits within a static process, some characteristics of the knowledge and technology implementation process can define best practice in NPD (Cooper et al, 2004 I; Cooper et al., 2004 II):

- Quality of execution through conducting reviews of the performance after the release of an output; an effective way to learn from the mistakes for future projects, and formally terminate a project if needed,
- Assessing the value of the product released and how much it adds or enriches the company's portfolio
- Focusing on the idea generation stage followed by testing the concept and the final product in the market and under real life conditions and getting feedback
- Studying the market and the consumer behavior while considering the users' unarticulated needs through UCD
- Clear definition of the product starting early stages

This list of best practice highlights some critical points of contact within the design process; the research, the components and ultimately the development process, and their continuity, which in turn impacts the exchanged knowledge and technologies and consequently the quality of the output:

**The user:** Developing a meaningful and technologically innovative product does not necessarily always follow user studies; many radical innovations take place simply due an epiphany of technology or change of meaning (Norman and Verganti, 2014). However the viability of a product depends on the timing of its release to the market, and its usability

(Norman and Verganti, 2014). As such the users' needs - echoed by the client approaching the designer in many cases - are a lead source of insight in the development and adaptation of any product (Norman, 2004; Vredenburg, Isense and Righi 2002), and they are treated as the directly impacted subjects and justifiers of the output, and the primary measure of its success.

**Prototyping:** a critical aspect of the NPD process is to evaluate and simulate tangible representation of the ideas. The value of prototyping is within the saved costs and time, the insight it offers, and the necessary understanding of the solutions and the chance to improve ideas (Cooper and Edgett, 2008; Kelley, 2001; Leonard-Barton, 1991, Mullins and Sutherland, 1998, Simeone et al., 2017). The earlier the firsthand observation of the user's interaction with the product takes place, the easier it is to make any changes and improve the output.

**Feedback and iterations:** Delivering a process and going through its different stages requires continuous observation, feedback and iterations as early as possible to elude any avoidable issues early on in the process, and include all of the stakeholders' potential insights. The involvement of teams in one process and providing the necessary feedback helps in dropping failing ideas early on, before spending resources on testing them or taking them forward (Waterton, 2018). Furthermore, feedback and iterations contribute to the learning process, which not only improves the process at hand, but generates knowledge and develop skills that, if managed appropriately, will not have to be regenerated for other projects (Morgan and Liker, 2006; Thomke and Fujimoto, 2000).

**Product integrity and Flow of Information:** Product integrity falls under two divisions: 1) Internal integrity relates to the coherence and consistency of different product functions; what it is meant to do as well as the organizational internal integrity, represented by the systematic cross-functional flow and exchange of information within the organization (Veryzer and Mozota, 2005). 2) External integrity is more customers oriented; it is the level of consistency between the users' expectation of the product, and its level of performance (Clark and Fujimoto, 1990). Both internal and external integrity are crucial for the success of the design process to achieve efficiency and effectiveness of output delivery. Therefore part of the success lies within the level and quality of

systematically managing internal and external interactions between stakeholders and resources.

***Internal organization culture:*** the continuous advancement and adaptation of internal capabilities of people and the organization as a whole are important factors to create long term relationships with clients (or industry), and consequently maintain a competitive advantage. The integration of capabilities in a dynamic way that would conform to any changes that occur on a strategic or process levels, through using previous experiences to inform future ones, is therefore an advantage (Marsh and Stock, 2003).

The NPD components listed above all involve an iterative incremental learning element resulting from interactions with internal designers and researchers as well as external stakeholders such as users and clients. The dependence of projects on existing and newly developed knowledge implies that not properly exploiting these interactions and capturing any potential newly created knowledge, requires a regeneration of this information at every new project (Thomke and Fujimoto 2000; Morgan and Liker, 2006) consequently wasting time, money and chances for exploring new knowledge and opportunities for innovation.

#### **2.4.2.2      *Learning from Previous Experience***

The development of knowledge and skills is cumulative; it is linked to past experiences of the designer, researcher, or the organization as a whole. Cumulative knowledge in certain areas is therefore crucial for design processes, investment related issues and risk reduction, thus increasing the chances of success in future projects. Tacit knowledge constitutes a partial element of the value accumulated through new product design processes.

NPD is the combination of knowledge and skills required to perform the different activities of an NPD project such as solving any emerging problems related to the concept of the product or its planning, the engineering, its production and even the introduction to the client or customer. The problem solving process is thus based on a series of previous experiences combined with formal accumulated knowledge and most importantly the tacit knowledge of people within the organization (Dosi et al., 1988). If

accessible, existing capabilities, technological breakthroughs, and any knowledge that is not fully exploited could be important components of the problem solving process or newly developed products.

Inter temporal Integration (ITI) is a conceptual model developed by Marsh & Stock (2003) defined as “the process of collecting, interpreting and internalizing technological and marketing capabilities” (p.136) from previous NPD projects, and using all that knowledge in future projects; it is a set of activities that enable the organization to acquire, distribute, interpret, retain, and apply the knowledge developed in prior new product development activities, and use the knowledge and capabilities to adapt them to the current projects and development. The literature on NPD argues the importance of codified knowledge from previous experiences, and how transferring it to other employees can improve the potential success rates of future designs (Dougherty, 1990; Brown & Eisenhardt, 1995; in Marsh and Stock, 2003, and Lee and Choi, 2003). The challenge however is the importance and at the same time the complexity of articulating this tacit knowledge and sharing it with the rest of the stakeholders for the mutual benefit on both the practical as well as the theoretical level (Berends et al. 2004; Friedman, 2000; Nonaka & Takeuchi, 1995). The efficiency of ITI and its role in the success on a project level comes from the fact that the information and part of the development process in previous projects are now available to be used in a new project, benefiting from the time and effort already invested once and reducing the amount of work in later project (Morgan and Liker, 2006; Thomke and Fujimoto, 2000).

To create and share knowledge there is a need for an experience and a reflection on this experience. Thinking-along is another method relying on temporarily applying the knowledge of one or group of stakeholders in other scenarios, in order to co-create new ideas and concepts or solve a problem with other stakeholders, potentially other disciplines (Berends et al. 2004). This method will therefore help in partially and indirectly transferring information, which could potentially carry tacit knowledge (Berends et al. 2004). Thinking-along relies on reflection and processing on already acquired information. Furthermore, reflective practice can bridge practice and research to achieve a mutual benefit and an understanding of the interchangeable impact that will help in bridging the two fields (Friedman, 2000; Kolb, 1984; Schon, 1999).

The success of the ITI and think-along methods heavily relies on experience, reflection

and re-application of this knowledge. Documenting and data maintenance processes, formative evaluation, and reflection are all features that can turn ordinary design activities to useful research results (Edelson, 2002); and in this case help transfer, share and integrate knowledge. These methods, however, assume a great deal of systematic and strong communication within an organization to achieve such level of knowledge exchange and re-application, which is not the case in every organization, and highly depend on the organizational culture and management's priorities.

#### *2.4.2.3 Artifacts' Role in Knowledge Transfer*

"Design can be seen as a process that revolves around knowledge acquisition with an end goal of embodying all the appropriate knowledge into an artifact" (Bofylatos and Spyrou, 2017, p.6). According to Bofylatos and Spyrou (2017), an artifact is a combination of three aspects: 1) the physical component that achieves the ability to 'perceive' the object; 2) the designer's intention and objective, and the purpose for which the product has been designed; and 3) the social context within which the output is contextualized and becomes meaningful to the user. Artifacts embody emotions, personal experience, and tacit knowledge of the 'maker' (Groth, 2016) in addition to the scientific and empirical knowledge (Bofylatos and Spyrou, 2017). This artifact is what transforms a current unwanted or problematic situation into a more desirable future (Zingale & Dominguez, 2015 in Bofylatos and Spyrou, 2017).

The importance of the user in the design process implies that the interaction of the user with the artifact, and the knowledge it embeds, are as important to the design process as the designers themselves (Zingale & Dominguez, 2015). As such artifacts play a major role in delivering that knowledge and its intentions, and in communicating and translating interests and needs, which can be instrumental to the value creation process (Simeone et al., 2017)

According to Groth (2016) the designer highly relies on knowledge accumulated through the sensory experiences. The constant interaction with materials and learning by doing develop the knowledge implemented by the designer. Artifacts and objects have also been increasingly used as tools in the design process, and have been highlighted as instrumental tools for entrepreneurial endeavors (Simeone et al., 2017). The importance of visual research methods in understanding human needs has become a central research

topic; the act of creating has been used to efficiently extract human needs, including tacit needs, which they did not know existed (Hare et al., 2018). Visual and interactive Exhibition – as a theatre for conversation - user research methods have also been implemented as tools for inclusive design. The visual, tactile and interactive nature of such tools, assisted in understanding the users' needs and capture and disseminate knowledge which can ultimately inform designs of intimate nature (Chamberlain and Yoxall, 2012).

Furthermore, designers use artifacts and objects as tool to assist in the different activities of design process and not only in studying the users' needs. Dittrich (2018) explains the uses of artifacts in:

- Helping as a memory aid, to make things concrete and clear, and to check if the assumptions made were accurate i.e. sketches, plans, drawings, fast prototyping.
- Communicate: the use of artifacts to make thoughts accessible and understandable by others (Simeone et al. 2017).
- Communication objects: vocabulary and interactions can cause boundaries in communication within the process. Artifacts and objects are an international language; using them as a tool for multidisciplinary communication has been effective in the increasing multidisciplinary interactions.
- Proof: the use of visual representations and artifacts in the form of drawings, plans, sketches to explain the reasoning behind the developed designs. Showing the design and development process can offer the rigour needed to support decisions.

It is unrealistic to deny how artifacts embody and assist in transferring value between the stakeholders involved in a design process. Beyond simply representing a final output, artifacts are imbedded in every stage of a process, transferring and translating knowledge, experience, emotions and science in an iterative process, leading to the final output.

### **2.4.3 DOCUMENTATION**

What is emerging across the previous sections of this literature review, is that there

needs to be effective ways of recording and sharing information in order for this information to be turned into knowledge.

Knowledge management in organizations, and the preservation of knowledge and information assist in learning from previous experiences (Navidi et al. 2017), reduce the loss of information and facilitate access to data and information (Al-Hawamdeh, 2002), and improve the quality of future projects by learning from previous mistakes (Parrin et al., 2004,). Moreover, learning from previous experiences while managing information and knowledge acquired throughout different projects, can be useful to improve processes or find the right methods to use. It has been argued that the ability of an organization to share accumulated knowledge can be an indicator of the number and success of future outputs (Smith et al., 2005).

Documentation processes of different structures such as facts documentation, lessons learned, and after-action reviews are already being used and proven effectiveness in some industries such as nursing and software engineering (Munyisia et al, 2011; Falessi, 2006; Tang et al, 2005), space and military sciences (NASA and US department of defense). Accumulating systematically organized data and information help building a critical sample of information to reflect on and share it.

To accumulate necessary technical data and information, designers and design organizations have also used documentation. In practice, many approaches have been put in place to evaluate new products and projects (ISO, Health Technology Assessment (HTA). As such, documentation is essential to maintain and preserve necessary data to report and prove compliance with such regulatory, health and safety audit systems.

Designers have the capability to filter through accumulated experiences and recognize where a current situation fits, if it does, within other previous similar experiences (Cross, 2004; Lawson, 2004; Thomas & Carroll, 1979). Meanwhile, documenting and reflecting on these processes and finding a pattern, can help designers reach a higher effectiveness in achieving the needed results, which has been previously tested in software design (Falessi, 2006). Furthermore, balanced scorecards, a strategy performance management tool, have been applied as a measure of impact and successful execution of university-industry collaborations (Al-Ashaab et al., 2011).

Regardless of the high importance of documentation in managing and sharing knowledge, not all recorded design cases need to be completely rigorous to have good and high value for design knowledge (Boling & Smith, 2009), however this does not imply that rigour is not needed, yet that it is not the main defining criteria of every recorded case (Boling, 2010). Although some have argued that over-detailed environmental information, and data from previous models or comparative products can affect the creativity of designers (Collado-Ruiz & Ostad-Ahmad-Ghorabi, 2010), recording design projects as precedent cases can assist in the learning and development of designers' expertise and communication across disciplines (Boling, 2010).

Gaver and Bowers (2012) argue that the relationship between theory and design practice can vary, sometimes the products and design processes can be of value to the research communities. This led them to question where design practice can be a form of research, since In an attempt to generalize and conceptualize some design practices, Gaver and Bowers (2012) suggested a method called 'annotated portfolios'. Annotating portfolios suggests adding statements about the thought process and decisions surrounding the output, on a sketch, image or plan of the product. Annotated portfolios respect the specifics of a design, yet offer the extra information needed to try and replicate a process, design tool, or inform future work. Adding the necessary remarks or annotations will illustrate the link between existing research issues and how these issues were approached in the specific artifact. The annotation will give information about the design itself, and suggest potential patterns between multiple outputs. While this method highlights issues that might be relevant to other designers, help in tracking previous designs, and suggest potential solutions, it does not offer the rigour needed to generalize concepts and support theory construction that characterize research by definition.

Literature on documentation in many industries tackles the need for documentation to improve process, limit information loss, and managerial tracking and execution (Falessi, 2006; Al-Ashaab et al., 2011). However, documentation has rarely been implemented in a way that makes knowledge exchange explicit (Boling, 2010). Documentation to assist in knowledge and technology transfer, and consequently knowledge creation in commercial projects within an academic context needs further investigation.



#### **2.4.4 MANAGING KNOWLEDGE EXCHANGE IN DESIGN**

In order to achieve an efficient level of knowledge exchange and potential knowledge creation within a collaborative commercial process, it is essential to understand both the organization within which this process is taking place (in this case design consultancy) as well as understand the design management process.

When companies are trying to find the best approach to get good results, there has to be a clear set of objectives and a structure that serves its corporate goals. The concept of the “right” available process hardly exists and off the counter processes are not available. Organizations are better off implementing dynamic processes and interventions to always respond to any changes in the stakeholders’ needs or the general context (Barnes, Pashby and Gibbons, 2002; Højberg et al., 2017). In order to create competitive advantage, it is important to integrate capabilities in a dynamic way that would conform to any changes that occur on strategic or process levels. This integration is an investment by growing and developing the capabilities in a way that will enhance the product development process and nurture future projects (Marsh and Stock, 2003).

The NPD process activities that promote success are linked to design management. Since the level of the product’s success is linked to certain NPD activities, the viability of a business is heavily dependent on the NPD process. The increase in the importance of soft skills throughout the years has shifted the focus of the NPD success from executive activities (related to the set of physical activities in developing a new product) to a process that has more focus on supporting executive activities (managerial activities that are more involved in the structure and the way a project is managed), and eventually to a combination of both (Hesslmann et al, 2012). The design process involves a set of interaction, development and exchange activities that define the quality and type of the resulting outcome. There is a continuous attempt in trying to find out these activities that can result in the best quality products that suit different organizations and companies in different fields. The use of knowledge, processes, or sometimes designs that previously proved to be successful or unsuccessful makes current products more likely to be successful (Marsh and Stock, 2003). This not only applies to the technical side of the design process, but it also applies to the managerial capabilities; using certain managerial practices that proved resourceful and successful in previous projects can reduce the risk of failure if used again (Marsh and Stock, 2003; Boling, 2010).

The effect of higher management's involvement and consistency, on the success of the company as a whole in the market is an important aspect of the design process (Homburg and Pflesser, 2000): making information accessible and communicating with colleagues even from different functions is highly valuable. As well as keeping track of the strategic objectives through the understanding of the NPD process and its expected outputs, senior management is expected to provide support and empowerment to people and teams working on projects to achieve a successful performance (Clark and Fujimoto, 1990). Senior management is also expected to be engaged in the design process of the product and keep score of the results achieved by the product after the launch (Cooper et al; 2004b; O' Donell & Boyle, 2008; Schein; 2004). Furthermore, in collaborative industries such as design and innovation related ones, bottom-up management is common and engaging employees in the informed decision-making process and change implementation is a necessity (Thomas and McGarry, 1994).

Managing knowledge and its exchange is therefore an inevitable part of managing the design process. As part of Knowledge Transfer Partnerships (KTPs) in SMEs - which form around 99.9% of total businesses in the UK (Ward & Rhodes, 2014) - allocating an in-house designer in a design consultancy showed three crucial factors in the success of the project: the SME's deep customer knowledge, combined with the consultancy's technical and theoretical knowledge of the field the SME operates in, and the logistically facilitated exchange of that knowledge (Millward et al., 2006). Moreover Cooper and Kleindschmidt, (1995b) found that a clear and well-communicated new product strategy; a strong product definition, and the continuous connection between the stakeholders, all helped in a solid performance and a faster and efficient NPD process. These were also essential factors to keep the synergy between the requirement of the industry and the process implemented by the consultancy.

Moreover, the people element can be a main discriminator between best and worst performers (Cooper et al., 2004a). Culture climate and its support for innovation and entrepreneurship play a role in projects' success. The willingness of the management to reward and recognize members who do make a difference in the organization in order to encourage the innovation help in cultivating productivity and successful product development. (Cooper and Kleindschmidt, 1995a). The idea of separate departments and different functions or what looks like 'assembly line' forms of managing teams has been

linked to low performances; overlooking the importance that these different departments' knowledge have on each other and on the success of the organization can be damaging (Kelley & Littmann, 2001). As such effective communication is a critical criterion for the success of collaborative work (Barnes, Pashby and Gibbons, 2002; Thomas et al., 1998). Open communication among all members stimulates creativity and helps develop the knowledge on an organization level. Communicating knowledge and information across different functions and externally can help in developing capabilities and insure successful projects and consequently products. However, some of the very critical value that needs to be shared is tacit, and in it lays the difficulty of sharing knowledge.

## 2.5. ASSESSING ENTREPRENEURIAL UNIVERSITIES' OUTPUTS

The evolution of the entrepreneurial university has driven its role, and three-strand mission understood under the triple helix model: developing excellent industry-relevant teaching, generating relevant and socio-economically impactful research, and transferring learning to industry. The incentivization of these roles through policy and governmental interventions means that the outcomes of these policies, and their resulting outputs need to be measurable.

As one of the core roles of universities, teaching performance is assessed through the Teaching Excellence Framework (TEF). In 2020 the TEF will also be used to determine whether universities funded by the state will be allowed to raise their tuition fees (Adams, 2016; Morgan, 2016). TEF includes measures relating to:

- “The teaching quality”: measured by the “student engagement, valuing teaching, rigour and stretch (course design and assessment), and feedback from students and how it is used for improvements” (Department of Education, 2017, p. 25)
- “The learning environment”: measured by the “available and implemented resources, research, scholarships and professional practice, and personalized learning” (Department of Education, 2017, p. 25).
- The “students’ outcome and learning gains”: measured by “employment and further study, transferrable skills and employability and positive outcomes” for all (Department of Education, 2017, p. 26). “Positive outcomes are achieved by its

students from all backgrounds, in particular those from disadvantaged backgrounds or those who are at greater risk of not achieving positive outcomes” (Department of Education, 2017, p. 26).

In assessing another aspect of the entrepreneurial university’s mission, the UK’s Industrial Strategy has recently proposed a framework to assess knowledge and technology transfer activities (Research England, 2019). The Knowledge Exchange Framework (KEF) proposes to measure knowledge transfer performance and university-industry interactions in order to increase the effectiveness of funding distributions. The knowledge exchange evaluation does not have a fixed set of criteria yet. Efforts to develop an assessment framework to compare HEIs based on their knowledge exchange activities are in place. A report addressed to Research England suggests clustering universities based on three criteria: “existing knowledge base, knowledge generation, and physical assets” (Ulrichsen, 2018. p.18) in order to efficiently and fairly compare their knowledge exchange activities. Research England’s call for further consultation to set up criteria for the framework has been launched earlier in March 2019.

As for one of the core university roles, the quality of research produced by higher education institutions highly informs the ranking as well as the funding HEIs receive from the government and private funding parties. As such REF has been put in place to assess the quality of research, and more recently, its impact nationally and internationally.

### **2.5.1 RESEARCH EXCELLENCE FRAMEWORK**

REF, formerly known as the Research Assessment Exercise (RAE), started in 1986. REF’s aim is to establish a common and standardized assessment process for research in academic institutions, to be used as a reference for national funds distributions (“What is REF”, n.d.). REF results also contribute to the distribution of the national research funds, provide evidence for governments in setting national research priorities, and show the outcomes of public investment into research. Informed by the REF results on research quality, the capacity and cost of research in different areas, and the policy priorities, funding bodies distribute the quality-related research (QR) funding supplied by the

government, between UK research and higher education institutions (Jump, 2013; Research England, 2019).

The REF relies on expert review; expert panels are appointed based on different disciplines by the four main funding bodies in the UK (REF, 2019 a). The panels assess the HEIs outputs submitted to 34 units of assessments (UoA). Each subpanel of experts is responsible of one UoA, and all the subpanels work under the guidance of four main panels (REF, 2019 a).

Subpanels evaluate submissions based on three criteria: output, impact, and environment. Outputs resulting from knowledge creation activities go through assessment cycles to evaluate their research quality and its effect on the discipline's research body. More recently the increasing focus on the universities' relevance and impact on their environment has led to the introduction of impact case studies assessment as part of this assessment process (Watermeyer, 2014).

Outputs: can include traditional and non-traditional research outputs, and the panels evaluate the research quality of the output based on originality, rigour and significance with regards to international research quality standards, and this forms 60% of the outcome.

Impact and environment form respectively 25% and 15% of the final outcome. Impact and environment are related to the practical implications of the submission on the socio-economic context and "the vitality and sustainability of the wider discipline or research base" (REF, 2019 a, p.9).

The focus in this research is not the teaching capacity or knowledge exchange efficiency within university-industry collaboration, rather it is aiming at evaluating commercial outputs as research outputs; capturing any existing research value within university-industry commercial outputs, therefore the rest of this section will focus on the REF and its criteria.

The new knowledge capacity of some types of university-industry collaborations (joint research) has been investigated (Hermans and Castiaux, 2006). However collaborative research outputs fall under traditional research while commercial outputs (artifacts) resulting from university-industry collaborations such as consulting, spin-outs, and patenting fall under the description of non-traditional outputs. They are the embodiment

of knowledge and technology exchange activities and represent the input of universities in the industry-university collaborations. Although different types of artifacts have been submitted to the REF for their research quality to be assessed, little attention has been given to the assessment of commercial outputs' research quality. Considering the potential socioeconomic impact and how commercial outputs could inform practice and potentially research, there is a high chance that these outputs withhold new knowledge. As such investigation into commercial outputs' research value is lacking, and more focus on how they could be assessed is needed.

The UK's Research Excellence Framework (REF) is the base of research quality assessment. Universities may use the REF results to inform their resource allocation policies, and set a benchmark for research quality on a national level and international scale. Meanwhile, the REF criteria assist individual institutions' internal management of their research quality and its administration, as well as increasing the quality and breadth of internal collaboration on research (HEFCE, 2015; Ratcliffe, 2014; Stern, 2016). As such, REF continues to be one important source of funding and quality assessor for HEIs. The REF's weight is on the quality of the research output, and research 'excellence' - evaluated based on three main criteria: originality, significance and rigour (REF, 2018 a) - is rewarded wherever it is found (Stern, 2016).

The REF guidance for submissions' list clearly reflects the eligibility of commercial artifacts as research outputs stating that research includes "work of direct relevance to the needs of commerce, industry, culture, society, and to the public and voluntary sectors [...] the invention and generation of [...] artifacts including design, where these lead to new or substantially improved insights; and the use of existing knowledge in experimental development to produce new or substantially improved materials, devices, products and processes, including design" (REF, 2019 a, p. 90).

The Stern Review (2016), an independent review commissioned by the minister of Universities and Science, to investigate the importance of REF and the problems and issues it faces, placed a strong emphasis on the impact of research on innovation, and the importance of research in driving the economy. Furthermore, the report highlighted the role of interdisciplinary collaboration (a major criteria of university-industry collaborations) as a more prevalent type of research, and the importance of considering

its impact on how the assessment exercise should be carried. The Stern report (2016) also highlighted the importance of applied research as actual research outputs including “Applied, practice based and policy-based research equally, as well as not-yet-applied research outputs.” (Stern, 2016 p.44).

Commercial outputs (i.e. commercial designs, artifacts, strategic set of decisions...) are gaining more focus with the increase in patent applications resulting from UK’s university-industry collaborations (OECD, 2019). The KEF could eventually use these outputs as criteria and representation of knowledge spillover, and therefore an indication of effective knowledge exchange. However, the research quality these outputs embody is not particularly gaining focus. Therefore, it is becoming increasingly important to focus on the research value of commercial outputs resulting from industry-university collaborations and that they are appropriately represented within the REF to attract enough funding and support, measure the impact of these collaborations, and contribute to the universities’ research power.

The HEFCE (2015) report highlighted the negative effects that the REF process could have on the institutions going through the assessment cycle. These difficulties include aspects such as the burdening cost on institutions (time and money), the divisive aspect of staff selection, the difficulties of internally judging what outputs to submit and the general complexity of the framework and the subjectivity of the process (HEFCE, 2015). These negative implications of the REF have driven HEIs to increasingly scrutinize research outputs, and, more specifically, non-traditional outputs. This scrutiny is due to difficulties in clearly reflecting the research value based on which their quality is assessed (Adams and MsCougall, 2015). As opposed to traditional research outputs, non-traditional outputs hold more abstract value and tacit knowledge, and do not necessarily explicitly reflect the research quality in terms of contribution to knowledge, methodologies, and impact on research or practice, etcetera. As such, it could be argued that the scrutiny placed on these non-traditional submissions may potentially result in a lower number of commercial outputs submitted to the REF, and consequently push universities towards reducing the amount of research funding dedicated to this type of outputs.

In order to maintain support for university-industry collaborations, which result in non-traditional outputs, there is a need to recognize whether or not their outputs hold any research value. While the literature recognizes the impact and research value existing in

some non-traditional outputs (Stern, 2016), and the knowledge embodied in artifacts (Bofylatos and Spyrou, 2017), it is still relatively easier to apply the quality assessment criteria (originality, rigour and significance) to traditional outputs.

The REF 2019 guidelines introduced a change in the assessment of impact; the definition and its emphasis, as well as a major change in who will be eligible for submission. REF 2020 will require the submission of all staff who have significant responsibility for research. The eligibility is of staff members whose “primary employment function” based on their contracts, “is to undertake either ‘research only’ or ‘teaching and research’” (REF2019a, 29). In contexts where staff members do not meet this definition, the HEI will have to create and implement a process to determine staff members who have “significant responsibility for research”, and will later have to follow these guidelines to assess any eligibility for submissions (REF 2019a).

The guidance developed and followed by the HEI should be consistent with what is expected of the staff rather than specific cases of outputs of research value. These processes should take into consideration the practices variations “based on disciplinary norms (for example, close working with industry), rather than purely local differences in practice.” (REF 2019a, p35). All the guidance and criteria 1) should be developed based on a thorough collaboration with academic staff, 2) should take into consideration the context of the field and its practices, 3) could be used to assess responsibility for research of all academic staff.

In terms of impact assessment in REF2020, Impact makes up 25% of the assessment process, in comparison to the 20% weighing it received in REF 2014. Furthermore, impact case studies do not get transferred between institutions. Impact stays within the HEI where the staff member/s have carried the relevant research. This means that if a staff member were to be recruited by a new HEI, the former institution would submit the impact case study.

Additionally, in REF 2020, Impact within the HEI where the research has been conducted is as relevant as the research’s impact beyond the institution.

#### *2.5.1.1 Research excellence in commercial outputs*



The evolution of potential REF submissions due to increasing variation in the nature of research outputs, particularly those which represent Mode 2 knowledge creation, and the need to create and transfer further knowledge resulting from university-industry collaborations, have had an impact on the potential opportunities and sources of new knowledge, and consequently new research.

One aspect that characterizes commercial outputs developed in an academic context is their multidisciplinary nature (Adams and McDougall, 2015). The REF committee did take into consideration many recommendations listed in the Stern review (2016), most notably the multidisciplinary aspect of the submissions and how the panels will deal with this matter. This has become more important in recent years due to the emergence of more applied forms of research (Mode 2). The access to multidisciplinary research as is a main motivation for industry to engage in university-industry collaborations (Ankrah and Al Tabbaa, 2016) puts multidisciplinary research at the core of university-industry collaborations. This, alongside the panels' need for academic and practical experience when it comes to assessing commercial outputs, poses some limitations for REF assessment panels, where there may not be appropriate skills and expertise within a single panel to assess the quality of a cross-disciplinary research outputs (Wilsdon et al., 2015, Stern, 2016).

According to the criteria in the (REF, 2018 a), the sub-panel acknowledge the interdisciplinary and multi-disciplinary nature of research, and its blurring boundaries. As a result, the sub-panels will accept submissions that could be equally submitted to other sub-panels and when necessary, "...expertise will be augmented by additional assessors, or work will be cross-referred to relevant panels." (REF 2018 b, p. 30).

Furthermore, according to Calmorin and Calmorin (2007), to demonstrate research excellence a process must feature specific research characteristics:

- Empirical; based on direct experiences and observations of people involved in the process
- Analytical and logical, following on valid procedures proven to be credible
- Cyclical, the process starts with problem or gap to be solved, and ends with new knowledge and opportunities for further knowledge creation
- Methodical; the process showcases systematic procedures and uses credible data
- Replicable; the process is reliable enough to lead to similar results if repeated in similar contexts

To assess research quality, the REF process relies on three main criteria: originality, significance and rigour (further discussed in section 2.5.2) that imbed the abovementioned characteristics. For a commercial output to demonstrate research value of excellent quality, it has to evidence a research process and some degree of originality, significance and rigour. Moreover, the commercial stakeholder must be willing to share evidence. The discipline must also provide some evidence of the output's broader impact (Thelwall and Kousha, 2015). Assessing a commercial output is thus a complex process affected by the tensions in applying the three criteria (originality, rigour and significance) to these outputs.

Having the same criteria for all non-traditional outputs and the lack of distinction between different types of non-traditional outputs e.g. design, performance, painting as opposed to books, chapters in books, policy (which offer enough capacity to explicitly communicate a level of originality, rigour and significance) is a major obstacle in the assessment of commercial submissions. It is harder for universities or research institutions to identify quality research in non-traditional outputs, driving the high scrutiny and risk avoidance when it comes to REF submissions (Adams and McDougall, 2016; Stern, 2016). To tackle this obstacle, some criteria could be used in assessing certain types of outputs such as books and publications; these same criteria however, are not applicable in other categories of non-traditional outputs (designs, performances, paintings). Libraries, for instance, use statistics on the number of demands and orders of copies of their papers as an indicator to assess the level of usage or impact (Cooper & McGregor, 1994). Moreover, a positive correlation has been shown between journal use in a library with citation count and impact (Tsay, 1998). Publishers' esteem is another indicator mentioned as a measure for the quality of books and publications; however, the difference between types of publishers, the "poorly-designed indicators – such as journal impact factors (JIFs)" (Wilsdon, et al, 2015, p.3), and the subjective nature of their assessment can cause problems in assessment.

The issue of unreliability and bias in using criteria that do not focus on the output itself and rather use the source's esteem has been a common concern. This same issue has been raised in the REF review process where some fear that the journal and academics' esteems are taken into consideration, even though it is clearly stated that the journal impact factor and the hierarchy of the journal will not be taken into consideration when assessing an output (REF 2018 b, REF, 2019 b).

Wilsdon et al. (2015) also discuss the possibility of using criteria such as sales numbers in non-traditional outputs such as commercial products, and the risk of using such indicators due to the lack of benchmark as well as the multiple factors that could hinder the level of sales e.g. marketing.

Regardless of the debate around whether the REF does in fact use these measurements as a lead to the quality of the output or not, the need to address and further clarify the criteria for non-traditional and more specifically commercial outputs remains a priority. In a time where the industry-university collaborations are increasing, the attempt to assess their research quality is needed.

The REF measures the quality of research by identifying the level of influence the research output has on its field and its position as a point of reference. The quality of the submission is decided by judging the research activity based on how closely it meets the definition of each starred level (REF, 2019a). The quality measures indicate that for an output to be classified as a research output, it has to feature originality, rigour, and significance, and for these criteria to at least meet the minimum requirements (1\*) to be nationally recognized up to 4\* to be considered as world leading.

This research focuses on PDR, and the potential commercial design artifacts submissions as research outputs. This category falls under the outputs' submission category for the UOA 32: Art and Design: History, Practice and Theory. Main Panel D is the panel responsible of the Arts and humanities (including Design), therefore the one relevant to this research. Below are the level definitions and the different star rating criteria by Main panel D, representing the way the research quality is evaluated. The definitions and ratings are organized in in a table form (table 2.2) for ease of comparison.

	<b>Position as a Point of Reference</b>	<b>Level of Influence</b>	<b>Role in thinking, practices, paradigms, policies or audiences</b>	<b>Effect on the Range and the Depth of Research and its Application</b>	<b>Level of Novelty, Innovation and/or Creativity</b>
<b>Four stars</b>	Primary/ Essential	Profound	Instrumental	Major expansion	Outstandingly
<b>Three stars</b>	Important	Considerable	Catalyst for, or important contribution	Significant expansion	Significant
<b>Two stars</b>	Recognised	Some	Incremental and cumulative advancement	Useful contribution	
<b>One star</b>		Useful contribution	Based on existing traditions of thinking,		

		of minor influence	methodology and/or creative practice		
<b>Unclassified</b>	Below the quality threshold for one star; or does not meet the definition of research used for the REF.				

Table 2.2 REF's five quality measures

### 2.5.2 ORIGINALITY, SIGNIFICANCE AND RIGOUR

The REF definition of research (section 1.3) can be broken down into three sections: 'a process of investigation', 'leading to new insights', and 'effectively shared' (Adams, 2013). For an output to lead to new insights it must be able to demonstrate originality, significance and rigour when situated in the research discourse that underpins it (Adams, 2013). The output has to undergo a rigorous and methodological process, resulting in an innovative output. Furthermore, the output can have the potential for significance but without publication or being shared with the relevant recipients, then it is not realized and justified by peers, defying the purpose of research and discovery; "the ultimate test of a scientific theory is whether it was accepted by the relevant community of scientists" (Kuhn, 1962 in Bofylatos and Spyrou; 2017, p.10).

Until today, the REF evaluation relies on peer-review based on the three criteria: originality, significance and rigour. The REF panel listed the definitions of the three main criteria that outputs will be judged against: originality, significance and rigour.

#### ***Originality***

Originality is defined as "the extent to which the output makes an important and innovative contribution to understanding and knowledge in the field. It may do one or more of the following: produce new empirical findings or material; engage with new and/or complex problems; develop innovative research methods, methodologies and analytical techniques; show imaginative scope; provide new arguments, formal innovations, interpretations and/or insights; collect and engage with novel types of data; and/or advance theory or the analysis of doctrine, policy or practice, and new forms of expression." (Research Excellence Framework, 2019b, p.34).

The increasing attention to non-traditional research outputs, and focus on university-industry collaborations leading to innovation that serves the economy and society

specifically ones resulting from industry-university collaborations (Wilsdon, 2015; Stern, 2016), highlights the strong link between research and innovation.

As defined by Fagerberg (2004, p.3); "...Invention is the first occurrence of an idea for a new product or process while innovation is the first attempt to carry it out into practice." Innovation is taking an invention and adapting, implementing, changing it and introducing the concept of use through production, marketing and distribution to it, where it adds economic value to the company (Garcia and Calantone, 2002). Therefore, innovation is directly linked to the concept of use or practical impact, regardless of the depth or magnitude of this impact.

The nature of innovation has long been under debate. It is commonly classified as being one of radical or incremental. A radical innovation is one that can be shown to have a substantial impact on the activity within, and economic performance, of a market. whereas, incremental innovation is the significant enhancement of a market, based on its existing activity. Schumpeter (1942) described radical innovation as leading to major, disruptive changes, whilst incremental innovations continuously advance the process of change. Both have the potential to advance research fields (Henderson and Clark, 1990; Fleming, 2001; Poel, 2003).

There is a tendency to link major breakthroughs to radical innovation and ideas that see over previous existing knowledge and make previous knowledge obsolete (Johnson, 2010), and to link economic benefits to disruptive innovation. Kasmire et al (2012) argue that radical and impactful ideas come from small obvious steps rather than a genius moment of unprecedented origins, and that incremental innovation is therefore as impactful and original as what is traditionally understood as the "epiphany"-resulting radical innovations. Meanwhile, Norman and Verganti (2014) argue that radical innovations bring new meaning or new technologies which creates potential for major changes, and incremental innovations capture the value of this potential. Disruptive innovation alone might not directly lead to economic impact; incremental changes are often needed in order to translate and improve the performance characteristic of a disruptive invention to have an economic or social impact (Globberman and Lybecker, 2014; Norman and Verganti, 2014). While the argument on the source of innovation differs, the decision on what is innovative seems to be reliant on the output's results and

impact on future developments of science and research, because it is easier to observe and measure (Dahlin, Behrens, 2005; Kelly, 2010; Koberg, 2003; Schoenmakers, 2010;).

Norman and Verganti (2014) believe that radical innovation is a result of an epiphany, and that the relationship between research for discovery/ understanding, and radical innovation is limited. They do not extend this theory to incremental innovation (Section 2.3.2). Therefore a further exploration of the potential new knowledge and learning, which can result from processes leading to incremental innovation, is needed.

### ***Significance***

Significance is defined as “the extent to which the work has influenced, or has the capacity to influence, knowledge and scholarly thought, or the development and understanding of policy and/or practice.” (REF, 2019b, p. 35). Research significance can be split into two aspects: academic significance and significance of research in a practical sense (Adam, 2013). While the term significance in its REF definition is linked more to the research value of the output, the practical significance or ‘impact’ is the output’s influence on a practical level (i.e. the economy, environment, society, policy, public sector, and in a commercial context).

It is essential to consider practical impact when it comes to assessing the significance of research quality of an outputs resulting from university-industry collaboration. Impact has its own category in the REF evaluation process, and the distinction between research significance and impact, has been made (Adams, 2013, REF, 2019). However, The primary mission of collaborations is to make a socio-economic impact. Since the definition of significant output as one that influences practice (REF, 2019b), then the practical implications of outputs are relevant to their significance.

In order to assess non-traditional outputs’ academic significance it is useful to understand the impact and its audience and span, and consequently consider the sources and affected areas of this impact; all of which are elements of potential value creation and sources for new knowledge creation.

### ***Rigour***

Rigorous outputs are defined as outputs that “demonstrate intellectual coherence and integrity, and adopt robust and appropriate concepts, analysis, theories and methodologies.” (REF, 2019b, p. 35).

Rigour is recognized in traditional research processes as the systematic and appropriate creation and analysis of data to generate robust findings. There is therefore a direct link between rigour and the methods adopted during the process. When it comes to interdisciplinary outputs, there must be a significant interaction between different disciplines or application of research approaches from one discipline to another (REF, 2019b). Therefore, the interaction and application of methods from one discipline to another have an impact on the level of rigour; highlighting the value of inputs from each stakeholder or discipline on the quality of the output.

While the definition of the three main criteria used in the assessment framework is available, the granularity of these definitions and what constitutes them is lacking, specifically for non-traditional outputs. Finding practical definitions of elements constituting these three main criteria when it comes to non-traditional outputs and more specifically commercial outputs is thus needed.

The need to evaluate success of university-industry collaborations is increasing. The application of research quality criteria (originality, rigour and significance) on non-traditional outputs still causes some tension and affects the staff’s ability to capture and disseminate it. While the quantity of outputs (patents) and revenue are measures of the collaboration’s success (Autant-Bernard, 2001; Rothaermel and Thursby, 2005), the need to evaluate the knowledge creation aspect is as essential. As such there is an increasing need to assess the value carried within these outputs and the quality of this research.

Commercial outputs fall under non-traditional outputs’ description, however the motivation for their creation differs from other non-traditional outputs such as books, exhibitions, and paintings etcetera. Therefore, evaluating their research value carries further complications.

Some components and interactions that take place within an organization may hold new knowledge (Nonaka and Takeuchi, 1995) while some elements of the design process share similarities with basic research processes (Dirks, 2005). Understanding these components and how they contribute to the research criteria (originality, rigour and

significance) might assist in the ability to capture any existing new knowledge in the commercial design process, and assess its quality.

## 2.6 THE POTENTIAL FOR RESEARCH VALUE IN COMMERCIAL DESIGN.

A commercial project is successful if it used the right resources in the right time with no extra costs, and manages to deliver a product with the required functions, generating profitability, market shares and good revenues (Brown & Eisenhardt, 1995). University-industry collaboration is successful if it generates revenues and contributes to the economy's growth through the development of technologies, opportunities and knowledge. And research achieves its purpose if it leads to new insights shared with the relevant communities (REF, 2019 a).

Design has been defined in terms of goals: it is taking a course of actions to change an existing situation to a better and preferable one (Simon, 1982, Friedman, 2000). The deep understanding and translation of learned insights from stakeholders (user and client) is core to a good design. The aim goes beyond adding something new to the market, and focuses on problem solving, creating meaning, and improving practicality, even if that means making small changes to an existing design or process. Any change that occurs within an environment on a micro level is ultimately going to change the context it falls within, and therefore have a domino effect on other components of the environment. Any change made in terms of design, innovation, policy, systems or tools are going to have a bigger effect on the culture and environment, and therefore the research context surrounding it (Waldrop 1992 as cited in Friedman 2000).

Furthermore, any evolving process has to base its changes and improvements on learning from previous examples, existing knowledge and trials and errors, to create new potential. The risks, success, and viability of any project heavily rely on the existing knowledge, the iterative process and the experts' justification of the output or process based on their accumulated knowledge through documentation (Doctor et al, 2001). A good track and exchange of information is thus necessary to tighten the knowledge gap and create newer insights (Tsey et al., 2019).



With the general direction towards more collaboration between industry and university, there is an increasing need to maintain the role of higher education and research institutions as producers and disseminators of rigorous and relevant research. Research quality is a must to attract research funding. Furthermore, the collaboration between universities and industry are significantly increasing and taking multiple forms, leading to an increase in non-traditional outputs submitted to the REF. Non-traditional outputs and more specifically commercial outputs resulting from any industry-university collaboration, thus have the potential to play a role in this academic mission.

Additionally, commercial outputs resulting from any industry-university collaboration via any medium have the potential to add value to the research community. As such, an understanding of how commercial outputs fit within the value production of research, and consequently how this value can be assessed, are paramount. This concept of generating knowledge from application to feed into new research and improved application is represented in figure 2.2 below, and will be investigated under the two research questions:

**Research Question 1:** How best to recognize where commercial outputs can be characterized as research?

**Research Question 2:** Where a research characterization is met, how best to recognize and describe the research quality?

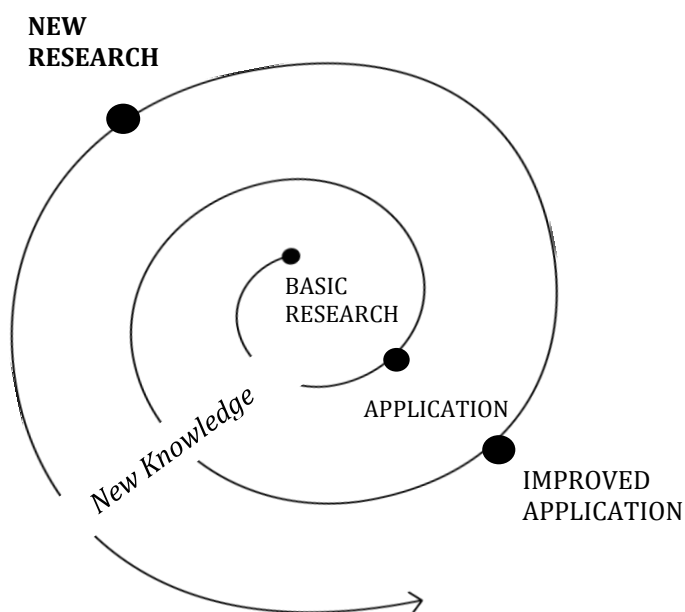


Figure 2.3 Representation of the knowledge production resulting from application and leading to further research

### **3 RESEARCH DESIGN**

This chapter begins with an explanation of the research perspective in terms of ontology and epistemology. It then discusses the research approach; strategy and data collection methods used, and discusses the coding and analysis processes carried out. The chapter will end with the ethical considerations of this research.

#### **3.1 SOCIAL SCIENCE RESEARCH PERSPECTIVES: ONTOLOGICAL AND EPISTEMOLOGICAL ASSUMPTIONS FOR THIS STUDY**

This thesis aims to explore ways of identifying where research value might exist within commercial projects and artifacts, and to try and identify approaches to assess the quality of discovered research and communicate the resulting knowledge. In order to achieve this aim, it is important to understand university-industry collaborations from the worldviews of academics, industrialists and other stakeholders. This suggests that a constructivist approach should be adopted. Constructivism is an ontological position where the meaning of social phenomena is reliant on the social actors. Their meanings are not static, but are created by both what we see and what we think of it (Charmaz, 2006).

Gray (2014) stated that physical artifacts and information exist within individuals' interpretation of their environment, which affects the meaning and significance of those surroundings. Even when it comes to the same phenomenon, individuals construct their understanding of their surroundings in different ways; therefore, the existence of contradictory viewpoints of the world can exist at the same time, without losing their validity. Constructivist thinking "provides a process or a context through which people can collectively clarify their problems and formulate new ways of envisioning their situations" (Stringer 1996, p.158). The nature of design, knowledge and management, and their dependence on their contexts and the stakeholders involved, means that positions and solutions are not static, and have to be flexible to the understanding and perception of the situation; there is a need for flexibility and acceptance of change in the fields of management and business research (Trunk and Shapiro, 2007).

Interpretivism is usually the theoretical perspective associated with constructivism. The importance of the professionals' opinions in how design is evaluated and analysed made it essential to carefully consider and examine each personal opinion separately, and conceptualise underlying structures and mechanisms that played a role in a research evaluation process. Achieving the aim of this research is highly dependent on different point of views, and involves a mixture of personal opinions and qualitative assessment. Thus this research study adopted an interpretive epistemological perspective. Adopting this epistemological point of view helps in focusing on understanding the world from the investigated sample's point of view, allowing the use of different methods in order to reflect multiple perspectives of the matter; a crucial aspect of a multidisciplinary research (Saunders et al. 2009).

### 3.2 RESEARCH APPROACH AND METHODOLOGICAL CHOICE

The increasing entrepreneurial role of universities alongside its research function has led to a rise in Mode 2 type research and therefore non-traditional outputs (i.e. performances, artifacts, expeditions, designs...) underpinning research excellence. This offers the potential to explain PDR's commercial projects and their function as part of the university's research agenda. To investigate the possibility of capturing research excellence within commercial projects in PDR, and where possible, the means of doing so, this research project adopted an inductive approach. An inductive approach is one where "The researcher begins with an area of study and allows the theory to emerge from the data" (Strauss and Corbin's, 1998 p. 12). A pre-conceived topic has been set as a starting point for this research. This implies that certain assumptions and decisions have been made based on a level of judgment and knowledge of the problem that requires a solution. However, even though there is a pre-set general direction and aim for this research, it did not start with a theory or hypothesis (Gary, 2014). General investigation of the stakeholders and the organizational context of PDR, has led to an understanding of the variables to suggest relationships and constructs that can potentially answer the research questions, while considering different perspectives of stakeholders to avoid bias. To achieve the objectives stated in Section 2.6, this research used in-depth qualitative research methods and analysis to answer the research questions by utilizing the conversational and situational data collected. Applying qualitative methods, helped

investigate the stakeholders' opinion on the academia-industry relationship, its resulting outputs, and the assessment criteria used to evaluate these outputs while at the same time "...mirroring or capturing the real social world" (Yanow & Schwartz-Shea, 2009). This process enabled the dissection of different components of the two fields from a professional point of view, since the evaluative process is highly reliant on stakeholders' understanding of the different components of this research; academia, commercial industry and evaluation processes.

### 3.3 RESEARCH METHOD: GROUNDED ACTION

This research study adopted a grounded action methodology. Figure 3.1 is a generic representation of GA , and figure 3.2 below is a representation of GA in relation to this research

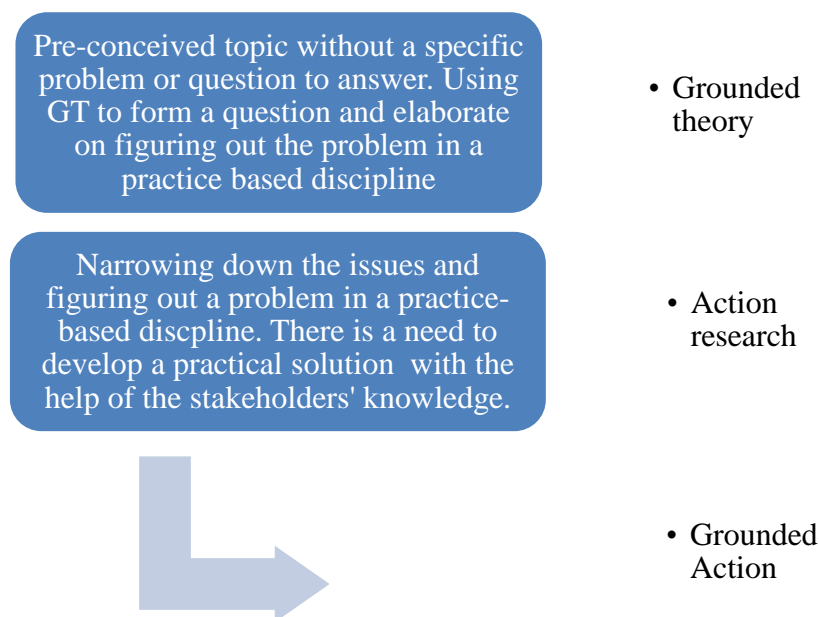


Figure 3.1 A representation of the grounded action method used in this research

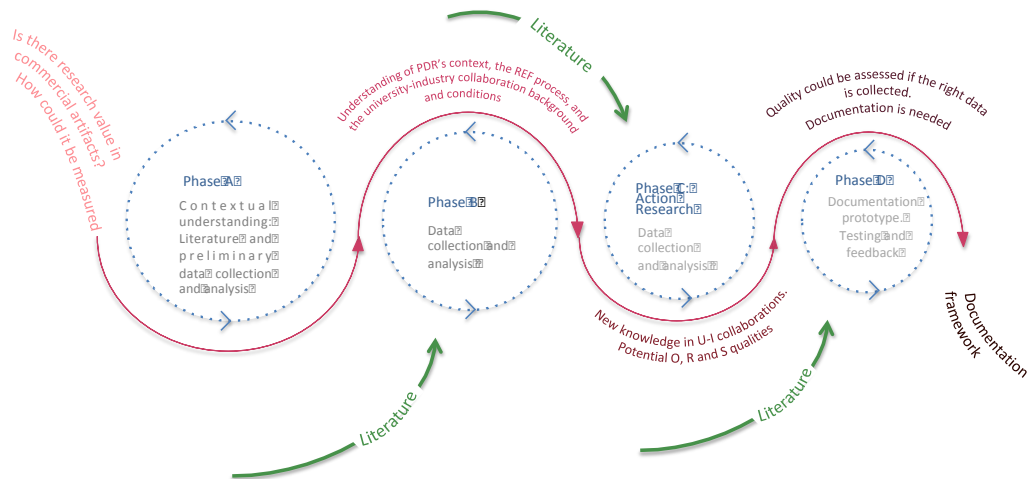


Figure 3.2 A representation of the grounded action method in relation to this research

According to Morris (2000), grounded action is a tool that offers the opportunity to study the core issues from the involved people's perspective. As such the generated understanding of the problems is as close as possible to the actual problems, and the proposed recommendations and solutions can target the core of the issue and bring more effective solutions for all the concerned stakeholders.

Grounded action is similar to grounded theory in terms of starting with few preconceptions; there are no prior problems or hypotheses formulated. There are also no ideas or concepts to make sense of the exact problem the researcher/practitioner is trying to solve before any data is collected or analysed (Simmons and Gregory, 2003). The essence of grounded action is a combination of grounded theory and action research elements. Grounded theory was used throughout the first stage of this qualitative research, which included the preliminary interviews and contextual understanding, and further down the timeline through the rigorous investigation conducted with experts, leading to the generation of concepts and categories from the data collected. These categories were then analysed and inter-linked, leading to a theoretical explanation of the concerns or gaps in this specific area and a theoretical understanding of how it could be better understood and solved. Following these stages, action research elements started to emerge. According to (Sagor, 2000), action research is:

*“... a disciplined process of inquiry conducted by and for those taking the action. The primary reason for engaging in action research is to assist the “actor” in improving and/or refining his or her actions.” (Sagor, 2000, p.3).*

After determining the initial problems or set of issues in the particular context of enterprise within a higher education institution, a more systematic data collection and analysis, leading to an explanatory theory, was developed using the grounded theory method (Charmaz, 2006; Glaser and Strauss, 1967; Simmons and Gregory, 2003). An operational theory, which provides a grounded base for an applicable plan to be implemented (Simmons and Gregory, 2003) was then generated based on that explanatory grounded theory. According to Simmons and Gregory (2003), grounded action aims at deriving understanding of a phenomenon using an inductive approach in order to create and apply practical solutions (Simmons & Gregory, 2003).

The end of Phase B (figure 3.2) of this research led to the conclusion of a possibility to tackle some of the problems faced in PDR, through a practical and viable tool to benefit from the existing potential of all the commercial work and its impact on the institution’s reputation and research excellence. Therefore, understanding the different reasons behind the lack of capitalization on this data and trying to stem a way to limit the loss of this valuable information and knowledge exchanged and created had to be done through grounded action due to the lack of readily captured records on the matter within this specific context.

Under grounded action, any solution proposed to a problem in a social system or organization, must directly reflect and deal with the complexity of the situation and the context. Failing to consider the complex system within which the research is conducted can create problems of greater magnitude than the ones we first select to solve (Simmons and Gregory, 2003). This explains the use of grounded action leading to an output that complied with the need to achieve what the research was set for, while taking into consideration the – directly and indirectly – affected stakeholders. According to Charmaz (2006), the key elements of the grounded theory are the simultaneous involvement of analysis, data collection and the development of the theory during each step of the process, and the use of sampling as a tool for theory construction rather than population representativeness. Therefore, the transcription always followed the interviews almost

immediately, which helped to further understand the context, to limit the focus in the proceeding interviews, and to guide the choice of the next interviewees.

### 3.4 RESEARCH PLAN

This section will discuss the research approach followed throughout this project, listing the undertaken steps and briefly explaining them. Figure 3.2 is a graphical representation of the steps followed during this research's timeline. Table 3.1 lists the different phases of this research and the results of each phase, leading to following one.

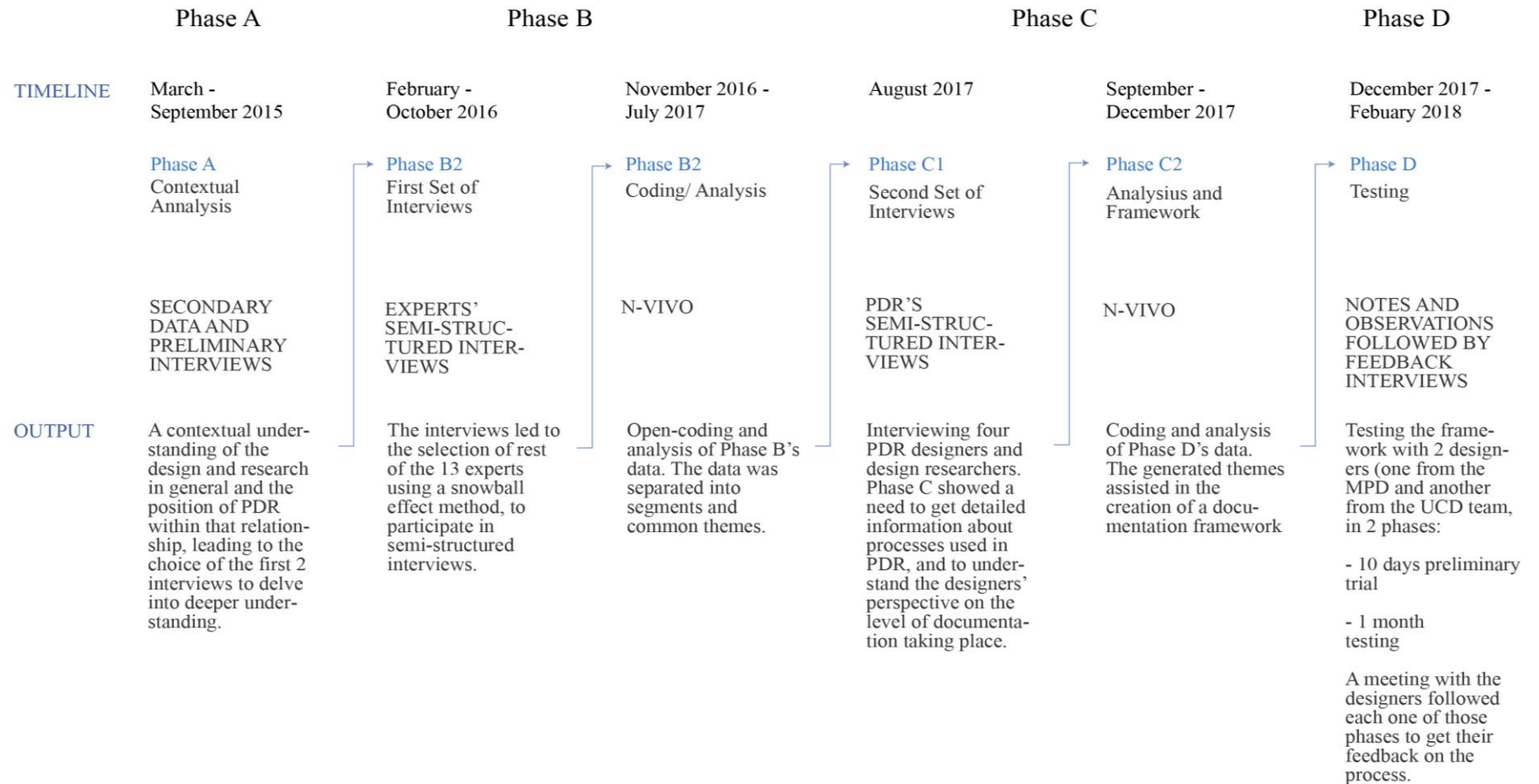


Figure 3.3 - Graphical Overview of the Research Process



Phase	Results of the phase
A	<ul style="list-style-type: none"> <li>General understanding of the available literature and context of PDR</li> </ul>
B	<ul style="list-style-type: none"> <li>Understanding of the difficulties in bridging academia and practice</li> <li>Looking at other practice-based disciplines to find a link with commercial design</li> <li>Understanding the perception of stakeholders on originality, significance and rigour.</li> <li>Concluding that the best available way to attempt at filling the information gap is to document data throughout the projects for the purpose of:               <ol style="list-style-type: none"> <li>1) Reflecting on the data,</li> <li>2) Transferring data when needed.                   <ul style="list-style-type: none"> <li>Recognising the need to understand the processes followed within PDR</li> </ul> </li> </ol> </li> </ul>
C	<ul style="list-style-type: none"> <li>Drawing a list of the elements needed in a documentation system</li> <li>Chose a software/system to help set up a prototype of that framework</li> </ul>
D	<ul style="list-style-type: none"> <li>Developing a documentation process and putting it under the test</li> <li>Observe the effectiveness of the process and receiving feedback.</li> </ul>

Table 3.1 List of the phases of the research along with the results of each phase

### 3.4.1 PHASE A: CONTEXTUAL ANALYSIS AND LITERATURE

Phase A served as a starting point to understand the contextual positioning of PDR within its academic surrounding, as well as the available literature on university-industry collaborations and the REF assessment process. Within Phase A, the main stakeholders in industry-university collaborations and their outputs were identified. This provided the opportunity to identify individuals within Cardiff Metropolitan University, PDR and the broader academic and industrial world, so that the particular situation within PDR could be investigated further.

#### **Research tools**

**Documentation review:** The process started with a general understanding of the subject through information available about the university and PDR. Available information on the role of PDR, its mission and strategies was reviewed. Similarly, data on the strategic mission of Cardiff Metropolitan University and its research objectives were analysed. Review of the REF criteria took place to build the background knowledge to lead the interviews.

**Preliminary interviews:** Preliminary interviews were conducted with designers and researchers within PDR and CMET who were or still are involved in REF process, and were

relevant to the understanding of the main challenges faced in bridging the academia/commercial design gap and the research undertaken within different departments. Their knowledge assisted in setting the ground for the next stage of this research.

**Literature review:** Review of the available literature took place to build the background knowledge to lead the research process. Strauss and Corbin (1990) suggest that rather than considering the literature review as a separate stage, they recommend engaging with it throughout all stages of the research, in order to build up the final literature review presented in Chapter 2.

### **3.4.2 PHASE B: FIRST SET OF INTERVIEWS**

This phase was formed of two parts: in Part 1, thirteen interviews were undertaken with stakeholders from university and/or industry. In Part 2, the interviews were coded and analysed.

#### ***Research Tools for Part 1***

**Semi-structured interviews (snowball sampling):** The need to understand the problem from different viewpoints and the multidisciplinary nature of design led to the choice of interviews as the main source of data for research. The focus was on qualitative in-depth data based on a smaller sample size and less structured data collection method. This meant that more structured methods such as surveys and structured interviews might not offer the flexibility required to understand different worldviews. Therefore semi-structured interviews allowed the option of delving into more details or to open the door to further understanding or focus on a specific emerging themes. This phase took place without prior knowledge, or pre-made decisions regarding all of the thirteen interviewees. This helped in avoiding the bias of interviewees and interviewer caused by pre-choosing the interviewees, which can jeopardize the data in the data collection process (Williams Jr, 1964; Williams, 1968). Semi-structured face-to-face interviews took place with thirteen experts with different perspectives on the relationship between universities, industry and research excellence (as shown in Table 3.2). Face-to-face semi-structured interviews were selected for the following reasons:

- Face-to-face interviews avoid difficulties in communication or understanding of the questions that can occur via phone calls or surveys.
- Semi-structured interviews can allow for deeper understanding of the answers and the subject matter, and allow further elaboration if needed.
- Semi-structured interviews allow the researcher to expose new lines of inquiry through open ended questions
- Semi-structured interviews allow the researcher to explain or deconstruct any question into small and clearer ones, to make it easier for the interviewees to answer.
- Face-to-face interviews avoid any misunderstandings or technical issues that could occur during phone or video calls.

**Interviewees:** The choice of a diverse group of stakeholders belonging to different, but relevant fields, was essential to get the opinion of informants who viewed this gap between industries and academic research from different viewpoints and helped validate the data (Eisenhardt and Graebner, 2007). It is important to highlight that the word industry in this thesis is not limited to manufacturing goods. Industry is used to indicate fields where practice and processes are used to generate an output (tangible or not) of practical rather than theoretical nature, and where mostly Mode 2 type of research (applied research) plays a major role in the development of such industry e.g. products, services, medical procedures, health and sports, policy development.

Thirteen Interviewees were drawn from applied academic disciplines (design, sport and exercise studies, business and management), university research and enterprise administration and Art & Design REF panel leaders (from two of the top 25 ranked art and design universities in the UK according to The Guardian's University guide 2017: league table for art (2017)). Experts from fields such as sports, business and management, arts, and design represent the applied fields, and share the common ground of using knowledge and research processes to achieve practical results underpinning non-traditional outputs. The career context of those same stakeholders: universities, research, teaching and consulting, represent the academic context of this research topic. Throughout the thesis, interviews will be referred to by the letters, accompanied by one of the following descriptions, depending on their main field of work: Academia (Aca),

Industry (Ind), Industry with academic association i.e. PhD, or research (Ind, Aca), and Academic administration (Aca, Admin).

Interviews' questions can be found in Appendix 1. Due to the variety of the interviewees' fields, and the nature of this research method, the outcome of every interview slightly altered the questions of the following one.

Fields of the Interviewees	Interviewee's Reference	Interview's Date	Reason for Selection
Design and Design research.	A: Industry 1 B: Industry 2 C: University 1	21/4/2016 3/5/2016 28/6/2016	The opinion of experts, practitioners and researchers in the design field is crucial for this research. These interviews were secured through contacts at the university department and via conferences attended. Their opinions as researchers with valuable ties to the commercial world gives a real life, practical view about the matter at hand. Their research, academic backgrounds, and current commercial work positions them in the centre between the two fields.
Surgical prosthetics and lab management.	D: Hospital	4/4/2016	Referred to by interviewee E; it was important to look at this collaboration from a practical perspective. D's collaboration with E on multiple projects, including award winnings ones, was a big motive for this interview.
Surgical prosthetics design and research.	E: Consultancy	9/2/2016	Although different in nature from commercial design, surgical and prosthetic design still shares basic themes and processes with commercial design research. This interview was based on the possibility of extracting techniques from the former to adapt them for the latter.
Arts and Arts research and REF administration.	F: University 2	30/6/2016	Art and Design shares the same unit in the REF assessment process. There is a lot in common, yet many differences that play a big role in creating glitches in the assessment process. Having an insider's point of view was important for a better-rounded perspective.
Design communications management.	G: Consultancy	3/5/2016	Getting a close look at communication basics between consultancies and current or potential clients; an important factor in bridging the two fields.
Design research and REF administration.	H: University 3	3/2/2016	H is a major role player in the REF submissions. From collecting all the necessary documentation to putting

			together a portfolio in the arts and design department, H's opinion about the process gave an insider's look at the submission process and difficulties it faces.
REF administration and funding allocation.	I: University 3	3/3/2016	A big part in a research project is research assessment, and knowing about the administration process of the submissions to UK's assessment exercise (REF).
Management research and practice.	J: University 3 K: University 3	3/6/2016 12/10/2016	The school of management, like art and design, has a great deal of work with the commercial and business world. This relationship, compared to the commercial design/design research one, can create many parallels to draw upon.
Sports research.	L: University 3 M: University 3	10/10/2016 20/9/2016	Sports education and practice are heavily reliant on theoretical work such as biomechanics and physics. The communication between practice and research is thus inevitable. Looking at this field's practices and ways of communication can lead to a transferrable set of skills or methods to the design world.

Table 3.2 List of Phase B1's Interviewees, the date, their reference used throughout the research and the research for selecting each one of them

### ***Research Tools for Part 2***

**Open-Coding and thematic analysis:** The interviews were transcribed and analysed using an open coding method. There were no preliminary set themes; first level themes emerged throughout the process. To check and confirm the validity of these themes prior to proceeding with the rest of the interviews, a triangulation process took place with two members of the supervisory team. The clusters of codes were discussed with the team, and were assigned to different themes, which were then compared to the previously assigned themes for consistency. Following the triangulation process, the coding of the remaining transcripts proceeded by assigning units of text to the existing themes that were previously agreed upon. An affinity map of themes related to barriers encountered in evaluating, evidencing and communicating research excellence in commercial projects resulted from iteratively reviewing and clustering the units of text. Figure 3.3 shows the themes resulting from the coding process.

Nodes		
Name	Sources	References
Commercial design and academia	6	45
Benefits of overlapping commercial design and academia	6	37
Evaluation Methods	3	13
Limitations	5	65
research constraints	1	5
Originality	6	49
Rigour	6	92
Significance	6	74
Communication of academia to industry	3	45
Communication of industry to academia	3	15
Design in Business	1	14
Impact Case studies (300 words criteria)	1	20
REF evaluation	3	76
Subjective judgement	3	19
Submission limitations	2	53
The understanding of non-traditional research output	1	7

Figure 3.4 Resulting themes of Phase B2 of the Coding process using the NVivo software

The analysis of the data showed a need for a deeper understanding of PDR's internal processes and for capturing the designers' opinion on the matter of research and documentation in commercial design projects.

### 3.4.3 PHASE C: SECOND SET OF INTERVIEWS

This phase is formed of two parts; 1) Interviews with four of PDR's designers and design researchers interviews and part 2) the coding and analysis of these interviews.

#### *Research Tools for Part 1*

**Semi-structured interviews:** Four semi-structured interviews were conducted with two designers and two other designers/ design researchers in PDR. A guiding script was designed, based on the outcomes of the documentation review conducted in Phase A and the interviews conducted in Phase B. The interview scripts can be found in Appendices 1 and 2.

Interviewees were selected based on the roles that they play within PDR's commercial design arm. The purpose of these interviews was to understand the internal design processes used in NPD and UCD research projects, as well as looking at the commercial

stakeholders (clients)'s perspective on the academic/industrial collaborations, and most importantly to help understand how to practically capture knowledge and daily circulating information while taking into consideration their needs within their commercial environment. The five designers and design researchers chosen were project managers and team leaders.. Table 3.3 describes the four interviewees and their roles within PDR.

Fields of the Interviewees	Interviewee's Reference	Interview's Date	Reason for Selection
Designers/ consultants	N	24/8/2017	A considerable number of PDR's projects come through the new product design department. The resulting framework of this research will be applied and used by the NPD and UCD team. The non-academic nature of the commercial work conducted by these 2 stakeholders makes their opinion and perspective on research quality valuable for this research.
	O	21/8/2017	
Designer/ researcher	P	29/8/2017	The stakeholders are both academically and commercially involved. The overlap of these two areas are heavily crucial for this research. Their point of view on the matter and the potential solutions add an insight to the development of the framework.
	Q	30/8/2017	

Table 3.3 List of Phase B1's Interviewees, the date, their reference used throughout the research and the research for selecting each one of them

### ***Research Tools for Part 2***

**Open-Coding and thematic analysis: Similar to Phase B part 2.** Interviews were transcribed and coded using Nvivo, following the method described in Section 3.4.2. Fig 3.4 shows the themes resulting from the coding process.

Nodes		
Name	Sources	References
difficulties of engaging in academia	1	6
for clients	4	16
for designers	4	34
PDR's process	3	20
decision making	3	35
REF submission	1	24
submitting to awards	1	4
value in	4	30
Benefeting stakeholders	4	30
how to capture the value	4	17
loss in not capturing that value	4	23
originality	4	26
process	4	28
product	2	9
rigour	4	29
significance	4	13
willingness to engage in academic research	1	1
from client's perspective	3	20
from designers perspective	3	28

Figure 3.5 Resulting themes of the Coding process of Phase C2 using the NVivo software

The analysis in Phase C helped in creating the list of questions and criteria that were later integrated into Phase D's documentation process.

#### 3.4.4 PHASE D: TESTING

##### *Research Tool*

The outcomes of the research conducted in Phases A – C suggested that a documentation framework might aid in the identification of research quality in commercial projects. This is described in more detail in Chapters 4 and 5.

An off-the-shelf team sharing software called Trello was chosen for the basis of the documentation framework. Trello was selected through discussion with the commercial design team, who was already familiar with it, and compared it favorably in terms of



usability to other team sharing tools they had evaluated for other applications. Due to the commercial information that might be logged throughout the testing phase, and after discussing the different options with designers who have integrated a variety of softwares in their work, Trello seemed the most suitable. Trello does not upload data, but rather creates a link to the local database. Therefore it seemed the most suitable choice. Creating Trello user accounts is extremely straightforward and free from any registration fees. The choice of this method is discussed in Chapter 7. A set of bullet points and questions were included in every step of the process to assist the users in logging the needed information.

### ***Participants***

The documentation framework was tested with the UCD and NPD managers. Due to the time limitation and the inability to engage all designers, only two of them were chosen. The managers seemed an ideal representation since they understood the typical process of a project best, and have an experience with a range of project types. Furthermore, as head of teams, they were important stakeholders to convince of the efficiency and benefit of the process. The managers also have an influence to embed such a process in the rest of the team, in a case where PDR decides to implement such process on a larger scale.

### ***Testing***

The documentation framework was tested in two stages.

#### ***Stage 1: Supervised testing***

In Stage 1, the documentation process was implemented across the current portfolio of projects the participants were involved in for one week. The participants were supervised during data entry and encouraged to adopt a think-out-loud protocol. This allowed the identification of sources of information, dynamics, the time requirements of data entry, and the ease of the process. At the end of the trial, the participants were interviewed together in order to collect feedback on the documentation process and its application. The differences between the UCD research and NPD nature of work meant that it was essential to see the differences and similarities of both experiences. Since the two

designers were monitored independently while entering the data, the feedback interview included both of them at the same time to allow them to build on each other's feedback. Findings gathered via observation of the documentation process, the quality of data collected and feedback from the participants were used to refine the documentation process prior to stage 2.

### *Stage 2: Unsupervised testing*

In Stage 2, the participants were asked to employ the documentation process for a month within their day-to-day work. No shadowing took place. Feedback from stage 1 informed an adapted version of the process.

The aim of this second stage was to have a more realistic idea whether the documentation process could easily be embedded into the daily activities of the commercial design team. At the end of the testing period, the participants were again interviewed. Analysis of the data collected was combined with feedback from the participants to inform the final version of the documentation process and to identify the strengths and weaknesses of the documentation process as a tool for supporting the identification of research and subsequent evaluation of quality.

## 3.5 RESEARCH ETHICS

Although the information and data collected during the interviews were not commercially sensitive, the nature of this research and the involvement of primary data collection and interviews required ethical approval.

Participants have been anonymised as far as possible throughout the study.

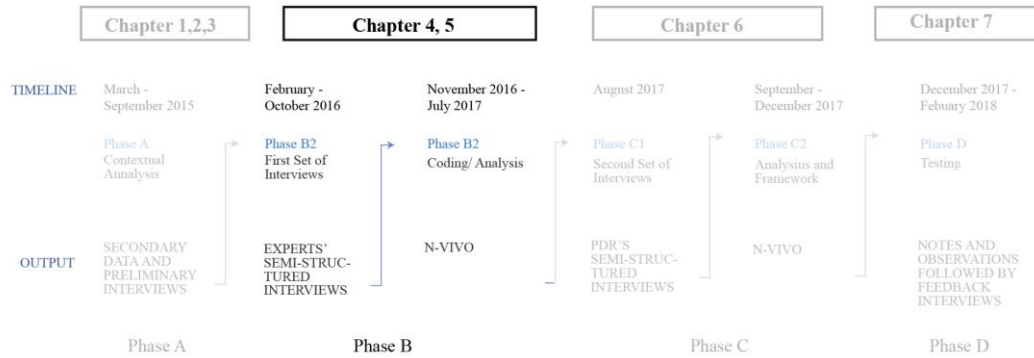
Participants were provided with an information sheet prior to participation in interviews and studies. Copies of the information sheets can be found in Appendix 3..

Ethical approval was obtained for this study via Cardiff Metropolitan University procedures. The ethics application and confirmation of approval are also provided in Appendix 3.

An ethics approval application form was developed, and approved by the Director of Studies and supervisory team. PDR reviewed the ethics approval form, and the university ethics committee then approved it.

Due to the commercial relevance of the documentation process and the time it was going to consume from the designers' working day, the consent to test the process was discussed with Jarred Evans, the Director and Commercial Manager of PDR where he granted his approval on the prototype and the length of its testing phase

## 4 EXPERTS' OPINION ON UNIVERSITY-INDUSTRY COLLABORATIONS: BENEFITS, LIMITATIONS AND COMMUNICATION



This chapter presents the first section of phase B2 of the research process; the analysis of the 13 expert interviews. The resulting data from B1 was thematically analyzed and each table in this chapter lists the themes and subthemes (sometimes clustered under subjects) discussed and analyzed in each one of the sections.

This chapter addresses the first research objective set out in this thesis:

**Better understanding the barriers and drivers of research-industry collaborations in a university context, and the elements contributing to success of these relationships.**

Dissecting this objective leads to two main elements: “industry” and “academia”; wherein interviewees were selected in a way that they could present informed opinions on one or both aspects.

The chapter begins with the benefits of collaboration between researchers and industry practitioners, and the impact could have on both parties, followed by the potential elements that could hinder the contributions they could offer to each other. The benefits and limitations are applicable to different types of university-industry collaborations; however, their relevance to PDR – the main context of this research – will be highlighted throughout the chapter. The chapter also addresses situations where research and commercial practice co-exist in the same organization and the nature of communication

in such contexts. Finally, the themes arising are discussed in the context of commercial design and PDR.

#### 4.1 BENEFITS AND LIMITATION OF THE ACADEMIA AND INDUSTRY COLLABORATIONS

Table 4.1 below presents the themes and subthemes identified under the category ‘collaboration of academic research and industry practice’. The headings represent the overarching themes identified: Benefits and limitations. Sub-themes are given in the first column under each heading. The letters in the second column identify the participants who discussed these subthemes.

Collaboration between research and industry			
Benefits		Limitations	
Commercial credibility	A, B, D, C, E, L, M	Nature of the relationship <ul style="list-style-type: none"> <li>• Trust</li> <li>• Commercial confidentiality</li> <li>• Ethical Responsibilities</li> <li>• Cost</li> <li>• Commercial risk aversion</li> <li>• Communication language</li> </ul>	C, F, G, K, L, E
Research credibility or commercial attractiveness: prizes and awards	D, E, H	Nature of the Project <ul style="list-style-type: none"> <li>• Transferability of outcomes</li> <li>• Academic or commercial relevance</li> </ul>	E, H, J, K, L, M
Knowledge transfer to support development <ul style="list-style-type: none"> <li>• Research/ teaching nexus</li> <li>• Access to academic skillsets: KTP's</li> <li>• Skills and capacity building across partners</li> <li>• Improving processes and practice</li> </ul>	A, B, D, E, G, H, J, K	Nature of the assessment process <ul style="list-style-type: none"> <li>• The importance of documentation</li> </ul>	C, F, H, K, M,
Regulations and audits	B, E		
Relevant research for Risk management: <ul style="list-style-type: none"> <li>• Access to real world activity</li> </ul>	A, B, D, E, G, H, L, M		
Sharing costs and increasing revenues <ul style="list-style-type: none"> <li>• Access to funding</li> <li>• Research as a revenue stream</li> </ul>	A, B, C, F, G, J		
Streamline and Impartiality <ul style="list-style-type: none"> <li>• Increasing bandwidth</li> </ul>	B, C, E, L		

Table 4.1 Themes and sub-themes arising from the category ‘Overlap of academic research and commercial practice’ and the interviews in which each sub-theme was discussed

#### 4.1.1 BENEFITS OF COLLABORATION BETWEEN RESEARCH AND INDUSTRY

The effect of the collaborations and knowledge exchange between academia and industries on both fields has already been discussed in Chapter 2. The interviewees also highlighted many of the themes identified within the literature review. Understanding the general benefits of collaborations helps in understanding how PDR could potentially benefit from its interactions with industries to serve its mission, and that of the university.

##### 4.1.1.1 *Commercial Credibility: Justified by the Relevant Audience*

Several interviewees discussed the role of academic research in enhancing commercial credibility. As shown in Table 4.1, the interviewees (A, B, C, D, E, L, M) who discussed commercial credibility have one aspect in common, their careers overlapped between academia and commercial practice at one point or another.

These interviewees are either researchers providing commercial consulting services, PhD graduates who started a career in industry, or researchers who have continuous interaction with industry due to the applied nature of their research. The nature of their career could be seen as the basis for their argument; they seem to use the research background as a support for their commercial interactions, claims of functionality and viability to a given commercial project. Research seemed to be recognized by interviewees in sports sciences (M and L) as a tool to inform sports practitioners

*“In sports science, there are people that are genuinely researching to solve performance problems, or to look at mechanisms of injury and risk prevention. For those people who focus on performance in the Olympics for example, this research is probably a big motivator in terms of how you try to sort of inform practice”*  
(Interviewee M – Aca)

*“There are no elite coaches or experts now that would not understand or are not expected to have information relating to some scientific aspects”* (Interviewee L - Aca)

This theme is also identified within the literature on the role of research in commercial credibility (Brundenius, Lundvall, and Sutz, 2009; Guimon and Agapitova, 2013;

Leydesdorff and Etzkowitz, 1998; Etzkowitz and Leydesdorff, 2000;) and the role of practitioners in justifying the impact of a research output (Hermans and Castiaux, 2006). This is likely to be applicable certain markets more than others. For instance, an interviewee from sports industry observed that providing proof of rigorous research is not always important for the end-user:

*“...They would also pay hundreds of millions of pounds for somebody like David Beckham to wear a pair of their trainers because they’ll earn more money from that than they would if they say these trainers reduce injury, so it’s a kind of battle” (Interviewee L - Aca)*

Scientific research to provide commercial credibility thus seems relative to the recipient of the information in the broader term. Companies that traditionally engage with universities are seeking the research and scientific evidence they could find in a university context. When it comes to PDR, clients are not all necessarily of this type.

The nature of activities taking place in PDR implies that its designers and researchers’ direct contact is primarily the client or business. These interactions are therefore informed by the clients’ technical knowledge of the industry, which PDR is collaborating with. As such, the client’s positive justification of the output: 1) can heavily impact the credibility of PDR on the long run, and 2) relies on PDR’s ability to deliver the necessary supporting evidence.

#### *4.1.1.2 Research credibility and commercial attractiveness: Awards*

The use of awards as a representation of the outputs’ quality and achievement of commercial activity is common. Similarly, academic institutions collaborating with industries in the form of consulting services, spin-outs or other forms of commercialization, seek these awards in the hope that they could raise the profile of the research establishment.

Some experts expressed their reservation regarding the objectivity, impact, and ownership of some of these design awards. Experts’ concerns surrounded the context

frequency, governing bodies, and the importance of esteem rather than quality of work, in winning the award.

One question raised by interviewees is whether these awards do actually represent the research excellence behind the output, or its impact, since in many situations the relevant output is not necessarily original and ground-breaking, but an effective one nonetheless.

*“ ... I think designers see as an affirmation of originality [...] so if a designer won an IF award or whichever award it is [...] I’m not sure who that award is for, is it for the designer? Is it for the client? Is it for both? But I think sometimes they see that as original, but is it about originality? Is the designer required to be original? Or are they required to be effective?” (Interviewee H – Aca)*

This statement coming from a researcher responsible for REF submissions reflects a concern regarding how they could benefit from any impactful or ‘award winning’ output.

Even though design awards have not been considered as highly technical assessment processes, due to the perception of their criteria and process (Self, 2014), they have been perceived as a sign of industrial success, symbolic value, and excellence in the industry (Gemser & Wijnberg, 2002; Zec, 2007). Table 4.2 below is an accumulation of the type of criteria listed in three different design awards: If design award, Red dot and Good design award. The criteria were categorized based on their nature (columns) and the perspective (rows) used in the IF award categorization of their criteria, and the criteria from the other two awards were later added under these categorizations. The criteria are taken directly from the design awards’ websites: iF World Design Guide (2019); Good Design (2019); Red Dot (2019).



	<b>Innovation and Elaboration</b>	<b>Functionality</b>	<b>Aesthetics</b>	<b>Responsibility</b>	<b>Positioning</b>	<b>Formal Quality</b>	<b>Durability</b>
<b>Human Perspective</b>	<ul style="list-style-type: none"> <li>- Attractive design that induces users' creativity</li> <li>- Uniqueness</li> </ul>	<ul style="list-style-type: none"> <li>- Usability, understandability, and friendliness</li> <li>- Ergonomics (Is the product adapted appropriately to the physical and, if necessary, psychological conditions of the user?)</li> <li>- Practicability</li> <li>- Manual explains the use</li> <li>-Self explanatory</li> </ul>	<ul style="list-style-type: none"> <li>- Aesthetic appeal</li> <li>- Emotional appeal</li> <li>- Spatial concept</li> <li>- Ambience</li> <li>- The design gains sympathy of users</li> </ul>	<ul style="list-style-type: none"> <li>- Safety and security</li> <li>- Physically weak persons are taken into consideration</li> <li>- Environment standards: carbon footprint</li> </ul>	<ul style="list-style-type: none"> <li>- User sympathy</li> <li>- Brand fit</li> <li>- Target group fit</li> <li>-Differentiation</li> <li>- Symbolic and emotional content</li> </ul>	<ul style="list-style-type: none"> <li>- Logical is the constructive structure and the congruity of the formal composition</li> <li>- How is the form related to the function?</li> </ul>	<ul style="list-style-type: none"> <li>- Maintenance</li> </ul>
<b>Industrial Perspective</b>	<ul style="list-style-type: none"> <li>- Issues solved through the use of new technology or materials and creativity</li> <li>- Contributes to the creation of new industry or business</li> <li>-Execution/ workmanship</li> <li>-Product new in itself</li> </ul>			<ul style="list-style-type: none"> <li>- Production efficiency</li> </ul>		<ul style="list-style-type: none"> <li>- Reasonably designed or planned with appropriate technology, method, and quality</li> </ul>	<ul style="list-style-type: none"> <li>- Have the product's material and non-material value been designed for a long life span?</li> </ul>
<b>Social Perspective</b>	<ul style="list-style-type: none"> <li>- Creation of new culture, such as a</li> </ul>			<ul style="list-style-type: none"> <li>- Realization of the sustainable society</li> </ul>			

	new method, lifestyle, communication  - New value, such as a new method, concept, style, etc. to society			- Social responsibility  - Universal design  - Product periphery: how is the product as part of a system integrated into the system environment?			
<b>Time Perspective</b>	- Puts past contexts and accumulated achievements to propose new value.						- Proposes a highly sustainable solution from medium- and long-term perspectives.  - Represents continual improvements in accordance with the times.

Table 4.2 Criteria from three different design awards; IF Design award, Good Design award and Red dot design award (iF World Design Guide, 2019; Good Design, 2019; Red Dot, 2019)

The importance of winning awards for a design capacity operating within an academic institution such as PDR has commercial implications. Design awards can be an indicator of impact and performance of the output itself and the institution behind it, and set a good benchmark for other institutions' performance (Ghobadian and Woo, 1996; Self, 2014).

Although the quality criteria set by these awards measure the quality of designs, they do not explicitly reflect research quality. However, the criteria listed in table 4.2, show multiple common aspects that fit within the definitions of the REF's criteria of originality, rigour and significance, and quality of process; research and output. Therefore, there is potential to explore these awards as a reflection of research credibility; the elaborate criteria of the awards are clearly stated in the public domain. Moreover, impact and practical performance also play a role in assessing research quality and academic performance (REF, 2019 a). Therefore, winning awards could also contribute to the argument of good research practice. The only limitation is that panels are mostly from industrial or practical backgrounds, and lack the academic knowledge needed to judge the rigourousness of research process.

#### *4.1.1.3 Research as supporting evidence for regulations and audits*

Interviewees from surgical and sports education fields expressed the importance of rigourous information to support regulatory requirements, and audit processes. As such, in-depth research surrounding the process and decisions made is crucial.

*"If you apply an entirely new design process and you haven't got the awareness of that underlying quality management system or the rigour that's behind that, than it might be a risk" (interviewee B – Ind, Aca)*

*"...For some areas we work in we will have to generate some sort of evidence, so within the NHS you got clear categories; if you are classified as a research project, you have to go through all the rigourous ethics procedures" (Interviewee E - Aca)*

Considering the health-related and regulatory concerns affecting such fields, the importance of following a rigid and rigourous process in building up towards the output seems evident. This could also apply to any industry where users will eventually be in direct contact with the products. PDR's design teams regularly go through health and

safety audits, and have to abide by the ISO standardization metrics and provide the necessary proof to support their practices. This shows that any available scientific support and research to back these fields' outputs is important, even compulsory, for the compliance and the viability of outputs.

#### 4.1.1.4 Knowledge Transfer to support development

The knowledge and technology transfer nature of university-industry collaborations mean that the learning process and internalization of knowledge (Hermans and Castiaux, 2006) is significant for both sides. Interviewees agreed that the interaction between researchers and practitioners in the context of consultancies, KTPs, collaborative research or research-teaching nexus; are all activities that support the transfer of skillsets and capacity building across stakeholders that can serve their development.

*"I believe that all things equal, a research active individual makes a better teacher...I get good feedback from my students on the basis that I know what I'm talking about and well prepared, so I'm up to date, I have to be in order to publish. And also, if I'm an applied researcher this is an advantage, because you have real life material, which is of a great benefit to the students" (Interviewee K - Aca)*

*"[After working for a while with a consultancy] we were capable of doing things on our own now. So we started developing our own research. And I think where we would come together is where we had a lot of commonality. I think our strengths are we can see the clinical need, I can see what we can create... and I can rely on them [the consultancy] to say ok, how can we take that forward as a design..." (Interviewee D - Ind)*

*"You tend to find that people running the projects are not necessarily designers, they may not have any real experience, so they kind of have a knowledge of this process they haven't come face to face with that role... So there are quite few challenges for them ...which is why I did research I guess" (Interviewee A – Ind, Aca)*

The quality of interaction between academics and practitioners is correlated to the level of knowledge exchange. The transfer of skills, access to data and opportunities to apply research, accumulation of real life case studies used in the teaching process discussed by interviewees, and available in the literature (Feldon et al, 2011; McLoughlin & Lee, 2008); impact both practitioners, researchers, and future graduates who are about to enter industry.

As a consultancy based in a HEI, PDR does engage in KTPs and other forms of knowledge transfer activities beyond its commercial projects. The ability to understand how to create knowledge through sourcing, translating, and transferring existing knowledge and skills, can significantly benefit all the involved stakeholders; by improving problem solving capabilities, and developing new skillsets.

#### 4.1.1.5 *More Relevant Research for better risk management*

In order to minimize risks, industries and practitioners tend to avoid trying new methods, and implementing new processes that are not extensively tested

*“say they don’t have any personal experience in using that, and that applies exactly the same in prototyping techniques as well, so then for them, it’s seen as a risk, and they want to go with what they know what’s safe, unless they had bad experiences or see the limitations of existing methods that they have historically used, then they will always be trying to deviate from something that they don’t know it works and does what they need”(Interviewee B – Ind, Aca).*

*“And you can see it all the time, you see these really great scientists coming up and saying: ‘this is the best way of developing power reducing injury at the knee, and this is how coaches should do it’, and the coach says ‘I’ve been doing this for 20 years, I don’t need you to tell me how to do my job’”(Interviewee L – Aca).*

Partnership-driven activities facilitate and organize researchers’ access to data and case studies in order to conduct relevant research. Equally, these partnerships offer opportunities to test the applicability of research in the relevant industries, where practitioners are not interested in conducting research or do not have the necessary skills to do so

*“There are people working in the industry on major projects and have no time to write up, and there are people in the universities, with great theoretical and academic skills and need material to write about”(Interviewee K - Aca)*

*“The big problem is being, because a lot of people are still very manual, they’ve got good ideas but they can’t, but they don’t know how to make that into a scientific paper, and so we’ve really struggled in the content for our journals and it’s only now that our training has become more improved”(Interviewee D - Ind)*

*"I think without an academic lead sort of to appreciate that, then it'll be people doing research that they think is interesting, but actually its applicability in the wider context of where it should be might be devaluated" (interviewee B – Ind, Aca)*

*"They don't find it easy to write and they don't want to engage that way, so maybe they then become disparaging about it, so they just find it difficult to do, few don't find it interesting or relevant, or don't have the skill to do it" (Interviewee F – Aca)*

*"all that kind of stuff that we're interested in understanding, and that we can feed into improving services, and ofcourse we get a broad perspective from different hospitals as well so not obviously working only with one surgeon, so we can report on cases we've done with multiple hospitals, where they're constrained in reviewing things just from their hospital." (Interviewee E – Aca)*

*"Medicine doctors, who do their sports medicine masters program here, and then occasionally do their PhDs, they have a huge wealth of knowledge in terms of cohorts, and samples and people you're actually testing and being able to access quite unique populations, yeah clinical populations, which is much more difficult for academics to access, partly because of ethics, but yeah the knowledge as well and being able to work with people with special issues and different issues. I think that's probably for us, because we're very centered on humans and what humans can do, that's a big contribution from practice, you know; being able to expose us to lots of diverse and unique situations" (Interviewee M – Aca)*

These observations implied that giving academics the necessary access to data sets and information leads to more significant applied research, more informed industry, and therefore more relevant outputs. Therefore if universities or consultancies such as PDR provide relevant research supported by experience and experts' confidence in its applicability, clients will be more willing to adopt new practices.

This confidence enhance communication between academia and industry, and build long-term relationships, therefore reducing the levels of potential risks and uncertainty linked to collaborations (Zucker & Darby, 1996; Tidd, Bessant and Pavitt, 2005). Interviewees also believed that the trust built between university-industry partners, has an impact on the way collaborations are perceived and sought, and how risk is managed appropriately.

*"I believe that industry often struggle to actually involve academia in projects where they clearly could improve the credibility or the process behind the piece of research. I think that industry have to be almost diving in academia and what it*

*requires, and sometimes it feels a little bit the other way around, it marginally depends on who's managing things really" (Interviewee B – Ind, Aca)*

*"So it's quite, the challenge always with design and with research, is to convince who we're talking to. They probably have to make an investment off the back of what you're saying, if they want to move into a more original or more risky idea (Interviewee A – Ind, Aca)*

*"they basically say [to a scientist] ok, based on your knowledge of mechanics and human movement, invent skills. There's the other way this works as well, the ok we can do this skill, let's make it more complicated, just the coach and the athlete working together, and then they say 'oh, we're getting injured, maybe it's because of this skill, let's bring in a scientist to ask 'why?'" (Interviewee L – Aca)*

The organizational structure and the logistical proximity of research and commercial activity in PDR can form strong grounds for these interactions to take place. The stronger the relationship between research and industry, the more engaged the research is with the context it is expected to impact (Gibbons et al, 1994; Nowotny et al., 2001).

#### *4.1.1.6            Sharing costs and increasing revenues*

Lacking the needed in-house skills to achieve the necessary level of research can hinder companies' R&D, design, and development processes:

*" Where I work, a research consultancy, we sell research as a service, so it's part of the design process and part of the senior people of the team are helping sell that to the companies, not only to make us money, which obviously it did, but also if we're trying to design on shaky foundations we don't get the maximum benefit for the client or the growth they might want" (Interviewee A – Ind, Aca)*

Selling design research as a professional service has become a new revenue stream. Offering research as a service can benefit the research institution owning the necessary technologies and knowledge, and provide another source of revenue, a concern that has been extensively discussed in literature (Leydesdorff and Etzkowitz, 1998; Hagen, 2002; Brundenius, Lundvall, and Sutz, 2009; Guimon and Agapitova, 2013). Having a source of profit in an environment that merges both research and commercial practice can provide the financial security for researchers to support their research activity when funding is not available. Risk-control in turn influences funding attractiveness; organisations that

can evidence sustained income from research activity represent a lower risk to funding bodies. On the other hand, being involved in a research or academic project gives businesses access to extra funding and allows them to share the risk and costs with academic parties (Brundenius, Lundvall, and Sutz, 2009; Correa et al., 2013; Guimon, 2013; Pavitt, 2005).

This scenario is specific to a limited type of university-industry collaborations. PDR is a form of consultancy that provides design research services as part of a strategy building or business solutions project (i.e. UCD, ecodesign and policy research). In these types of projects, PDR generates revenue through transferring the technical and knowledge expertise of its designers and researchers to provide solutions for industry.

#### *4.1.1.7 Streamline Research and impartiality*

The priorities and interests of curiosity-led academic researchers differ in many ways from applied researchers (Robson and McCartan, 2016). Mode 2 research (Blackburn, Huang & Pozzolo, 2000; Noble 1977; Van den Belt & Rip 1987) offers a foundation for professional practice, and that includes impartiality. Negative research results are crucial to identify good and bad practice. Similarly, failures in industry are of significant importance from a research point of view. Reporting negative findings assists in finding solutions to avoid any further repercussions or provide alternative decisions.

*“I think without an academic lead sort of to appreciate that, then it’ll be people doing research that they think is interesting, but actually its applicability in the wider context of where it should be, might be devaluated a lot” (Interviewee B – Ind, Aca)*

*“There’s the ethics of it, and I think if it’s an injury based thing as opposed to commercial, we have to report it, then I think it’s different, because so for example the shape of the pommel horse in gymnastics, changed because of the injuries junior gymnasts were getting”. (Interviewee L - Aca)*

*“But I think where we stand in benefit and where we do better than other people is we’re prepared to talk about the negatives of this, again, research is just not prepared to do that, we are prepared to be more rigourous about things and say ‘these techniques don’t necessarily work in all scenarios’”(Interviewee E – Aca)*



Interviewees expressed their belief that negative results are crucial for both; the development of practice and further research. However, the increasing demands on researchers to publish (De Rond and Miller, 2005) combined with the increasing need to attract funding puts researchers under pressure to publish positive results and report high impact research (Fanelli, 2012). These all affect the impartiality in reporting information. Commercial stakeholders are not interested in reporting negative results either for fear that it might affect their brand credibility. However, recording negative outputs can provide PDR with a greater number of case studies to interrogate. Through this a greater understanding of good design practice can be shared with broader community, based on a larger number of examples. Commercial results can therefore justify the effectiveness (or not) of any applied research, leading to more relevant, impartial and generalizable outputs.

#### **4.1.2 LIMITATIONS OF IDENTIFYING RESEARCH IN UNIVERSITY-INDUSTRY COMMERCIAL ACTIVITY**

As discussed in Chapter 1, PDR faces challenges when attempting to identify research in its commercial activities, due to the scrutiny applied to non-traditional outputs being submitted for REF. Similar difficulties are faced by academics engaged in Mode 2 research and knowledge transfer. Three areas of barriers were identified based on interviews with academics involved in university-industry collaborations in multiple disciplines: commercial/academic relationships, commercial/academic projects, and research quality assessments.

##### **4.1.2.1            *The nature of the commercial/academic relationship***

###### ***Trust***

If the trust and credibility of the researcher are not clearly established in the minds of the commercial partner, and laid out at the beginning of the collaboration, then the perception of the different objectives of partners can be problematic in establishing an effective relationship:

*“Once they accept that they can’t develop this skill, maybe then a scientist comes in and does the research question and says ‘oh, these are the three options that*

you have. *Then yeah they have to trust you, and know the information you are giving them are meaningful and correct*" (Interviewee L – Aca)

The commercial partner may fear that the academic will enter this collaboration with an agenda and prioritize research outcomes over commercial needs, an issue also highlighted in the literature (Ankrah, & AL-Tabbaa, 2015; Correa et al., 2013). Fear of jeopardizing competitive advantage or intellectual property rights can negatively influence a commercial partner's willingness to contribute to the dissemination of knowledge created

*"...even if they are going to allow you to publish, they will try to censor what you are about to say, and that is a huge issue..."* (Interviewee K – Aca)

*"... do they [client] want it [research results] out there ? Because of confidentiality, they would want to keep competitive advantage"* (Interviewee G - Ind)

This can partially explain the importance of established long-term relationships in building trust between partners (Greitze et al., 2010; Lambert, 2003; Liew, M. et al, 2012; Wilson, 2012). PDR has formed long-term relationships with some clients and acquired repeat business. These relationships can in turn play a role in shifting what started as a purely commercial interaction, to one where all stakeholders can benefit from the generated knowledge and outputs, which will be discussed in this thesis in chapter 6.

### ***Ethical Responsibilities***

There are times when ethical considerations can bring partners into conflict; interviewees cited examples of industry-university collaborations in the health and sports sectors that had revealed patterns of injury or ways of avoiding illness, which the academic considered essential to communicate to the wider public. However, when failure is translated into a dissatisfied client, customer or user, then commercial organizations may not be inclined to bring it to the attention of a broader audience, as discussed in section 4.1.1.7 on impartiality. That is when the opportunity to translate the commercial project into an academic output may be passed over, even if there is no risk of breaching confidentiality.

## **Cost**

While collaboration helps in sharing the costs between the academic and commercial partners (Pavitt, 2005; Zucker, 1996) and the possibility of accessing more funding increases through collaborating with research institutions (Hagen, 2002), interviewees consider the cost of research to still be a limiting factor.

*“The bit that costs companies money, is losing the way, stopping down the path and then stopping a project. There are lots of reasons why you might stop a project, you might not have resources to support it, it was a great idea but we can’t organizationally deliver it” (Interviewee A – Ind, Aca)*

*“presumably, they’re generally, if they’re commercial they would want something, not on a massive cost, and they would want something fairly quickly” (Interviewee J – Aca)*

*“if an academic suggests to do this rigourously in order to get a better outcome, there’s very often little tolerance to that, because they don’t have the time, they want a quick answer” (Interviewee K – Aca)*

Time, financial cost, and the way projects are scaled and justified differently in commercial and academic contexts are major problems faced in building effective university-business collaborations.

Commercial partners may be concerned that academic definitions of successful projects (Barnes, Pashby and Gibbons, 2002) might lead to longer projects and greater incurred costs, compared to the commercial imperative for faster results. Weighing up the risks versus the benefits gained will effect willingness to engage (Ankrah and AL-Tabbaa, 2015), and can lead to commercial partners limiting the extent of research conducted prior to commencement. This may in turn impact on research quality and validity.

## **Communication Language**

Interviewees involved in commercial activity expressed the concern that their industry partners would read and not fully understand academic texts.

*“... An American driven journal in operations management, the only 4-star journal in OM, and it is very quantitative, and it is written in a very academic style. Right, there’s a direct inverse relationship between that and the accessibility of that material to the practitioners, because they cannot understand what the they are talking about.” (Interviewee K – Aca)*

Furthermore, in multidisciplinary projects this concern extends to partners from other academic fields:

*"I'm about to do some stuff for rugby club, and I've never played rugby, I don't know the rules, but you just have to work on it, so the communication skills is much more difficult. While if a gymnastics coach was sat there, I'll be able to talk to them without a problem, but, but I also find the fact that I was a coach and a practitioner, there's a shared language and communality... it's communication, it's the key thing."* (Interviewee L – Aca)

Improving communication could potentially be solved either by embedding the research skills (Frantzen, 2000) during early career stages and studying years, or through engaging in knowledge exchange programs where knowledge communication is more participatory and less reliant on technical jargon (Friedman, 2000, Berends et al. 2004).

#### 4.1.2.2 *The nature of the commercial/academic project*

University-industry collaborations can take a range of scales and forms. The extent to which there is scope for original research within the project depends very much on the type of collaboration and the scale (budget and length) that project takes.

*"to establish a gap, and which you address typically by answering a research question by a rigorous manner, you plug that gap and you make a contribution to knowledge. There's a fundamental difference between that approach, which I learned and which demonstrates insight and understanding do the root cause of the problem if it is a problem oriented, and then determine where the intervention should go. What is being done sometimes, is behaving like a bunch of consultants, 'we have an answer, now what's your question?'"* (Interviewee K – Aca)

As discussed in Chapter 2, the form that the project takes can define the level of research that can be disseminated (Perkmann & Walsh, 2008). Academic relevance of commercial projects or commercial relevance of research is not always guaranteed. This is not to say that commercial projects that cannot be exploited for research outcomes are not valuable in their own right; just as both 'exogenous' (curiosity-driven) and 'endogenous' (market-driven) research have a place in the modern university (Dooley & Kirk, 2007). It may be possible that a project on its own does not demonstrate research value, however

in combination with several other projects, it may contribute to a broader systemic change in practice that holds research value in itself

*“it’s back to demonstrating our expertise in different areas and showing, say we’ve got one piece of work, and linking that to previous bodies of work that we’ve done before. So it was like continuous” (Interviewee G – Ind)*

*“So the question of whether it was actually contributing anything, to people’s understanding of design, and often it isn’t actually; it may be very good, it may win prizes, it may achieve everything and more that the clients and users want, and that doesn’t make it something that you can submit as a research output. So what we often find the challenges are, is in making the case that there is something unique or special, that is making a contribution to knowledge” (Interviewee F – Aca)*

#### 4.1.2.3      *The nature of the research quality assessment process*

Conflicts discussed in the previous two sections can have further impact on the research assessment process, and consequently the drive and capabilities for further collaborations and funding.

#### ***The importance of documentation***

Academic metrics of success include two elements: further grant funding and traditional research outputs. Academia is about producing and communicating knowledge, which is not usually the intended result of commercial or art projects. The loop of knowledge-creating-further-knowledge is an important indirect element of some industries, but not the primary objective. The lack of drive towards academic involvement or lack of information sharing community within the commercial world, works as a barrier to the evaluation of the research since there is little documented history to draw upon (Blessing & Chakrabati 2009).

*“It’s the profit that matters for clients, so they’re not interested in the research side of things, or what you do after that, or if you write something, that’s why they don’t want to invest money in that, although it needs money and time” (Interviewee G – Ind)*

*“if they’re any good [artists], they do keep interest in what’s going on in their field. Ummm, but there’s something slightly different about it, it’s almost a way to being professional, you need to know about developments in your field, if you’re a GP or architect, it’s different in art” (Interviewee F – Aca)*

This suggests that differences in the general drive of these fields ultimately affects the rigour of the documentation, making the assessment of research quality resulting from commercial projects more complex.

It seems that a common aspect of the different fields covered in the interviews is a lack of documentation throughout collaboration projects. This is making it harder to reflect on data and disseminate any existing research in the future. This is further increased when access to the information is at the behest of the commercial partner. Lack of documentation is particularly problematic when academic practitioners are attempting to build the evidence base (for the REF), where the need to revisit the project may come several years after a project has concluded.

*“I think accessibility and applicability is something that could be a big barrier. So to start to put the information in the right place, in the right format that industry can quickly get the grips of it, but also making sure that it’s relevant. But it’s a framework as opposed to a single case study, a total as opposed to one thing, or a process as opposed to a particular step.” (Interviewee B – Ind, Aca)*

*“So when we’re trying to make a distinction between what we would call contract to design, or designing brief or commission, we do sometimes submit that kind of work, and sometimes we don’t, and people find it difficult to see where we draw the boundaries. So some of the things we do in the documentation of the process I think. So if you’ve got good documentation of all the decisions that went into the design, this helps you build a case” (Interviewee F – Aca)*

## 4.2 COMMUNICATION FOR EFFECTIVE KNOWLEDGE CREATION

Interviews reflected that communication between the different stakeholders was necessary to achieve an effective level of knowledge creation in collaborations. Intra-organizational and inter-organizational communications are both critical for the management of relationships, the communication of the value of outputs with the larger community, or in assessing new knowledge. The importance of communication is highlighted in PDR, where representation of stakeholders from industry, and multiple academic specialties exist within one organization.

Table 4.3 represents the different aspects of communication purpose and tools. The headers are themes (purpose and tools) that emerged during the B2 phase of coding and analysis. The columns include the subthemes under each one of the themes that were discussed by different interviewees.

Communication	
Purpose	Tools
<ul style="list-style-type: none"> <li>Rigour and knowledge generation</li> </ul>	Prototyping/ artifacts and Visual communication
Accessibility and timeliness <ul style="list-style-type: none"> <li>Improving practice</li> </ul>	Media and press
	Teaching
	KTPs

Table 4.3- Purpose and tools of effective communication towards a research-industry collaboration and an effective knowledge creation process

#### 4.2.1 PURPOSE

The topic of communication was brought up frequently during the interviews. Employing and managing effective communication can achieve effective capture and creation of knowledge in university-industry collaborations.

##### 4.2.1.1 *Rigour and Knowledge Generation*

Academics see a great deal of value in the content they can extract from industry related work to use as data sets or case studies for applied research leading to impactful outputs; discussed in details in section 4.1.1.5 on ‘More relevant research for better risk management’

Some experts highlighted the risks of trying to impose an existing solution on a new problem, in an attempt to prove that a solution is generalizable. Assigning an existing framework or output without conducting the necessary research to establish the root cause of the problem, can jeopardize the validity of the solution.

*"If there's a design consultancy, and the client has commissioned them to develop a pen or whatever product, one of the things that a consultancy does is that it sells its services, so it has to justify its services. So for example, we will provide a competitor analysis report and it will, and this stage will cost 5000 pounds, sometimes the consultancy believes that the client wants something for their money, so they will do a competitor analysis and all that, but, the question is, are they doing that to understand the market and it's really going to inform the design work or are they doing it for the client (Interviewee C - Aca)*

*"...This allows you to go for causes and rectify them, and put them right and prove them and tidy the mess, rather than treating the symptoms based on a pre-designed solution I've got in a bag." (Interviewee K - Aca)*

*"I suppose you have to consider how many, or how big the size of the sample you're looking at; is it one process? It's hard to generalize. Because are those results generalizable, they could be valid but not reliable. I think that level of granularity, the purpose you're communicating that research elements for; are you trying to just understand the research process, so you can do it again under the same conditions, or you are trying to make it available for other people to do?" (Interviewee C - Aca)*

In order to show a level of impact, it is in the academics' best interest to generate the right research to solve the problem from its roots. Furthermore, academics need to show relevance of their research by having direct access to opportunities for application and testing.

Access to in-depth data sets and case studies requires knowledge of the different stakeholders and effective and sustainable relationships, achieved through well-developed communication and long-term relationships (Greitze et al., 2010; Liew et al, 2012). These relationships will assist in better opportunities for intra-organizational knowledge exchange and consequently in the creation of new knowledge (Hermann and Castiaux, 2006; Nonaka and Takeuchi's, 1995).

A good level of knowledge and information communication can offer opportunities for generalizability and applicability of knowledge in different disciplines. This loop of existing knowledge leading to new knowledge and applying to generate more application possibilities is thus essential to prove validity of a process or output, and potentially support claims of research significance. This is possible if the application and extraction of knowledge follow the rigorous trajectory of research then results, rather than results followed by the necessary research to fill in the gaps.



#### 4.2.1.2 *Timeliness in accessibility to improve practice*

The career progression of practitioners in several fields, especially in health-related practices, can benefit from maintaining an involvement in academic research. However often the lack of access to research opportunities and the relevant data is a limitation:

*"I think surgeons by their nature tend to be more inquisitive and interested in research, there's I think a contest I suppose. Everyone wants to try and do something clever or a fairly large proportion of surgeons want to do something clever, they want to do the best for their patients, they want to try technology if they think it has benefits." (Interviewee E – Aca)*

*"For example we do a lot of sport wales, which is obviously a practice area, but we had also 3 or 4 people from sport wales, who are also doing a PhD in conjunction with their full time role, and that's really making a difference between the bridge to academia." (Interviewee M – Aca)*

*"time is really important, access probably to journals within industry , they have access to journals but certainly not the same access that you do through university, actually the accessibility of that information could be a barrier, and I guess it's just timing as well, a good method or good approach might exist out there but might not be aware of it in the right time for the proposal or the brief, then you tend to go back to things that have done in the past, things, that also I'm not sure if there are industry firms where these kinds of things are discussed really. I know a lot of conferences where people go but they don't say a huge amount, you get the impression that probably there's a lot of best practice out there, but whether it is discussed to the point that you could actually replicate it"*  
*(Interviewee B, Ind, Aca)*

The ability to access the right information at the right time using a common language is essential for the transferability and the relevance of information. Research and practice are continuously evolving fields and once new knowledge emerges, information that is relevant today might become obsolete. Practitioners need to get hold of the necessary information and understand it regardless of their level of academic involvement, and academics need to be aware of the available and relevant industry opportunities.

#### 4.2.2 TOOLS

The methods and tools generally used to communicate and transfer knowledge between stakeholders - academics and practitioners - were not explicitly discussed during the interviews. However, while discussing evaluation and communication, interviewees stated a few tools that they believe facilitate the valuable exchange of information.

Academic papers are a traditional method of communicating new knowledge to the research community and other interested fields. This method presents its own limitations, mainly in the language and accessibility as discussed in section 4.1.2.1 of this chapter and in the literature (Dirks, 2005; Rynes et al, 2002). However, exchanging knowledge and skills between research and industry has the potential to take many other forms:

- Prototyping and artifacts are tangible ways of showing potential results or the impact of a specific output. Prototyping is used extensively in design R&D, arts, sports and surgical prosthetics, to test the output prior to its final development, and to communicate its potential performance.

Artifacts are also used as a communication tool in ideation, meetings, and presentations. Since knowledge transfer has become more of a multidisciplinary concern, the ability to reach different audiences is essential, hence the increasing use of visual communication (Dittrich, 2018; Simeone et al, 2017). Artifacts or products can also be used as a vehicle to display work potential, not only to attract and retain clients, but also as a representation of quality.

- Platforms such as awards and conferences should in theory offer opportunities to share non-traditional research outputs, publications, and papers and introduce a broader community of practitioners to emerging innovations and discoveries. However, in practice, this is not always the case

*“I know a lot of conferences where people go but they don’t say a huge amount, you get the impression that probably there’s a lot of best practice out there, but whether it is discussed to the point that you could actually replicate it” (Interviewee B – Ind, Aca)*

- Media, including press and social media have no doubt provided an accessible means to deliver new knowledge and discoveries in a cheaper, easier to

understand and less time consuming manner. While sometimes this type of coverage lacks the depth, it can give easy access to information that would otherwise be alien to many

*“So with what you’re doing if you can link for example sales figures, you can see why this work for example is good work because it sells a lot or if it win awards, or featured in magazines; like top 15 products of the year. So if it kind of gets pulled up in things like that it’s beginning kind of show how the research that went into that product was of significance, then you need to argue for rigour. (Interviewee H – Aca)”*

- KTPs (knowledge transfer partnerships) are interactive methods used to help industries by linking them with academic institutions and graduates. KTPs play a role in bringing and transferring knowledge back and forth to develop the right solutions for the industry involved, based on a rigorous research process. The ability to watch and practically approach problems in an immersive manner on regular bases makes the process of identifying any structural solution along with its benefits and its impact, easier and more rigorous.

Shadowing people involved in the practical applications is one way to learn and ‘internalize’ knowledge, and more importantly tacit knowledge (Martín de Castro, 2007; Millward et al., 2006; Nonaka and Takeuchi’s, 1995). This accessibility is also an opportunity to inform current or future research through new unexpected insights:

*“If you think about the KTP’s and all these partnerships, they are set up that’s a kind of the European funding, it’s set up to have a graduate go and work in a company, and obviously the school that is research driven, and so they can be going in and looking at the design process that the company is using, so the result might be working on changing the design process.[...] So in that instance, obviously the company is going to be interested in the research, maybe not necessarily how it’s done but definitely the outcomes.” (Interviewee H – Aca)”*

Successful capture and transfer of information are core aspects to assess the impact of the resulting knowledge and consequently produced research. Understanding the different functions and work done by partners or other departments of the same institution is essential to avoid work repetition, identify potential collaborations, and

benefits of other people's work, knowledge, and achievements. A strong internal exchange of information is a good sign of a resourceful inter and intra-organizational communication, leading to productive collaboration and trust.

#### 4.3 THE IMPACT OF BENEFITS AND LIMITATIONS ON PDR AS AN INDUSTRY-RESEARCH COLLABORATION

Fields represented in the interviews showcased benefits and concerns that commercial design, and more specifically PDR, might have when it comes to university-industry collaboration and knowledge exchange. Moreover, PDR's context offers mutual benefits for both the university and industry. University benefits from PDR's achievements (e.g. the Queen's Anniversary Prize in recognition of work done in PDR; WIRAD submissions from PDR which contribute to the REF results of the university; design awards contributing to the reputation of the university). Equally, PDR gains from its existence within a university (e.g. outsourcing research skills in different disciplines within the university; the ability to conduct PhD research programs with supervision from different disciplines; conducting research with other schools using the commercial knowledge of PDR's designers and researchers). These shared benefits add credibility, and support any PDR claims of research excellence, which add to the university's portfolio of successful industry collaborations.

The benefits and limitations discussed in sections 4.1.1 and 4.1.2 are equally applicable to PDR. Product designers face similar requirements when it comes to risk, ethical and health and safety regulations (discussed in section 4.1.1) due to their direct work with either users or clients. Although not always governed by health and safety regulations, design and engineering are regularly audited. For instance, PDR operates under ISO 9001, which requires rigorous quality management, access to data, and research to support the chain of decision-making of any project. Particularly since design involves engagement with people for user studies and testing processes, or interaction with the product after release, the need to provide satisfactory evidence of the necessary research is inevitable.

From a commercial perspective, PDR represents a non-traditional form of university-industry engagement, and is responsible for research generation. Profit generation and

commercial activity are not the sole purposes of PDR. This emphasizes the need to understand what research could be generated from commercial practice.

Furthermore, the involvement of rigorous academic research in the design reflects the importance of research to PDR's practice. Research contributes to commercial credibility, reputation and trustworthy research among some industry partners. From a legal perspective, rigorous research and documenting are necessary to meet regulatory requirements; policies, IP, or health and safety regulations.

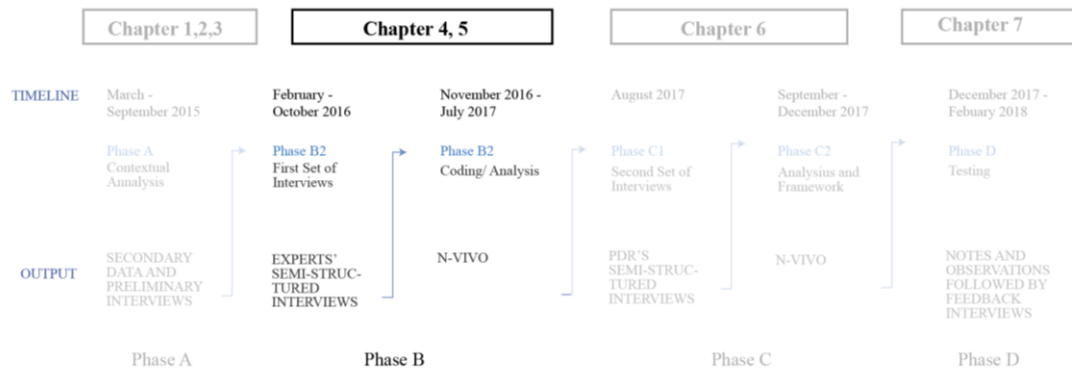
Due to the multi-disciplinary nature of design, this interchangeability of knowledge and research assists in improving design by offering a more rounded knowledge of the disciplines involved in the process. The usability, viability and functionality of a commercial product do not solely rely on design studies. Other scientific fields are generally involved in the design process; therefore, the presence of PDR in a hub of disciplines opens up opportunities for collaborations. The increase of industry-relevant research can result in more relevant design. The ability to translate theory generated through in-depth research into design that satisfies users' needs, and adds to the competitive advantage, leading to better chances of achieving original and significant outputs, while minimizing risks and costs.

The risk of losing commercial sensitive data is a concern for the product design industry. Building trust between clients becomes a complicated, but essential aspect of maintaining this relationship to convince commercial partners to take part of any academic-related collaboration. Formal and longer relationships due to repeat business, awards, and elaborate portfolios play a good role to enhance the possibilities of nurturing those relationships. Pre-set rules and conditions assist in making sure that both partners are satisfied with the ethical and legal considerations when it comes to protecting intellectual property and confidentiality of data, and allowing trust and flexibility for commercial stakeholders for a buy in.

Considering the limited resources, synergies between commercial commitments and academic research are important for the industry and academic stakeholders to set their expected gains they get from engaging in such collaboration, making any line of

communication easier to build. Education and background are good examples in this scenario, where the academic involvement of designers (previous PhD candidates and collaboration with researchers) can benefit clients who lack the in-house research power. This knowledge and skills exchange, taking place in a multidisciplinary environment, thus has an effect on the resulting outputs and the knowledge created, and can be a reason why such multidisciplinary environment is an important criteria affecting the quality of research according to the REF evaluation process.

## 5 RESEARCH QUALITY IN NON-TRADITIONAL OUTPUTS



Chapter 4 discussed the first section of Phase B2 the benefits and limitations of understanding and communicating knowledge creation and research from industry-university relationships within an academic context. The chapter ended with how knowledge creation and exchange applies in its benefits and limitations in the context of commercial design and more specifically in PDR. While the majority of the limitations were of technical nature, one main limitation was how to assess these collaborations and their outputs and how to communicate the value of these outputs.

This chapter covers the second part of phase B2, it will tackle non-traditional outputs' evaluation in more depth, focusing on the three criteria: originality, rigour and significance. The objective of this chapter is **to investigate the potential presence of research value within commercial design outputs.**

The aim is to identify a set of requirements under each one of the three main criteria: originality, significance, and rigour that would best assist in identifying and assessing research quality in commercial design.

The chapter starts with a brief discussion of the REF evaluation processes. It focuses on the limitations faced when submitting non-traditional outputs before and during the evaluation process. The chapter then tackles how some interviewees and their departments have dealt or could deal with these limitations. The chapter also discusses the three criteria: originality, significance, and rigour from the interviewees' perspective, combined with the feedback on WIRAD potential submissions received from external examiners, ending with how this criterion applies to PDR's commercial designs.

## 5.1 REF AND NON-TRADITIONAL OUTPUTS

This section covers the limitations perceived by the interviewees regarding the REF submission and evaluation processes, the metrics used in the evaluation, and how different interviewees have dealt or could potentially deal with these difficulties. Table 5.1 below represents the different aspects of the REF process; the headers are themes (limitations and potential solutions) that emerged during the B2 phase of coding and analysis. The columns include the subthemes under each one of the themes that were discussed by different interviewees.

REF	
Limitations	Potential solutions
Agenda	Mediation of REF panel responses
Causality	External review
Lack of feedback	Building a portfolio

Table 5.1 Limitations of the REF submission and assessment process and potential solutions

### 5.1.1 LIMITATIONS OF THE PROCESS (SUBMISSION AND EVALUATION)

#### ***Agenda***

Communicating research in non-traditional outputs is not as explicit as traditional outputs in terms of clarity of the written word and ability to explicitly express value. Although the clarity of requirements is being increasingly tackled with every REF cycle (multidisciplinary submissions, UoAs skills, criteria clarity), staff still face difficulties in submissions. These limitations vary between pre-submission processes (including the criteria of submission) and post-submission (covering mainly the evaluation process).

Based on interviewees' experiences, the preparation for REF 2014 starts by setting an agenda. This agenda then informs how different schools decide on the submitting staff, depending on two criteria: the perceived ratings these submissions could potentially secure, and the feedback of external assessors.

*“So we had a REF policy before the REF happened, to say that we were going to look at certain percentage of the 3 and 4 star work going in , so we wanted our profile to be this % at 2\* and this % at 3 and 4\* and nothing below 2\*, so we would’ve put in people and outputs that we think would achieve that profile. And also we were governed this time by impact case studies. The number of case studies, you had to return was based on the number of people in your return, so if*



*you went above a certain number you had to put another case study.” (Interviewee I – Aca, Admin)*

This limitation will however change in the next REF cycle due to the changes in the submission guidelines explained in the literature review. The pressure is now on the HEIs to identify who are the staff members with significant responsibility for research. This change might in fact have a positive impact on submissions, by reducing the numbers of staff being dismissed due to the type of their submissions.

Even staff members who will be submitting shared their worries regarding high scrutiny that seems to take its toll on the non-traditional outputs more than traditional ones

*“So I would say, let’s say 25% of the submissions were non-traditional forms, I would say 90% of the scrutiny was around that 25% of that submission. So we were recruited to have external verifications, so we had external people look at these things, far outweighing how much scrutiny was given to a journal article [...] At one point we had to go to 3 separate external people” (Interviewee C – Aca)*

This in turn is leading some people to avoid submitting their non-traditional outputs, in order to dodge the risk

*“I think I would spend it on doing standard journal article, and empirical study or something like that, rather than critical review, because I think that, I think I feel safer with an article that is in a good quality journal would hopefully be submitted, where I’d be less certain about a critical review because it’s such a perspective issue I think as well, and I think with critical reviews, possibly, seniority counts a lot towards how’s that viewed” (Interviewee M – Aca)*

The scrutiny could potentially be linked to the lower number of non-traditional submissions to the REF, affecting the ability to build a benchmark throughout time. The scrutiny could also be a result of the abstract nature of the research value. The difficulty communicating the research value in non-traditional outputs inherently puts the assessment under higher risk of bias by relying on the esteem more than content:

*“Well the guidance will say we accept all forms, with no bias and no prejudice. That, the REF will say that, I think there’s a huge amount of subjectivity in the whole process, and I think that is heightened\* when there are non traditional forms of outputs” ( Interviewee C – Aca)*

*“I donno, the reputation of the institution is going to make the argument more or less believable, there’s an element of that going on” (Interviewee H – Aca)*

### ***Criteria and potential causality***

There is a level of uncertainty in the preparation, choice, and internal evaluation of potential non-traditional submissions. Interviewees expressed their concerns regarding 1) the clarity of how the nature of research is interpreted in non-traditional outputs, 2) how the criteria could be miss-interpreted, and 3) the risk of linking some results to the wrong causes or evidence:

*“But then you have the clash of how much you invest in marketing and promotion because well is it the process of developing? Or is it how good your marketing is and you basically sold someone something that they don’t need, but you created the need and then sold them that product, and that’s the case in a lot of products.” (Interviewee B – Ind, Aca)*

*“So you sort of know what they’re looking at, but it is a peer review process and it’s going to come down to the people in the room I guess and the kind of discussions that happen.” (Interviewee I – Aca, Admin)*

*“There was a confusion of what this is and it can be an ambiguous area, but the people in charge of REF would argue, they’ve given the criteria, go forth and interpret it.” (Interviewee K – Aca)*

*“I hope that the guides for the next REF if we have one, or whatever it becomes, is a little clearer on the nature of research in non-traditional output. I suspect that it won’t be, and it will be as it was last time, quite a broad brush approach, to the point that it doesn’t really tell you very much, so while there is guidance, and I can read the word and I can understand them, it doesn’t really inform me, it doesn’t really give me clarity on difference between let’s 2 or 3 stars, so 2 stars being nationally, 3 star being internationally, how do you measure that, what is the research that is coming to it” (Interviewee C – Aca)*

Institutions try to meet the existing criteria by finding their own interpretations of how to apply the REF criteria to non-traditional outputs, and that is a subjective, but essential element to any submission (HEFCE, 2015).

Even in cases where the outputs’ criteria of success are visible, there is still a risk of causality. It is possible that the success is a result of some external factors such as marketing of the output, or esteem and reputation of the people involved, rather than the research quality of the output (Bence and Oppenheim, 2005; Cave et al. 1997).

### ***The lack of feedback***

Due to the high number of submissions in every REF cycle, there is an understandable lack of individual feedback to each submission. This lack of feedback affects the HEI and staff's ability to reflect on the results, and improve the quality of any future submissions

*"No way of judging, because we don't get anything back except of the final result, what we don't know is whether we could have submitted more things, that's what we don't get feedback on, because we've made, I have made some judgments on what to rule out, and it may be that we could've drawn that line" (Interviewee F – Aca)*

The importance of feedback in the learning process is well recognized (Cramp, 2011; Hounsell et al., 2008), and this applies to producing research suitable for the REF because of the latter's changing nature and its relatively short history, particularly in the non-traditional outputs' submissions. Having feedback could also provide proof of objectivity in judgment, and reduce the scrutiny in submissions.

### **5.1.2 GETTING BETTER AT REF**

One way of informing a better management of REF submissions in a commercial design context is to investigate how different disciplines manage their non-traditional output REF submissions.

### ***Mediation***

It seemed that experts who have taken part in the REF process, believe that consensus of multiple responses to the same output can help in better assessing a submission.

*"It is because we get consensus in my team and people from different disciplines, so then there's a danger of group think, because we all agree, eventually we work together for so long. But then we have people at the university, who are sort of, from ourselves, but not the same people, and then they look at the material fresh" (Interviewee F – Aca)*

*"So you could have someone who was putting in 2 x 2\* outputs and 2 x 4\* outputs, so if they happened to read the 2 4\* outputs, then you're winning, if they read one of each then you know that's a fair reflection, if they read the 2 2\* ones, than that would be brought down a bit, but you know that's all part of the game chance*

*really, and you know maybe for a person they read the 2 2\* ones and for another person they read the 2 4\* ones, so in the end they even out.” (Interviewee H – Aca)*

*“Someone would’ve reviewed Cardiff, 2 people, and another 2 people or more, would’ve reviewed another university, let’s say, Manchester, and they would’ve crossed over on something , they wouldn’t just do one university submission.” (Interviewee C – Aca)*

Double reviewing and comparing results is used to reduce the impact of any potential bias on the final score. Double reviewing is exercised in specific cases such as group submissions, or when the same submission is reviewed twice.

Internal, iterative assessment by multiple experts from different disciplines within the same institution is a viable option of peer reviewing. Equally, inviting external experts to review and offer feedback on potential REF submissions is another practice taking place in many institutions:

*“So we’ve gone through a multiple-blind peer review process with moderation and then those were any form of contention sent out to an external to pass comment on that as well, so we’ve been as objective as we can” (Interviewee K – Aca)*

Reaching internal consensus provides a level of reassurance that there is a general agreement on the quality and level of the output. Internal iterative processes can assist staff in critically assessing their own, and other people’s work.

### ***Building a portfolio***

Interviewees expressed the importance of developing portfolios to assist in filtering and judging potential submissions. Starting ahead of time and building up a pool of information can help deliver a well-rounded story to communicate the output’s value

*“I think probably just starting sooner, and we’ve done that this time, we’ve been guilty in the past for leaving things till the last minute, not the last minute, but in the REF terms, till the last minute. So I guess the last couple of years of the cycle, really we need to start after the last day the last REF finishes, we need to start for the new one, and I think we’re doing that now, but in the past we haven’t done that” (Interviewee I – Aca Admin)*

*“So some of the things we do in the documentation of the process I think. So if you’ve got good documentation of all the decisions that went into the design, this*

*helps you build a case. One of the biggest barriers I think to submit commercial work is that often is just only good practice. [...] So what we often find the challenges are, in making the case that there is something unique or special, that is making a contribution to knowledge. So originality, significance and rigour, so rigour you would get from good documentation of the processes, mainly, and that would be aesthetic decisions, it would be practical decisions, it would be manufacturing decisions [...] and what we try to do now, is we try to, the staff that will be submitting, we try to get them aware of that much earlier on, so that we're not trying to assemble this material post hoc, we do inevitably try a bit of that, but you know." (Interviewee F – Aca)*

Working on the portfolio of material to accompany a non-traditional output is important due to the lack of capacity for some non-traditional outputs to explicitly self-reflect the originality, rigour and significance. While it is not always obvious whether an output will or will not be submitted to the REF, documenting the decisions made throughout development process will be useful when it is time to make the decision. Observing changes and accumulating supporting evidence of impact require tracking over a long period of time (Tsey et al. 2019).

### **5.1.3 REVIEW OF REF 2014 SUBMISSIONS AND POTENTIAL SUBMISSIONS**

To reflect on the REF requirements and get a better understanding on how to highlight any existing research excellence for the purpose of this research, the feedback on previous potential submissions (WIRAD) and the actual 2014 submissions for UoA 34 were reviewed.

In the 2008 – 2014 REF cycle, around 200 potential submissions, some of which were non-traditional outputs, were assessed by external examiners (previous REF panelists), as part of WIRAD (a collaboration between „ University of South Wales, Cardiff Metropolitan University, and Amgueddfa Cymru – National Museum of Wales). The feedback given by the examiners was thoroughly reviewed for the purpose of this research. The examiners' feedback was based on the evaluation method and criteria generally followed by the REF panels.

Comprehensive lists were formed after reviewing the WIRAD feedback, and comments were presented in the two tables below: Table 5.2 includes the themes that appeared in the feedback categorized under positive and negative attributes which can either support or jeopardize the output's submission. Table 5.3 summarizes the external feedback on the

quality of the output and how clearly are the originality, significance and rigour criteria reflected in the submissions.

The same comments which have been allocated to multiple submissions, have been listed only once in these tables. The tables are followed by a discussion of their content and how they relate to what has already been discussed in this chapter about the REF evaluation process.

Positive attributes	Negative attributes
Good Documentation	When output cannot be described as international.
Importance in terms of world leading: citation/internationally adopted.	In the 300 words description: -Relying on online links -Does not include a discussion of the new knowledge or outcomes of the work -Does not mention the question and methodology employed
Can demonstrate a profound influence	Too general, no focus points or particular research points
Focus on research instead of only researcher's esteem.	Some work is too commercial to be submitted
Contribution to new insight, thinking, practice or innovation and impact	Evidence in the form of press releases, letters and invites are not relevant
Defined context	A very narrative context: 300 words very subjective
No duplication with other outputs	Narrow focus (more in written articles)
Drawing out the originality, rigour and significance points in the supporting text (against the output), and include (if possible) positive academic reviews	When an invitation to submit to a special issue has been offered, the submitting party should pay attention to how to contextualize the statement, because it can be taken as no objective peer review has been done. As long as it is made clear that it went through the peer review process, 'invites' could impact the submission negatively
Funding and awards winning, that can contribute to the esteem	
Interdisciplinary	
Meets the published definition of research	
Includes research process	
International funds/ exhibitions/venues	
The submitting author's role should be highlighted in co-authored submissions	
Clearly mentioned research imperatives	
Visual portfolio that matches the written information	
Material provided by client and input of the research done, rather than the design work done	
Clear case to which UoA the output should be submitted.	
International implementation: integration or adoption in teaching and practice	
Cited elsewhere	
Used in the development of a field	

Product or tool has been used as an international reference point	
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Table 5.2 External feedback for potential WIRAD submissions: positive and negative attributes of submissions

The feedback listed in table 5.2 is discussed below in two sections: feedback on the international quality of research, and feedback on technicalities relevant to shaping the REF submission.

#### 5.1.3.1 *Attributes of international quality research*

##### ***Building the context***

Good documentation was one of recurrent comments addressed in table 5.2. This comes in good agreement with what was discussed in the section 4.1.2.3 as well as section 5.1.2. The easy access and build up of information were essential for the submissions, and for developing a case of research quality output. The rigorous documentation of the process and its results appeared as essential practices to define the context of the output and its development.

Providing evidence of a rigorous research process (e.g. ownership of ideas, context, detailed R&D process, availability in the public domain) are all necessary to build the context surrounding the work.

This is particularly crucial since a ‘defined context’ is frequently highlighted as a positive attribute in submissions. Defining the context is essential in narrowing down the area of research where contribution to knowledge is being made.

##### ***Research process***

The examiners highlighted the positive effect of having a detailed description of the research process in the submission, to demonstrate research excellence of the output.

Some work is too commercial to be submitted as a research output (Section 4.1.2.2). In order to differentiate between research for understanding (i.e. R&D, market research) and exploratory/ basic research, there is a need for detailed descriptions of processes. This description includes time, material, brief provided by clients, the research input of the consultancy/researcher/author, as well as the design activity.

### ***Credit***

Intellectual property and the submitting party's contribution and identity are essential elements of REF submissions. Assigning ownership and giving credit to the source of information is important for the evaluation process when two institutions submit the same output.

### ***Leading research quality***

As per the REF definition of research, examiners highlighted the evidence indicating the existence of new knowledge creation and insights, improvement in practice, or introduction of innovative skills and ways of thinking. Other evidence indicating quality and rigour included: citations and international adoption of the output e.g. referenced internationally, international funding, or citations' numbers.

According to the external feedback, the use of venues and exhibitions' esteem to prove significance and impact appear to be a legitimate piece of evidence and sign of leading research quality even though some consider that the use of esteem can cause bias in judgement (Bence and Oppenheim 2005; Cave et al. 1997). While esteem seems to be accepted as evidence of research quality, 'focus on research rather than esteem' seemed to be a positive recurrent feedback given by one of the external examiners. One way to explain the contradiction in these two statements is that esteem could only be used if it is recognized in the academic community (i.e. well known academic publisher instead of magazine for practitioners). Same rationale applies to evidence such as letters, invites and press releases. Such evidence is irrelevant unless it is well contextualized, otherwise it can have a negative impact on the submission, by implying that the output did not undergo objective peer review.

### ***Multidisciplinary research***

Multidisciplinary outputs have an advantage due to the higher exposure and potential international reach. This comes in agreement with what was argued in chapter 4, section 4.2 'Communication for effective knowledge creation'; multidisciplinary environments lead to richer knowledge exchange and creation, and therefore more innovation. The multidisciplinary work's positive effect on the quality and depth of knowledge has also been highlighted in the literature (Blessing & Chakrabati, 2009; Norman, 2013; Veryzer



and Mozota, 2005). Therefore there is an advantage in highlighting and tracking any interdisciplinary interactions taking place within the process of non-traditional outputs creation.

#### 5.1.3.2 *Technical elements of the submissions*

As part of the contextual understanding of the REF, there is also a need to investigate the nature of submissions and what makes a 'good' practice based REF submission.

Below is a breakdown of the relevant numbers of the 2014 submissions to the UoA 34. The data related to the numbers and types of submissions is available on the REF 2014 website, 'Results and Submissions: UoA 34' page, under the outputs category (REF, 2014b).

- Total number of submissions to UoA 34: 6321
- Number of Non-traditional outputs submitted to UoA 34 - the choice of these submissions is based on what this research considers as a non-traditional output (Software, Performance, Composition, Design, Artefact, Exhibition, Devices and products, and Digital or visual media): 2239
- Total number of submissions related to design and artefacts (Design, devices and products, and artefacts): 762
- Total number of devices and products: 19 (submitted by 4 different universities), 12 of which are the result of a collaborative work between the university or the designer/researcher, and industry.

The numbers show that products resulting from university-industry collaborations form only 0.5% of the total non-traditional outputs submitted to UoA 34. This percentage does not reflect the importance given to the impact factor in REF assessment process. Similarly, this low percentage does not represent the growing focus on university-industry collaborations to achieve economic and social impact. This could be linked to scrutiny these submissions are subject to, and the difficulties in effectively reflecting their research capacity in a submission. That is why there is a pressing need for more supporting criteria to help identify submissable material to the REF.

In order to identify what makes a good submission, two approaches were tested. The first approach was to search for repeated phrases/ words in high performing cases that are omitted from low performance cases using the RStudio software – a free and open source

programming software, used to generate codes for graphs and statistical computing. In many disciplines, assessment can be a process of scanning through texts and detecting specific vocabulary or jargon. Based on this assumption, the idea was to analyse the submissions by creating word clouds and compare submissions of top performing institutions and less successful ones, based on the UoA 34 intensity-weighted GPA (calculated by multiplying the GPA and the proportion of eligible staff) (Times Higher Education, 2014b). The hope was to detect words and themes which are frequently used, and that could potentially play a role in making a submission more successful or appealing to the reviewer. This method yielded inconclusive results.

The second approach was to manually analyse and look for themes present in high performance cases that were not in low performing cases. From this second approach, the following was determined:

Successful submissions avoid getting into too much research process details (including ethics, and research technicalities, methodologies), assuming that the detailed information is available in the portfolio submitted with the output. They appear to focus on the contextual setting of the output and the personal process and experience undergone to achieve the output.

A typical submission for a high performing HEI, seems to focus on the meaning of the work; an explanation of what it signifies beyond just the research – impact, inspiration and sources of the idea. A typical submission might include:

- Brief description what it is (e.g. an installation, a product, art work)
- The history/background behind it, or maybe the source of influence
- The output's context and meaning or relevance to real life activity/scenarios/situations; an analysis of the work (it is an attempt to reflect the importance and benefits of the work for the curator as well as other stakeholders)
- Then briefly: Who funded or commissioned the project, and any awards or available publications

On the other hand, less successful institutions' submissions start with technical and esteem-related details, i.e. publications, awards, location of exhibition, collaboration partners. Their submissions appear to reflect details on the technicalities and less of a flowing story. Some even attempt to explicitly state what makes their submission original, rigorous, and significant.

These observations did not take into consideration the actual quality of the output. Although the way an output is described might potentially play a role in the judgement of the panel, the actual quality of research is still a priority in the assessment process. Therefore the lower or higher submission scores are not solely attributed to the style of writing, or the content of the 300 words submitted with the output

### ***Originality, rigour and significance***

The external feedback stated the need to reflect originality, significance and rigour in the submissions. Table 5.3 below lists the feedback given by the external reviewers categorized under the originality, significance, and rigour of the potential WIRAD submissions.

Originality/ Novelty	Significance/ Influence	Rigour
New knowledge/ publication/research/ideas	Expansion upon existing research.	When talking about rigour: it is about structure and method
The text in the portfolio cannot only be of a review nature, It needs to be research.	Influences and contributes to the field, and has lasting influence.	Grounded in the history of the field with innovative collaborative elements
Should not be only descriptive.	Significance is highly linked with impact	Positive Academic reviews
Provide evidence of new knowledge and/or exhibition/ publication	Use of reviews and press are not very acceptable	Good underpinning research
First of its type: new methods to solve problems that haven't been solved before	Relevance and economical viability	Strong context
Speculative ideas		Significant amount of supporting evidence
Make an incremental contribution to advancing study of the subject matter.		

Table 5.3 Feedback from the external reviewers on the originality, rigour and significance of potential WIRAD submissions

## **5.2. ORIGINALITY, RIGOUR, AND SIGNIFICANCE**

In order to evaluate research quality in non-traditional outputs and mainly commercial outputs, it is important to understand where to locate that research value. The three considered options are: 1) the process leading to the output, 2) the output itself as research, and 3) the holistic process (output and process).

Interviewees highlighted the importance of the output as embodiment and visualisation of the research criteria such as originality and potentially significance, however they always referred to rigour as being mainly a part of the process:

*"You know rigour tends to be, you look at the methodology [...] and say ok so where they got the data from? How big is the sample? What sort of analysis they've done? Can you be confident that the results they are claiming are actually valid etc. etc. So that's number, but even if you're taking case studies, I mean you know, how many case studies have they done, have they just done one, or they've done 3 case." (Interviewee J – Aca)*

*"I think people are concerned about the rigour. In some ways I think the originality could be even easier to see because it's more manifest in a physical artifact, but I think rigour is where people think; 'oh, have they just thought of that, how rigorous is the process?' and that is something that is hard to get across in 300 words [...], you can be very rigorous but it's not very significant, and perhaps the quality of the research is not very good. If you look at the three dimensions: originality, significance and rigour, I think you have to look at them in a totality rather than individually, you have to look holistically" (Interviewee C – Aca)*

*"To me it's really important to get a sense of understanding to a problem, and that entails, rigour data collection, to differentiate the causal issues from the symptomatic issues, and to treat, to insure that you get as close to the causes of the problem to put right, rather than treating the symptoms" (Interviewee K – Aca)*

Significance is portrayed as a validation of a rigorous process. A process is considered significant if it has undergone an iterative cycle of application and justification, proving its effectiveness in achieving positive results. A process is significant if for example it can demonstrate improved or more efficient practice, faster processes, new functionality or processes to an industry, the success of adapting a process from one industry to another:

*"Once the methodologies you use or you are using are employed in practice to lots of different coaching groups across the world, across the UK, that's when it becomes a measure of significance I think" (Interviewee M – Aca)*

*"The bits where you feel that it was a significance bit of research or that might influence something, it's really the bits that changed someone's mind, or changed the direction of a project, or, it tends to be things that made you think about it in a different way." (Interviewee A – Ind, Aca)*

*"Well significance in terms of the practical sense, could be linked to the reach of research as well, and does this information have a reaching factor on maybe how*

*children should land, or maybe how other sports people should land” (Interviewee L – Aca )*

Originality is also used to describe elements or methods used in the process leading to non-traditional outputs, and to describe the innovative output. As such, engaging in interdisciplinary application of methods and tools was also suggested as an indication of originality.

*“So I then came up with this ‘the X landing strategy’, so all gymnasts will use this strategy to land [...] So in terms of originality, the originality could come in with the fact that we’re actually monitoring people over time, and that’s not happening before, and the metrics we’re using are original and novel etc.” (Interviewee L – Aca )*

*“In having originality in your process, might not necessarily be anything huge , it might just be something a little bit more robust , it might just be a thing from a slightly different angle” (Interviewee B – Ind, Aca)*

The interviewees’ perception of the research value within non-traditional outputs seems to be focused on the process as a whole, including the output as a representation of the process. The output has a function to communicate that value and assess the relevance of this output in an industrial context. The focus on the process and output holistically seems equally apparent in the external reviewers’ feedback. ‘Economic viability’, ‘impact and influence’ and ‘no similar existing outputs’ (Table 5.3) are considered proof of significance and originality and could be represented within the output itself, ‘introducing new ways of thinking and ideas’, ‘grounded in the context’ and ‘contributions to advancing a study’ (Table 5.3) are all references to the process the output has gone through and the research process that led to this output.

As such, although artifacts can transfer and embody knowledge (Bofylatos and Spyrou, 2017; Groth, 2016), it is hard to claim that an excellent research quality in an output could be solely demonstrated by only submitting the non-traditional artifact. Any argument of existing research value in non-traditional outputs needs to be accompanied by the context of the process, methods and tools that led to this output, in order to prove that the non-traditional output embodies excellent and rigorous research.

It is important to point out that providing evidence of process and methods does not always mean providing traditional research outputs that support the non-traditional output.

The main three REF criteria are the same for both traditional and non-traditional outputs: originality, significance and rigour. The uncertainty remains in how to apply these criteria and their components in a non-traditional output resulting from a commercial collaboration. The following section will discuss the three criteria based on the interviews with the 13 experts (Phase B2), the WIRAD external examiners' feedback (Table 5.3), the REF guidance 2019 and the commercial design awards criteria (Table 4.2). Although their elements overlap at times, the three criteria: originality, significance and rigour, will be discussed separately in order to understand the different components forming each one of them.

### **5.2.1 ORIGINALITY**

The value of different types of research and collaborative processes as sources of innovation i.e. exploitation, exploration, discovery projects, or human centered research, basic research (Hermans and Castiaux, 2016; Norman and Verganti, 2014) has long been a debate. Norman and Verganti (2014) argue that certain research methods involved in R&D and collaborative projects, such as human centered research, do not lead to radical innovation, and only contribute to incremental changes. Others also believe that exploitation projects aiming at turning theoretical understandings and meanings into practical opportunities contributing to industries (Hermans and Castiaux, 2016) will not generate new understanding. Furthermore, creating new radical innovation is only a result of basic research (Norman and Verganti, 2014) or exploration or discovery projects (Hermans and Castiaux, 2016). Kasmire et al (2012) debate that in research, incremental innovation can be as impactful as radical innovation.

Since the decision on what is innovative seems to be reliant on the processes' results and their impact on future developments of science and research (Dahlin, Behrens, 2005; Kelly, 2010; Koberg, 2003; Schoenmakers, 2010), it could be argued that when judging innovation and originality in research rather than practice, incremental innovation is as valuable as radical innovation.

This definition of innovative research comes in agreement with the REF's 'results' based' understanding of originality. According to the REF (2019b) guidance "Research outputs that demonstrate originality may do one or more of the following:

- Produce new empirical findings or material;
- Engage with new and/or complex problems;
- Develop innovative research methods, methodologies and analytical techniques;
- Show imaginative scope;
- Provide new arguments, formal innovations, interpretations and/or insights;
- Collect and engage with novel types of data;
- Advance theory or the analysis of doctrine, policy or practice, and new forms of expression." (p.34)

The REF assessment distinguishes between incremental and radical innovation through its grading system. According to the REF (2019 b), cumulative advancements based on previous knowledge can achieve 1 or 2 stars while 3 and 4 stars are allocated for catalyst or instrumental contribution to knowledge. This does imply that proof of incremental innovation might not guarantee high ranking, however, it does not deny the role of incremental innovation in the creation of innovative, impactful, and rigorous non-traditional outputs.

When discussing originality, interviewees did not explicitly express their thoughts on incremental and radical innovation, and rather focused on highlighting where they locate originality in an output or its process. The elements that seemed relevant to interviewees were listed in table 5.4 below. The components listed in the columns are the sub-themes discussed by the interviewees as to where originality could be found in an output. The headings are themes identified during the coding stage and associated to the cluster of subthemes.

Originality		
Components	Relationships	Points of reference
New Problem	Connections	Stakeholders
New Material	Relationships	Track and observe changes
New methods or methods adopted from other fields	Engagement with stakeholders	
Business Model	Management and internal climate	

Table 5.4 Themes and subthemes arising from the 'Originality' criteria.

### 5.2.1.1 Components

When asked about locating originality, interviewees frequently highlighted originality in processes; the methods used, the processes implemented, the problems faced, or the material adopted. There was no distinctive differentiation between what is newly created and what is adopted from another field or discipline (interdisciplinary use of knowledge or technology). The idea of adopting a component from other disciplines and implementing it in another, is considered original if it has an impact on the latter, by changing or improving the output, the practice, or the understanding of the field:

*“There are lots of different ways they can innovate and be original, but not necessarily has to do with the product, it might have to be with the business model, new distribution channel [...] I also think it’s a challenge for most companies, I don’t think it’s designing the idea, it is getting it from supply chain to market” (Interviewee A – Ind, Aca)*

*“I think you can pull out though what is novel or original, you can demonstrate that by the fact that the methods we’re using haven’t been used before, the the metrics we’ve developed are new.” (Interviewee L – Aca)*

*“Being able to work with people, with special issues and different issues, I think that’s probably for us, because we’re very centered on humans, and what humans can do, that’s a big contribution from practice, you know, being able to expose us to lots of diverse and unique situations. (Interviewee M – Aca)*

*“So in terms of originality, the originality could come in with the fact that we’re actually monitoring people over time, and that’s not happening before, and the metrics we’re using are original and novel etc.” (Interviewee L – Aca)*

As reflected in the REF definition and the literature, innovation is understood as the added value it provides to the involved stakeholders (Garcia and Calantone, 2002). Stakeholders who will interact with a non-traditional output are the research community, practitioners, or end users. As such, originality can be a differentiation, or an incremental change in the components of an already existing artifact, or a completely new component incorporated in that product, that may have an impact on its use or development in the future. These new components can be the methods used, the ideas developed, the problems solved, the tools used to present to the public domain or even a new business



model adopted for the management of the process. Whatever the new component is, it is considered original if it adds to the understanding or the practice of a field. The new component has to produce relevant and impactful results and solutions to stakeholders while adding value to existing knowledge.

Hermans and Castiaux (2016) argue that new knowledge is only created in exploration R&D projects or discovery research projects. This theory does not take into consideration that the application of existing knowledge in a new industry is leading to new understanding and development of that industry. Similarly, human centered design and user studies that are argued to deliver only incremental innovation (Norman and Verganti, 2014), and not a radical new knowledge, have a clear element of new added understanding to a field, which is acknowledged in the REF definition of research and its assessment guidance as developments of research value.

#### *5.2.1.2 Relationships between existing components*

According to the interviewees, the interchangeability of concepts, ideas or processes between different sectors or cultures contributes to the innovation process. This supports the literature available on multidisciplinary interactions and their impact on quality and innovation of outputs (Buchanan 2004; Friedman, 2000; Norman, 2013; Samuel and Lewis, 2001; Saunders *et al.* 2009; Veryzer and Mozota, 2005;). Knowledge transfer in collaborative university-industry projects leads to new insights and knowledge, and thus leads to original outputs (Hermans and Castiaux, 2006).

Interviewees from different industries (design, art, health and sports) highlighted the role of relationships and connections between the different components discussed in the previous section. Even without new components, a change in how these elements are put together can create a change in the result, and potentially lead to significantly original outputs.

*“What was conducted as original research, may be original because it made new connections between things, what is the material uncovered, what is material discovered, relationships between things, and those are presented to the public, and it just happens that those things are better presented to the public sometimes in an exhibition instead of writing.” (Interviewee F – Aca)*

*“And I think you can have similar parallels with other non-traditional outputs, whether it is a performance, perhaps it’s a really novel engagement with the audience, perhaps the performance is not really original.” (Interviewee C – Aca)*

*“But you’re examining that problem using a very different approach, or interdisciplinary way. Maybe it’s always been dealt with from a psychological point of view, but the problem is the same. So actually originality is not the problem you’re looking at, I think, when the problem is new and the approach you use is new, and innovative, then I think you’ve got both, originality and significance. (Interviewee M – Aca)*

Managing the culture and the relationships between different stakeholders within institutions, leads to changes in the ways knowledge and skills are transferred and exchanged. Encouraging innovative thinking by embedding it in the decision making and daily practices, using innovative thinking and risk taking in problem solving strategies, or implementing strategic innovation and short term innovation plans, are all vehicles to increase the chances of achieving originality.

*“I think it massively depends on the industry and the market you work in, so if you work in a market, which is perhaps heavily regulated, you probably want to follow a very tried and tested and quality managed prototype. In having originality in your process, might not necessarily be anything huge, it might just be something a little bit more robust, it might just be a thing from a slightly different angle,[...]” (Interviewee B – Ind, Aca)*

*“So much of it is about changing the internal climate of a company, and help them think differently” (Interviewee A – Ind, Aca)*

By creating internal change, institutions are building up their capabilities to ensure that they deliver relatively new outputs and more relevant to the contextual and environmental changes surrounding the stakeholders (Cooper & Kleinschmidt, 1995; Cooper et al., 2004a; Kelly & Littmann, 2001;). Furthermore, the ways interactions are managed affect the knowledge exchanged and therefore the insights created (Hermans and Castiaux, 2006). Investment in innovation-specific activities, such as employing fresh graduates with new ideas, and the willingness of a commercial entity to invest in risk taking activities is an innovative step by itself.

### 5.2.1.3 Points of reference

Comparison between different projects, employed processes, and methods can help in detecting new patterns, and recognize originality and its impact (cost, time, efficiency, etcetera). Tracking a process and the justifications offered by the relevant stakeholders (academics, practitioners, users) can help in identifying small knowledge interaction practices, which can impact processes and outputs. This tracking can give a well-rounded vision, and therefore support claims of originality.

*“I think he learned throughout time that you need to stand back and make your initial measurements, otherwise you can create the greatest thing but you can’t actually say that you made a difference unless you record that difference early on” (Interviewee D – Ind)*

*“You could sort of take originality for granted, but it also needs to be original in the sense I think that the community recognizes it of being important in some way, so I think in this case, you need to sort of think of significant and originality as one thing”. (Interviewee F – Aca)*

*“But I think we need to have the ability for things to evolve overtime for us to to be able to develop knowledge.” (Interviewee L – Aca)*

The build-up of information and case studies over time can improve the quality of observation and analysis of the results, leading to new potential insights, which could be validated as academic knowledge. This validation is relative to the impact these new insights have on stakeholders and their experiences and knowledge. This comes in agreement with the need for long time-frames, and accumulation of case studies, to report and assess research impact specific contexts (Tsey et al., 2019).

New understandings that an output brings to an existing field of knowledge, are the original contributions expected during assessment. As argued by Henderson and Clark (1990), radical and incremental innovations are two extremes to the components and the arrangement of those components. This means that innovative components, or changes in relationships, which result in high impact, are considered radical. Since originality and innovation are a result of new components or new ways of connecting existing

components, tracking and capturing the sources of this originality (components or their relationship), is thus needed to predict and justify originality.

### 5.2.2 SIGNIFICANCE

Below is a table representing the results of interviews on the significance criteria of the REF evaluation process. The headings represent the overarching themes identified. Sub-themes are given in the columns under each heading (Signs, Pillars and Evidence). The sub-themes are distributed in a way that represents their categorization in relation to one another.

	Significance	
Signs of significance	Pillars of Significance	Evidence
Benefit Change Improvement Satisfaction	Extent (Magnitude)	Fields of influence (Social, economic, political)
		Scale of influence (Local, national, international)
		Citation (number and location)
		Exhibitions
		Publications
		Conferences
		Awards
		Incremental changes
	Reach (audience) the user	Time
		Prototype
	Context (relevance)	Commercial performance (Sales and Testimonials)
		Prior art
		Literature
		Location and Environment

Table 5.5 Themes and subthemes arising from the ‘Significance’ category.

As defined in the REF guidance, significance is understood in terms of influence (already established or the potential influence) an output has on the knowledge and understanding of a certain field and/or the development of its practice (REF, 2019a).

According to Interviewee F, an output is significant if it is considered responsible for a change in the practice or research of a field it identifies with, as well as other relevant fields, while offering advancements in knowledge, skills and practice.

*“Designs tend to be justified in relation to how they serve what they are meant to be serving, so in a way they are self-contained in that way, do they do, do they*

meet the needs? *Do they meet the aspirational needs and the functional needs and the other needs, and if they've done that, then they've sort of done the job"* (Interviewee F – Aca)

Similarly, the feedback from the external examiner (Table 5.3) on how to evaluate significance, states *"Influences and contributes to the field, and has lasting influence"* and *"Expansion upon existing research"*.

Additionally, the REF guidance suggests that providing proof of significance does not necessarily mean showing evidence of already captured significance. The REF clarifies that it is acceptable to provide rigorous reasoning to why the 'authors' believe their work can or will have significant impact in the future (REF, 2019a). It is arguable, in this case, how effective it would be to justify 'potential' significance as opposed to tangible proof of already existing impact and significance, without skewing the judgment.

According to the interviews' analysis, three factors play a role in the significance of an output: extent, reach and context. Each one of these pillars can be attributed to a number of factors and evidence that could potentially act as supporting evidence for significance.

#### 5.2.2.1 Extent

##### ***Fields of Influence***

Extent can be defined by the magnitude or depth of the academic impact an output could have on the field it emerged from, or any other fields that might be benefiting; directly or indirectly. The extent of the significance is identified by the change or improvement this output has had: the areas this influence has reached (social, economic, political...) and the geographical scale (local, national or international).

Academic significance means that there has been an influence that could be translated into knowledge or skills surrounding the output or the stakeholders.

*"So the question of whether it was actually contributing anything, to people's understanding of design, and often it isn't actually, it may be very good, it may win prizes, it may achieve everything and more that the clients and users want, and that doesn't make it something that you can submit as a research output. So what we often find the challenges are, is in making the case that there is something unique or special, that is making a contribution to knowledge"* (Interviewee F – Aca)

*“You know, the way that that was put together meant that there is a product that is easier to use, it’s intuitive” (Interviewee C – Aca)*

*“So academic significance and practical impact. You can make more than one contribution, it can be multi-faceted, I would argue, one of the last papers I wrote, a method that was developed in the airline industry, was taken and applied on a completely different production industry. So from the point of view of impact, it was bullet proof.”(Interviewee K – Aca)*

The influence could be on practice and technology e.g. there was an improvement in: the performance of a certain activity or behavior; a product that is more user friendly; a surgery could now be performed quicker due to the improvement of some tools; the production process is now faster and less costly and more environmentally friendly; or a performance has a social impact on a particular community.

The influence could also be on the theory; where the development of an output (the output itself, its process, or the theory behind it) contributes to a better understanding of a specific field, or to the development of a set of skills and knowledge involved in it.

Furthermore, the fields impacted by an output’s development are also a measure of the influence; as suggested by the external examiner in table 5.3, relevance and economic viability and development, are measurements of academic significance.

Policy design is another big area indicating the extent of significance. The use of design thinking, and design research in policy development has been an example of interdisciplinary significance. The use of such academically developed and taught methods and applying them in different sectors i.e. exploitation of existing knowledge (Hermans and Castiaux, 2016), generates further knowledge and applications. As such, the development of new ways of implementation of existing knowledge can also create significant knowledge; whether it is in the form of pure theory or a reflection through practice.

### ***Scale of influence***

The scale of this influence (Local, national or international) indicates the level of significance an output has and the way research quality is assessed by the REF. Although the REF acknowledges that these dimensions refer to the academic relevance rather than the geographical reach, having an impact on a different geographical scale and breadth

gives an output more value; offering new possibilities and application opportunities for further understanding, insights and justification by other relevant communities.

*“So there’s a massive amount of experiments, testing of things, a large amount of historical research and all those sorts of things we have all that documentation. So we submitted that, and we think it’s significant because anyone else who’s looking at doing 21st century in London, will obviously refer towards that, and it will become a landmark in both sense” (Interviewee F – Aca)*

*“But using my background and my approaches and my research in not the way that I would have intended I was going to use it, but in a really global project, that’s when it can work actually and when you can use research to try to inform people with other expertise” (Interviewee M – Aca)*

*“But you’re examining that problem using a very different approach, or interdisciplinary way. Maybe it’s always been dealt with from a psychological point of view. But the problem is the same, so actually originality is not how you look at the problem you’re looking at, I think, when the problem is new and the approach you use is new, and innovative, then I think you’ve got both, originality and significance” (Interviewee M – Aca)*

*“If it’s been shown in the Guggenheim, and gone to the Berlin film festival, you know those are indicators to the people evaluating that work to think of its importance in some way” (Interviewee F – Aca)*

Influence on a multi-disciplinary level implies more power and value of the output as indicated by the external feedback discussed in section 5.1.3.1. Therefore, communicating research on a bigger scale increases the possibility of spreading its influence. Exhibitions and conferences are tailored tools to exchange knowledge on a larger scale and to a wider audience, therefore influencing the depth and breadth of the impact on the targeted group of stakeholders.

### ***Publication, Reviews and Citations***

The influence of a research output can be measured by how much the new knowledge generated is used. In traditional research outputs, citations can be an indicator of the implementation of this knowledge. Non-traditional outputs can also be measured by publications or references to the use of outputs or processes; however, these outputs are not always referenced in publications. In some cases; however, non-traditional outputs serve as act as case studies inspiring new insights and applications

*“I mean even significance it’s going to emerge afterwards isn’t it, I mean in like 5 years time, if something has been cited a 100 times, 200 300 times, then you have the argument to say, well that is significant to something that hasn’t been solved” (Interviewee J – Aca)*

*“Particularly the one focused on head-neck reconstruction it’s all very case-study led, it’s all based on using a new bit of technology to make another bit ahead, and it’s like great, but I think that’s where we stand again, is looking at the wider impact of this, how you can transform a healthcare system where the costs are bourn differently, how you can change, the order processing, how you can influence industries manufacturing processes all that kind of stuff just isn’t published about at the moment, so I think we’ve got a bit of a leap on that in that area and that’s what we’re focusing on” (Interviewee E – Aca)*

*“We think it’s significant because anyone else who’s looking at doing 21st century in London, will obviously refer towards that, and it will become a landmark in both sense, you see what I mean” (Interviewee F – Aca)*

Similar to peer-review, editorials and reviews of a specific project or product are a good indication of significance. As indicated in Table 5.2, media reviews and press releases do not count as scientific measures; nevertheless, professional and academic appraisals, reviews, and editorials can still count as an applicable indication of significance.

### ***Incremental influence***

Incremental advancements score only 2\* (REF, 2019b), yet according to the external feedback to the WIRAD potential submissions (table 5.3), incremental contribution to the advancement of a subject or area of study was listed as a positive attribute linked to originality and significance. Similarly, design awards when judging functionality in terms of ergonomics, responsibility in the development, innovation and elaboration from a time perspective, design awards use incremental improvements as an indicator of impactful innovation and implementation of technology (Table 4.2), an importance equally highlighted by the literature (Fleming, 2001; Henderson and Clark, 1990; Poel, 2003).

Incremental improvements on already existing products such as switching functionality from non-renewable energy dependent to products using renewable energy or recyclable material can be considered impactful. Adapting and observing the performance of these adaptations is certainly a representation of the significance of an output. This significance is especially meaningful since people have more access to information, allowing them to



be more involved in conscientious decisions, and knowledge economies are built on informed and impactful decisions and industries.

#### 5.2.2.2 *Reach*

Reach is linked to audience; in this context the audience is potential stakeholders who benefit from or could be affected by the output (traditional or non-traditional). Considering the nature of this research and the focus on non-traditional outputs, the stakeholders are researchers, artists, designers, practitioners in the health and sports industry, or users (general public).

*"I think it very much depends on who is actually reading the article in the first place to know how to actually target their interest. (Interviewee G – Ind)*

*"Significance really comes from that recognition by the discipline or beyond the discipline, this is something that changed or that is important in that field, so it can be something quite modest" (Interviewee F – Aca)*

*"You could have a very significant, a very original and a very rigorous piece of research, that was perhaps an artifact, and if those 300 words don't explain clearly, so it won't get a good score because people won't understand the underlying research (Interviewee C – Aca)*

The relevance of the research to the audience is essential to its significance; how the audience perceives the research output, value it, and assess its relevance and applicability. Reach is expressed by the ways an output is contextualized and delivered to the audience. The way any output is perceived and processed impacts the knowledge and technology learned from it, and consequently the new insights and generated understandings (Hermans and Castiaux, 2007; Nonaka & Takeuchi, 1995), which then could inform any significant research value in an output.

#### **Time**

*"You know if you publish a journal tomorrow, it's unlikely, I mean it might be cited in a conference paper or something, so you publish something tomorrow. Someone reads it the day after, cites it in a paper the day after. Then if that's a journal paper, then that journal article won't be out there for a year. Generally it's going to take a long time for citations. What you can't do, say it's been cited 5 times in 1 year it means it's cited 10 times in 2 years. (Interviewee J – Aca)*

The lead-time between the availability of the output in the public domain and its REF submission is an important variable in the evaluation process. Whether the panels are considering citations, reviews, sales or feedback, it all requires time to surface, and the shorter the time gap between availability in the public domain and the time of evidence collection; the less evidence is collected to support a submission. The REF guidance (2019 a) acknowledged the importance of timing in this context and addressed the issue by considering citations' number relatively to the time of the output's availability in the public domain.

The accessibility to technology and knowledge at the right time can make a significant difference in the development of another output or research as discussed in section 4.2.1.2 on timeliness in access to improve practice. The importance of timing and its relation to accessibility has been also tackled in the literature (Tsey, 2019) and in this chapter under section 5.1.2 on building a portfolio and collecting timely evidence. As such, the ability to track knowledge and information leading to and resulting from non-traditional outputs, is essential in detecting impact and potential significance.

### ***Commercial performance***

Positive commercial performance did not seem a relevant research quality indicator to some interviewees. Sales figures do not always reflect the quality, success, significance or even originality of an output. Interviewees seemed to agree that higher sales could simply be a result of price cuts, or good promotion.

*"Let's say they had good end results, the reason was the actual promotion, marketing and sales effort that we put, or was it really research, the research effect on what we've done [...] so it's usually very blurry to what really caused, what really caused this success or impact of this product. (Interviewee A – Ind, Aca)*

*"You could try and say well, how many people went to that exhibition? But it could be a reasonably small exhibition or for a short period that it was very significant, very original, or you could have a piece in a large exhibition perhaps, and the TATE or the Tate modern, and lots of people went, but it's not very original, it's not very significant" (Interviewee C – Aca)*

*"They would also pay hundreds of millions of pounds for somebody like David Beckham to wear a pair of their trainers, because they'll earn more money from that than they would if they say these trainers reduce injury" (Interviewee L – Aca)*

*“So you could have what’s the cheapest, so that’s the most successful, no it isn’t , so it’s the one that has the balance between the quality , affordability ,, performance , so there are different factors, and you could say, the most successful product is the one that sells the most , and it will be one product in every sector and every market that sells the most , but it doesn’t mean that it’s the most significant, the most rigourous and the most original. It just means, that it’s the one that sells the most. (Interviewee C – Aca)*

This agrees with the content of “The Metric Tide” report on the difficulty in using quantitative measures as an indicator of quality (Wilsdon et al., 2015). The report also argues that some data such as sales are plausible indicators of impact, even though in most cases this data is too varied and does not have any benchmark to be compared to (Wilsdon et al., 2015).

Although these statements all agree in essence to the fact that high sales alone do not reflect the research quality or significance of the output, they appear to have a common factor that limits their applicability in all scenarios. These statements are mostly limited to one type of output: commercial products purchased by general public rather than a group of users with a specific set of expertise or knowledge. In the case where the consumers are not experts, consumption is not necessarily based on significance or rigour of the development process, which is a constraint as argued in chapter 4 section 4.1.1.1.

In cases such as medical products used by medical technicians or physicians, or gymnastics equipment used by professional gymnasts or coaches, or industrial machinery used in a production process; the context changes, and the argument on whether high sales are an indication of quality therefore differs. In this instance, claiming that high sales are a result of significant and improved quality becomes a valid consideration. When the adoption of the output is more reliant on specific skills and knowledge justification by the relevant community (Hermans and Castiaux, 2016), the high sales can reflect the knowledge the output embodies

*“So once we’ve got a letter from the accountancy department, saying we’ve independently evaluated this piece of work, and it saved us a million pounds a year, it’s impact isn’t it” (Interviewee K – Aca)*

*“So stuff that we started to pioneer 10 years ago a decade ago really, has now become a commercial influential for a big company, so we have a testimony from them to say, so this work has influenced their ability to get into this kind of field” (Interviewee E – Aca)*

Testimonies and reviews of benefits from significant stakeholders can be effective evidence. Proof of how an output or process have improved aspects of the user's experience or changed stakeholders' behavior, can be used as an illustration of significance. Such 'reviews' type of evidence of significance could be achieved either through post-use market research, or data produced throughout the prototyping and testing phases. Observing a change in the quality and speed of surgical procedures, difference in the patient's quality of life, or in commercial products such as speeding up the process of achieving daily tasks are non-dismissible evidence of performance.

As such, the use of any quantitative evidence has to be within a set context; a strong link has to exist between the performance of the output, and the rigour of the process it went through. In other words, there needs for a proof that all else constant, the rigorous process and the quality of the output are directly linked to the output's performance.

### **Prototyping**

Where justification of existing impact does not yet exist, an alternative indicator of potential significance is needed:

*"If you class it as a clinical order all you're trying to do demonstrate whether your product or our new approach meets the necessary clinical requirements, you can legitimately call it audit of services, so you're testing something against no clinical measures and using procedures that have been validated already like questionnaires and stuff like that" (Interviewee E – Aca)*

*"And to the point, where you can assess whether that prototype approach, or the designers have that capability that you can add value to the early stages to where that is going."(Interviewee B – Ind, Aca)*

*"Where I am now, you know you can push the design out, you can test it with users, you can go, depending if there's a 20% sales uplift, that is worth."(Interviewee A – Ind, Aca)*

Prototyping in industry serves as a tool to justify discoveries and innovations, equivalent of testing a scientific hypothesis. Prototypes reflect the potential viability and usability of an output by testing what it claims to do. However, the errors that prototyping and testing carry, and the changes taking place post-trials imply that any prototype does not perfectly reflect the functionality and value of the output. Many external factors can

interfere with the functionality such as the environment surrounding its use and production. Nevertheless, prototypes can still be indication of a rigorous R&D process and its potential results.

Since knowledge transfer has become more of core to the university-industry collaborations and an international necessity, the ability to reach a multidisciplinary audience has become essential. Prototyping is an interactive way to deliver technology and reach stakeholders. Producing new knowledge and research that cannot reach and is not built to the needs of the relevant audience limits its potential impact and therefore significance.

#### 5.2.2.3. Context

##### **Prior Art and Literature**

Setting the context for any research output is essential to the understanding of its benefits and contributions to knowledge. Context is even more relevant in non-traditional outputs due to the lack of explicit written explanation and description of the output's attributes, relevance and benefits compared to traditional outputs. The external feedback in table 5.2, and the review of top submissions in section 5.1.3.2 highlight the importance of context for a successful submission.

*“Let’s say in design, you should have to give the context in which something should be looked at, cause otherwise I could show you a 60 min film, and otherwise if I don’t give you all the surroundings of how to look at it, you can’t see it. (Interviewee F – Aca)”*

*“I think the research that helps us understand the context that we’re designing in, be that looking at the market, looking at competitors, so the competitor analysis is an important part in knowing what everybody else is doing and making sure we not repeat or not duplicate.” (Interviewee C – Aca)”*

*“it might be in the execution of the designer intent, how maybe the usability is heightened, and they’ve been analyzing competitors’ products and they realized that weakness in an area and they are trying to address that. Some of that is original and some of this is significant, and some of it is just trying to provide the differentiation between the competitor and its clients”(Interviewee C – Aca)”*

When it comes to addressing artists, designers, practitioners and researchers in health and sports sectors, the ability to locate the output within previous work, or literature is essential to highlight its position:

*“Designers often don’t have really good scholarships, so they’re often not very good at being able to say the significance of their work in relation to other work, because they’re doing that work and they are delivering it and the clients are happy or it wins award...and it’s not really a tradition in design to know who is doing work like you are in the world, they’re not so good at it (Interviewees F – Aca)”*

While there is not enough evidence to assume that this statement is applicable in all contexts, it might be applicable in some cases. It could also be true in fields other than design where the practitioner is not heavily involved in the research. Not being able to locate work within its broader context can jeopardize the ability to argue the level of significance. The knowledge of prior art and existing literature (Friedman, 2000) is as crucial as practical experience in communicating and achieving significance. This also affects the ability to tell a story to support the decision making process within an organization or a collaborative commercial/research project between multiple institutions.

### ***Location and Environment***

Experts in specific fields such as surgical and prosthetics design and sports education highlighted the importance of location and environment as relevant factors to the significance of outputs:

*“As you said there are other places around Wales that you can go to and say just print us something, but what’s holding us together is that it’s still a research relationship [...] We are all working on different projects and producing some really good stuff, so developing those relationships and especially in some small areas, we’re very lucky in South Wales.” (Interviewee D – Ind)*

*“You have universities like this where our sports research scientist a fairly good nationally and internationally, and it’s the environment for example, I’m able to do research down on the track I have all my equipment there, the national training center for a lot of sports, my network here is big, I’ve got a good sort of PhD base, postdocs now and then, so it’s quite productive [...]this environment facilitates the development of research. If I suddenly left and moved into the University of South Wales for example, I don’t know what their facilities*

*are like but they can just give me more money but then I wouldn't be able to do anymore research.” (Interviewee L – Aca)*

While some research argues that geographic proximity does not highly impact the success of collaborations (Greitze et al., 2010), more recent literature on university-industry collaboration argues the opposite (OECD, 2019). The importance environment and location, specifically to health-related fields, could be due to the importance of timely and cost effective solutions (governments, health and safety regulations, and NHS). Such outputs could be more effectively achieved when the stakeholders are logistically close to one another, and able to establish a more successful and long term and trusting relationships, leading to better collaborative grounds (Dyer and Singh, 1998; Garcia et al., 2019; Gibbons and Henderson, 2012; Wit de Vries et al., 2018). Therefore, proximity can also play a role in facilitating the smooth and highly vital knowledge exchange interaction between industry and academia, in order to reach optimum value standards and cost, as well as achieving a high understanding of the surrounding social and economic context.

On the other hand, environment and location affect the output's radius of influence: local, national or international. While proximity can achieve empathy and understanding of the local or national context, international collaborations can increase the potential for accessibility to resources and audiences resulting in a larger scale influence as argued in section 5.2.1.1- Scale of influence.

Due to the value of time and resources in fast moving industries with increasing competitions, cost, time efficiency, and impactful collaboration achieved by long-term relationships stand relevant. It is thus apparent that the location and environment surrounding the university-industry relationships are highly relevant to the outputs' impact and their potential radius of influence. Therefore the environment and location are criteria to be taken into consideration when understanding significance from a practicality point of view:

- Proximity in location: time and cost efficiency, better potential to nurture long-term relationships, in-depth understanding of the contextual surroundings of an output, familiarity with the environment.
- International collaborations: higher reach and accessibility of resources and audiences.

Significance of an output is therefore captured through three main facets; 1) its extent represented by the magnitude and fields of impact resulting from the research and knowledge pumped into the output, 2) the reach represented by the stakeholders justifying the output, and 3) the context surrounding and shaping the output and its relative importance.

The variety of stakeholders involved in university-industry collaborations implies that significance means different sets of benefits for different stakeholders. The stakeholders' interests justify these differences. From the industry's perspective, especially for commercial collaborations, significance of the output is often measured by its impact on practice. Details on the process or its academic significance beyond the output's performance or its impact on practice, is not always of interest (Hermans and Castiaux, 2016). The concern in the depth of information is therefore diluted, consequently affecting the conservation and management of a detailed level of information. As such, analysing and reflecting on this information in a manner that will serve in detecting and processing any potential new knowledge or research, or producing a rigorous portfolio in the case of a REF submission, are not a priority for industry.

### **5.2.3 RIGOUR**

While academic rigour in science is methodological and explicit, the nature of non-traditional outputs means that identifying rigour is not as straight forward. Rigour; therefore, has to be proven in elements and patterns featuring a methodical, analytical and replicable process (Calmorin and Calmorin, 2007). It is likely that the processes identified as research could be drawn and reapplied when looking at multiple and repeat processes.

Rigour is understood in the 2019 REF guidance as "the extent to which the work demonstrates intellectual coherence and integrity, and adopts robust and appropriate concepts, analyses, sources, theories and/or methodologies." (REF, 2019b, p.35).

Dissecting the 2019 REF definition of rigour results in four major points:

- "...intellectual coherence and integrity ..." where the output has a clear aim and objectives, leading to relevant outputs that contributes to the existing body of knowledge or technology.



- “...robust and appropriate concepts, analyses, sources, theories and/or methodologies ...” where the appropriate methodologies and concepts etcetera have been used, providing that the results are not occurring by pure chance, and providing that the use of this specific methodology is valid. In non-traditional outputs, this applies to research (user study, material research...) and the development process (generating ideas, comparing alternatives, prototyping, testing...) involved in R&D process.

The academic approach of the REF in defining rigour is based on the methodological composition of the output’s process: an appropriate method using appropriate data to solve a problem. The external WIRAD feedback (Table 5.3) regarding rigour also focused on a rigorous methodology process and its context.

The interviewees’ opinion on how to locate rigour within non-traditional outputs came in harmony with the REF definition of rigour. Table 5.6 below represents the subthemes that emerged regarding rigour listed under two main overarching themes identified in the headings the source of rigour or where to locate it, and the evidence.

Rigour	
Source of Rigour	Evidence
Process	Validity
Methods	Time
Failure as a source of information	Quantitative versus qualitative evidence
Repeat business and Meeting regulatory requirements	

Table 5.6 Themes and subthemes arising from the ‘Rigour’ category.

#### 5.2.3.1 *Source of Rigour (Where to locate rigour)*

##### ***Methods and processes***

The perceived importance of academic rigour differs between commercial industry and academic contexts. Industry stakeholders tend to focus on the results, the output and the benefits it will generate. While this does not imply a complete disinterest in the rigour of the process, the depth of interest differs from academic stakeholders’ focus on rigour.

Reporting rigourousness to commercial stakeholders varies depending on their requirements or nature and set up of the project. The nature of collaborative projects

means that stakeholders with potentially different interests are involved, and needs to meet their objectives. Factors that inform the collaboration's decision-making process are similar to the ones that inform academic research rigour, when the project aims at solving a problem or improving a current condition. The use of validated research methods is crucial to argue rigour, i.e. providing proof that a systematic well designed process was developed and followed throughout the project to achieve the brief set prior to any collaboration.

*"There's a fundamental difference between that [academic] approach which I learned which is to demonstrate insight understanding to the root cause of the problem if it is problem oriented, and then determine where the intervention should go, and what we were doing, which is behaving like a bunch of consultants: 'we have an answer, now what's your question?'"(Interview K – Aca)*

*"You know rigour tends to be, you know you look at the methodology. So you know, you'd look at it and say ok so where they got the data from? How big is the sample? What sort of analysis they've done? Can you be confident that the results they are claiming are actually valid etcetera. So that's numbers, but even if you're taking case studies, I mean you know, how many case studies have they done, have they just done one"(Interviewee J – Aca)*

*"I think rigour is where people think, how rigorous is the process, and that is something that is hard to get across in 300 words [...] So people can equate rigour with quantity and that isn't always possible in non-traditional research. It's more quality rather than quantity. Yeah ok so I did a performance, 'oh , so how many times did you rehearse ?' so that is sample size, 'how many ideas did you come up with before you develop that product?'. So people tend to equate rigour with quantity, just the amount of research, and you can have 1000 of survey respondents but the analysis is poor and you end up with unreliable results."(Interviewee C – Aca)*

*"So rigour you would get from good documentation of the processes, I think, mainly, and that would be aesthetic decisions, it would be practical decisions, it would be manufacturing decisions , things like that. And what we try to do now, is we try to, the staff that will be submitting, we try to get them aware of that much earlier on, so that we're not trying to assemble this material post hoc," (Interviewee F – Aca)*

Scale, time, costs, the production cycle length, prototyping and testing, and user sample are all elements used in justifying the rigour of the methods used. Collecting these supporting evidence of the chosen tools and their execution is required in order to meet

ethical and regulatory requirements. This evidence can also be used as necessary supporting evidence for the rigour of any output entering the public domain.

Keeping track of all information and data is thus essential in building up the proof of legitimacy of any decision made throughout the process. Being able to pinpoint the source of any idea or decision made throughout the development of the output can turn claims of intellectual property, or reporting to health and safety regulations an easier task.

### ***Repeat business and failure as a source of knowledge***

Tracking repeat projects and businesses is important to prove successful collaborations and achievement of the objectives (Hermans and Castiaux, 2007) and to track any impact that the output has (Tsey et al., 2019).

*“And if it’s a portfolio piece, it’s back to demonstrating our expertise in different areas and showing, say we’ve got one piece of work, and linking that to previous bodies of work that we’ve done before. So it was like continuous, so it shows that we’re not a one trip pony.” (Interviewee G – Ind)*

*“But I think where we stand in benefit and where we do better than other people is we’re prepared to talk about the negatives of this, and that’s, again, research is just not prepared to do that, we are prepared to be more rigorous about things and say “these techniques don’t necessarily work in all scenarios” (Interviewee E - Aca)*

Partners’ satisfaction is thus essential for the communication and repeat-collaboration. Achieving an successful output, that meets the initial set out agreement of the collaboration and satisfies the objectives of all partners, requires an understanding of the stakeholders, their needs, and the environment, and a well planned and executed output ‘production’ process.

Understanding the successes and failures of collaborations, learning the differences between stakeholders, and strengthening their relationship offer opportunities to transfer knowledge, validate outputs, and produce insights (Hrmans and Castiaux, 2006; Nonaka and Takeuchi, 1995). This cycle can inform future collaborations, consequently feeding to the spiral of creating new knowledge, research and outputs.

***Time, validity and the qualitative v/s quantitative debate***

While methods and processes are the core of the rigour debate, the quality and nature of the data involved in this process direct the quality of outputs and validate the created knowledge. A large data set or number of case studies and a narrow analysis can limit the results, while a rigorous and in-depth analysis of smaller sample size can be the source of original and impactful ground-breaking knowledge.

*“So people tend to equate rigour with quantity, just the amount of research, and you can have 1000 of survey respondents but the analysis is poor and you end up with unreliable results.”(Interviewee C – Aca)*

Concerns that quantitative scientific research faces, such as the sample size, cannot be directly applied in non-traditional outputs. Although many reviewers highlight the limitation of small sample sizes, and the importance of sample size saturation for research validity, this concept provides limitations especially with the cost and time constraints, which are major concerns in collaborations with industry (Guest et al., 2006). Small sample sizes (as low as one) can be justified and be equally as relevant and representative as bigger sample sizes in qualitative research (Boddy, 2016; Onwuegbuzie and Leech, 2005).

As such, the availability and validity of the relevant data, at the right time are more important factors in proving rigour of a process in non-traditional outputs. Maintaining track record of the information over a long period of time can differentiate the rigorousness of the process and its results (Tsey et al. 2019):

*“Rigorous data collection, to differentiate the causal issues from the symptomatic issues, and to treat, to insure that you get as close to the causes of the problem to put right, rather than treating the symptoms” (Interviewee K – Aca)*

*“And if it’s a portfolio piece, it’s back to demonstrating our expertise in different areas and showing, say we’ve got one piece of work, and linking that to previous bodies of work that we’ve done before. So it was like continuous, so it shows that we’re not a one trip pony.”(Interviewee G – Ind)*

*“So rigour you would get from good documentation of the processes, I think, mainly, and that would be aesthetic decisions, it would be practical decisions, it would be manufacturing decisions , things like that.” (Interviewee F – Aca)*

Therefore, considering that non-traditional outputs are generally a result of Mode 2 and applied research, the aim is to provide in-depth information and detailed case studies, which could be achieved with a long-term accumulation of information, learning-by doing (Tsey et al., 2019).

### **5.3 RESEARCH EXCELLENCE IN COMMERCIAL DESIGN**

Chapters 4 and 5 both covered university-industry collaborations in multiple industries associated with the participating interviewees. One of those industries is commercial design (the focus of this research and one main output of PDR).

This section will introduce research excellence in commercial design. The section will explain how the previous chapters inform the identification of research value in a commercial design context such as PDR, and more precisely in commercial outputs. This section will also present content that informs the next two chapters.

University-industry interactions, their benefits, limitations and communication, along with the possible criteria to identify quality research have been identified in these two chapters. In order to understand how these elements apply to commercial outputs, there is a need to: 1) Compare the commercial design process to the traditional research process, 2) Identify elements from non-traditional outputs that apply to the specificities of commercial design.

#### **5.3.1 COMMERCIAL DESIGN AND TRADITIONAL RESEARCH**

If compared, common elements could be found between the R&D process of a commercial output (tangible output, a service or a process) and a collaborative research project leading to traditional research output. Figure 5.1 is a simplified flowchart comparing the two processes

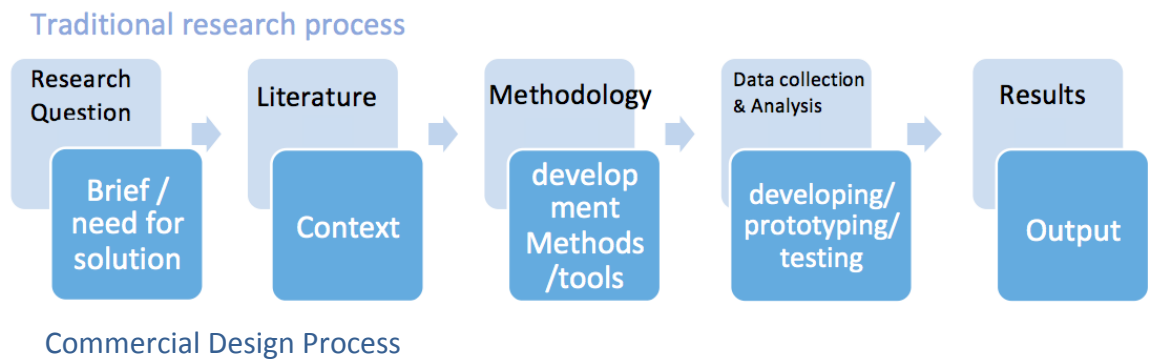


Figure 5.1 Comparison between traditional research process and commercial design processes

As opposed to non-traditional outputs, traditional research has been going through peer review processes for a longer period of time. The criteria and ability to assess such research is heavily reliant on the explicit and clearly laid out stages of a rigorous research process. Looking closely at Figure 5.1, some similarities between the research process and commercial design processes are highlighted, showing research elements leading to new insights and knowledge imbedded within the process.

A market gap or identified problem leads to a brief. Similarly, a gap within the literature or existing research leads to further research or new research question that requires answering.

Naturally, a research gap or a need for a solution both require a deeper and further understanding of the context, whether it is in the form of existing literature, competitors' analysis, or user studies, leading to the development of an identified research, method, or process to be carried out throughout the rest of the project. This research method then becomes the backbone of the project, whether it is traditional research or R&D process, to identify the data collection methods needed or the idea generation process or brainstorming, and later on, the trial and testing. Both processes eventually lead to an output; a written publication, an artifact, or a new process.

The process comparison shows similar elements to a traditional research process, and agrees with the definition of research set by the REF 'a process of investigation leading to new insights, effectively shared' (REF 2019a, p.90). The commercial design process also matches with the WIRAD external feedback in terms of holding a continuous process that

shows the research process not only the development process, creating an output that represents the process and is an international point of reference (table 5.2).

While the distribution of stages is similar, the depth and rigour of each one of these stages can potentially differ between a traditional research output and commercial output, depending on the context, the time, cost, and the nature of the university-industry collaboration project. Therefore the aim, the process and the output should be considered collectively.

The downside of considering the process on its own as the research-holding element is that it disregards the final output as an embodiment of knowledge (Bofylatos and Spyrou, 2017; Groth, 2016) and a representation of originality and significance. Furthermore, the output also plays a role as a 'tangible' measure of reach, validity of the research process it went through, testing and justifying relevance and performance of the output. All these measures are necessary aspects to highlight research excellence in a commercial output. The way an output gets curated, designed, researched or communicated, are all elements of the research definition that play a role in evaluating the output as research; hence the importance of managing the design process and discussing it in a holistic manner.

The complex and non-self-explanatory nature of commercial outputs potential research value, or inability to reflect the contribution to knowledge solely through the output itself, means that the set of supporting evidence has to be elaborate enough to justify the output's significance, originality and rigour.

The nature of the R&D processes and some of its independent elements are not traditionally believed to result in significantly new ground breaking knowledge i.e. human centered research (Norman and Verganti, 2014) exploitation of existing knowledge (Hermans and Castiaux, 2016). The collective evidence and the relationships taking place within the process leading to the output, serve as tools for new knowledge. The exchanged knowledge and technology, the incremental knowledge development, the new insights, and the development of the relationships between partners, all form a spiral leading to new insights and knowledge (Hermans and Castiaux 2006). This knowledge could be of research quality in terms of improving or adding to the individuals' set of skills, knowledge, or performance. Furthermore, the accumulation of these

experiences, and their intercommunication, lead to further new and relevant insights, also serving towards new knowledge.

### **5.3.2 COMMERCIAL DESIGN AND NON-TRADITIONAL RESEARCH OUTPUTS**

The current context of university-industry collaboration's responsibility to deliver impactful outputs requires capturing the learning and added knowledge resulting from these collaborations. The capacities represented by the interviewees in this research share three main elements with commercial design: 1) the dependence on existing knowledge and technology, 2) the intention to contribute to this knowledge and develop expertise, and 3) the need for rigorous processes to fulfill ethical and legal regulations, and create new knowledge with socio-economic impact.

Commercial design is one example of the collaborations resulting in non-traditional outputs contributing to existing knowledge and technologies, to create improved design practices, and potentially design knowledge. To be acknowledged as an embodiment of research value, a commercial design output needs to showcase evidence to support claims of valid, original, significant and rigorous knowledge creation.

Building an evidence base and a context around the decision-making timeline, and representing the knowledge interactions and transfer taking place, can create a reflective opportunity to capture information and insights leading to new knowledge. This accumulation of project references can also help accumulate a database of evidence of originality, rigour and significance.

The collection of this information cannot take place when needed all at once in retrospect, otherwise it will be time consuming, and a big chunk of the detailed data will therefore go missing or forgotten. Furthermore, if retrieved after a long time of its occurrence, the data will not reflect the designers' logic behind the decision; reflective information is needed to build the context around the design. As such, there is a need to record the activities carrying this information, as they occur, to reflect relevant interactions.

One way to collect rigorous evidence and accessible data for any future use or reflection is documenting; a process already adopted by many industries (Falessi, 2006; Munyisia et al., 2011; Navidi et al. 2016; Tang et al, 2005). Documenting the design process alongside



the designers' reflective thoughts and interpretation of these decisions, adds value to the occurring design process, and potentially facilitates the outsiders' visualization of the design (Gaver and Bowers, 2012) and the original, significant and rigorous knowledge and research value resulting from this design (Edelson, 2002).

Documentation of different formats offer the opportunity for designers to learn from existing experiences, knowledge, and technology, to inform new ones (Falessi, 2006; Gaver and Bowers, 2012). The WIRAD external feedback highlights the noticeable advantage documented work has (Table 5.2). Furthermore, chapter 4's analysis (section 4.1.2.3) highlighted the experience of some experts and the use of documentation for an effective preparation for the REF submissions.

In order to accumulate and collect relevant information from design projects, there is a need to identify what information needs to be collected under the three main criteria: originality, significance and rigour.

Most elements forming the three criteria and identified in this chapter for non-traditional outputs can be applied on commercial design as explained in this section. An accumulation of commercially relevant data could be useful to highlight information and activities relevant to the creation of new knowledge.

The commercial projects data is presented below to assist in documenting the relevant information. While this type of data does not directly reflect the new knowledge, this level of rigorous information can assist designers and researchers in drawing links, analyzing, and reflecting on interactions to materialize valuable new knowledge of research quality.

### ***Originality***

The three main aspects of originality are: the components of a process, the relationships between these components, and the point of reference. As such when it comes to data that could be extracted from a commercial output, this data needs to reflect any new components used, or a new relationship established/ environment surrounding the process, and the stakeholders involved:

- Stakeholders at different stages, source of clients, and reason of choosing PDR.

This information can assist in understanding why a relationship with PDR (or a

similar context) can increase the potential of original outputs and the reasons for the repeat/ new collaboration with PDR;

- Organizational environment, and business model are important elements in detecting incremental changes. Tracking the effect of the environment on the output and how it influenced and helped in managing relationships between stakeholders as well as resources, is crucial to detect any impact or innovation resulting from these incremental changes;
- Contributions of each stakeholder in the process are necessary information to be logged to allocate IP, give credit to the right stakeholder, and track any eligibility of claiming originality;
- Initial version of the brief, and every alteration, along with the final output; their evolution and applications at multiple stages help in tracking the changes and linking them to their sources;
- Dates and the stakeholders involved are crucial for detecting the availability in the public domain, and the source of information/ ideas to allocate credit.

### ***Significance***

As described earlier, designs originating from a gap, problem, or unanswered question in an area of research, generally hold within them the impact and the significance they embody through the problem they solve, and the way they solve that problem. Extent, reach and context are the defining components of significance:

- Stakeholders and their location can define the extent and scale of the work and its potential impact. These elements also categorize the fields the output might have an influence on, and the relationship and ease of knowledge transfer taking place (OECD, 2019),
- Awards and publications to inform the level of reach;
- Commercial performance and feedback; tracking these factors is necessary in correlation with the changes implemented in the process and reflected through the design. To investigate the drivers of a performance, it is important to identify the performance of the output, while monitoring the different activities, skills, and knowledge that fed into that output;

- Context and prior work/ literature (commercial and academic) are necessary to build the context and the existing knowledge and alternative solutions, competitors and availability in the public domain.

### ***Rigour***

The choice of the methods implemented in the process and how new and different these methods are, is a representation of originality, significance, and rigour. Using different methods to what is usually used, and how much these changes can be applied in similar contexts and still be as effective, or even applied in a different context yet still be as impactful, are a representation rigour and overlap with significance and originality. Furthermore, the methods and tools used can reflect and any insights generated and incremental changes inflicted.

- Methods: elements (sampling, prototyping, testing, analysis),
- Source (similar previous work, other disciplines, combination of multiple methods)
- Audits and ethical/ health and safety documents

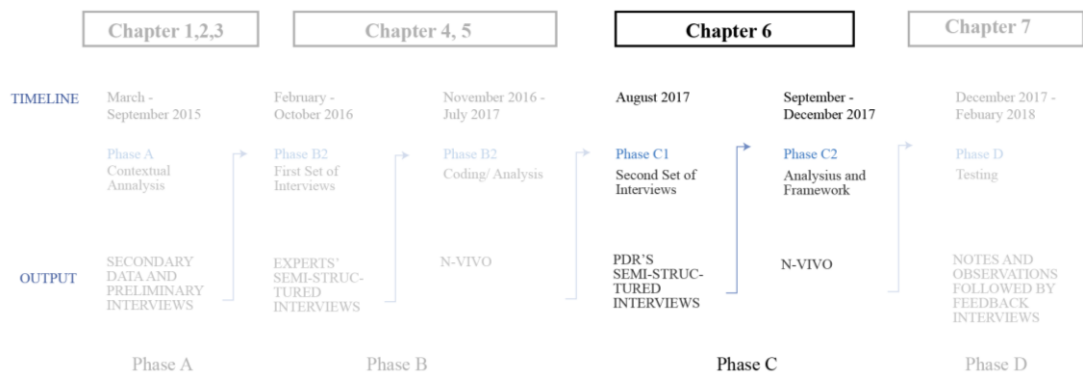
It is clear from all the criteria listed above and categorized in table 5.7 below, that many criteria overlap between originality, significance and rigour. While it is challenging to draw a clear line between the three of them, their overlap offers the opportunity to better understand the existing relationships. The design process combined with any existing transfer of information leading to new knowledge, and the output that serves to justify this combination, can all lead to the new knowledge and any existing research value.

Originality	Significance	Rigour
New process: non-existent, in the public domain, or adopted from another field	Directly and indirectly-involved stakeholders and roles	Clarity of methods used for: Testing, prototyping, research, sampling, tools
Application of new methods or adoption of methods from different fields	Environmental standards surrounding the output	Common aspects with previous or other work: mentioning previous relevant work
Management and internal climate surrounding the process	Publications and citations	Documentation of necessary forms
Relationships and engagement with stakeholders: meetings, times, input	Awards	Health and safety, ethical regulations, auditing material (ISO)
New target market	Timeline of events	Source of ideas and information
New collaborations	Prototypes and methods used	Clarity of purpose/ brief
Track of changes in brief	Prior work used in the	Qualitative and quantitative data

	development of the output	supporting the project: surveys, meetings, interviews, focus groups...
Track of changes and development stages of the output	The applications of the output: location and fields	

Table 5.7 Information to collect from a commercial design project to help argue potential originality, significance and rigour.

## 6 CREATING A DOCUMENTATION PROCESS FOR COMMERCIAL DESIGNERS



Chapter 5 addressed the availability of research value with potential original, significant and rigorous quality within commercial designs, in the R&D and output combined.

To capture this research quality and disseminate the knowledge, a level of granular information unfolding the different components of originality, rigour and significance need to be available. It became clearer with phase B that there is an obvious question around the availability of the right information at the right time in multiple occasions: the REF submissions, opportunities to capture transferred and created knowledge, transferring knowledge to new designers or staff, and exchanging information between departments. Relevant data accompanied by the reflective analysis of the people directly involved in its production and processing, is scarce.

The end of phase B also revealed a list of information that could assist in capturing any existing originality, rigour and significance in commercial design outputs, presented in table 5.7.

The next step is to explore the designers' opinion on a process to document information that will assist in capturing knowledge and sharing it. This will help in understanding the type and viability of implementing a documentation process in a commercial design context such as PDR.

The aim of Phase C (chapter 6) is to analyse the stance of PDR's product designers and design researchers, and based on their experience, where do commercial clients stand on knowledge extraction and sharing research with the broader academic community and industry. Chapter 6 will start with a better understanding of PDR's design process, which will embody the documentation process. The chapter will then present the drivers and barriers in knowledge extraction and sharing, followed by the available opportunities to do so.

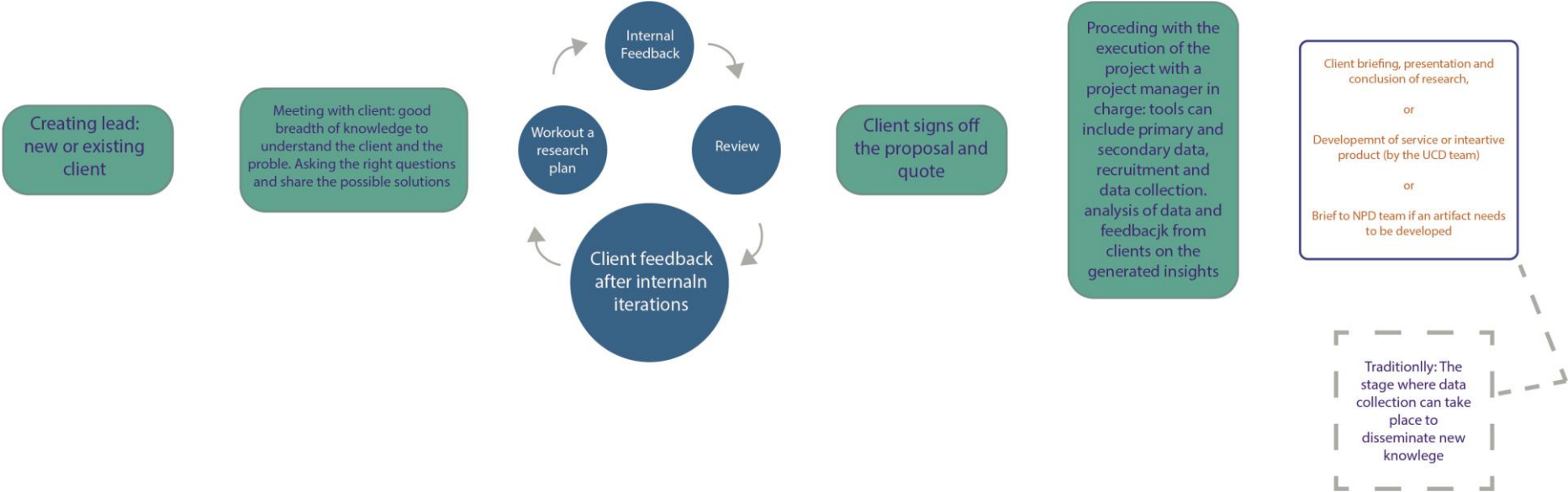
## 6.1 PDR'S DESIGN PROCESS

*"I guess that kind of highlights how difficult it is to pin down one process for product design, because there isn't one process" (Interviewee N)*

Design methods and strategies used in commercial design consultancies can be based on similar processes and common standards. The literature covered the main UCD research and NPD processes generally used; however, trying to draw a typical PDR commercial process seemed essential to look at potential points where valuable information for knowledge creation can be detected.

Figure 6.1 shows the different stages a typical commercial UCD research and NPD processes go through in PDR. All the designers agreed that, although this timeline showcases a typical design project, it does not necessarily mean every project goes through all these specific stages. A brief description of the process will follow the figure. Specific aspects of the process will then be highlighted. These aspects included difficulties mentioned by the designers, some matrices and methods, and the elements that constitute the iterative cycles; all of which might benefit from the learning process and increasing the efficiency.

UCD Research



NPD

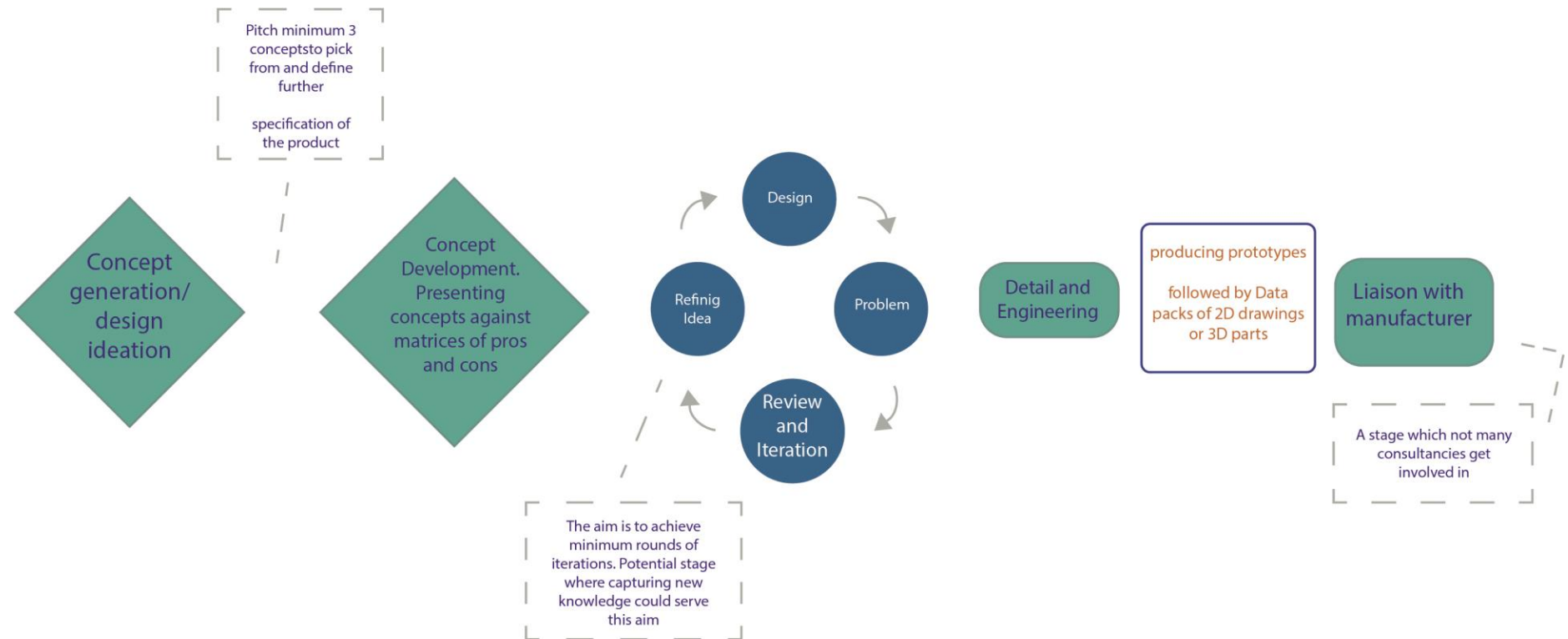


Figure 6.1 PDR's UCD research and NPD design processes timelines



The timeline in figure 6.1 is split into two sections, UCD research process and NPD. The reason why NPD follows UCD is simply because in some cases, what originally starts as a UCD research project - where clients are seeking recommendations or service development- can potentially lead to a brief for an NPD project to work on artifacts embedding these recommendations. This, however, does not mean that every NPD project follows UCD research method. In fact, most NPD clients seek NPD services independently.

#### **6.1.1 UCD RESEARCH PROCESS**

- The UCD research project is initiated by creating a lead through networking, personal connections, clients reaching out for the first time or repeating business.
- The next stage is to understand the client's initial brief, understand their needs and suggesting a potential plan of action. This stage could be led by the business development team, however, the capabilities and technical knowledge necessary for a thorough investigation can sometimes be limited; people from the commercial design team therefore need to intervene at this stage to investigate and capture the required information and give the necessary answers.
- After thoroughly understanding what the client is looking for, a research plan is drawn based on the available information
- This research plan goes through an internal iterative process within the design team to get feedback and improve it, while also receiving input from the client to make sure they are on board.
- After signing off the proposal and quote for the plan, a project manager is assigned, and all the activities are planned and distributed to other designers and/or researchers.
- The research work is executed and includes: literature and contextual understanding, recruitment, data collection, data analysis, and reporting to the client.
- The next stage depends on the agreement; either briefing the client and signing off the project, or signing off this stage and taking the project to the next stage of designing a service or product by the UCD research and design team. A third option is briefing the NPD team in case they are responsible for the next stage of

designing an output. In the case where a product or service is to be designed by the UCD team, they would implement a similar process the NPD team goes through.

### **6.1.2 NPD PROCESS**

After being briefed (directly by the client or the UCD research team), the designers collect all the required information, and go through a double diamond process.

- The team leads a concept generation/design ideation stage to filter the ideas
- At least three concepts are pitched to the client to choose their preferable options and specify the product.
- After redefining the concept, a stage of concept development takes a place while presenting it against a matrix of pros and cons.
- The refined concept goes through an iterative process: designing the product, finding out the problems and getting feedback, followed by reviews and iterations.
- When the design is agreed on and finalized, the detail and engineering phase takes place. This phase naturally includes prototyping to communicate and test the design, and is finalized by a prototype presented with the data pack to the client. In some cases, PDR provides the extra service of liaison with the manufacturer.

It is important to point out that these processes were drawn based on the cumulative information that resulted from the interviews. Some details varied between different designers, but the generic stages overlapped in what formed this design process.

The little details that cover the different suggestions from the designers, and the problems/ difficulties that affect these processes will be discussed in the next section

### **6.1.3 DIFFICULTIES IN THE RESEARCH AND DESIGN PROCESSES**

Throughout the process, the designers seem to face common difficulties, some of which are due to external factors, which are out of their control, and others can potentially be improved over time through learning. Table 6.1 lists themes that emerged from the

coding of phase C2 where designers discussed the design process they go through and the difficulties they face, which they think they could be managed more effectively.

Difficulties in the design process
Getting a defined brief from clients
Choosing the right methods
Opportunity cost
Cost of repetition
Business development knowledge
Managing expectations

Table 6.1 Difficulties faced by the designers in the design process (NPD and UCD)

### ***Getting the defined brief from clients***

One common challenge to both UCD research and NPD designers when dealing with clients is the lack of defined briefs or a defined market. Clients on multiple occasions present a very vague theme/ brief/ idea they are trying to work on, or if they have an idea, they struggle to answer some important business related questions: the target market, the span of their output etcetera. Although the designers and their experience is important in guiding the clients with such details, business strategy is not part of the designers' role, it is rather more of a managerial and marketing nature. Designers believe that some clients lack the understanding of a design consultancy's role in the commercial design process e.g. clients seeking advice beyond design related matters

*"Getting definition from a client is probably one of the hardest, like getting a well-defined brief, and, the client to understand enough for us. I guess the phase you can waste most time in, is the first one, concept design." (Interviewee N)*

*"No, no, we're not a business advisory service and not a marketing agency, so it's the client's job to figure this out." (Interviewee O)*

*"So, yeah that [defining the brief] takes a long time, but the value of that stage to us internally is very high, so we take a long time to do it, more the issue there is how few people are able to do it, and I think that's training issue and confidence. So like I said, the business development team, don't have the confidence to do that stage, so instead, it ends up being the practitioners doing that stage, because we're the people who have the knowledge of the methods and the application of the methods. And actually that doesn't work great, because if you have to pull the practitioners off a project work to write scoping design proposals that may not even come in, that's where it gets problematic, if we are super busy, I don't have time to write proposals, because I'm busy doing the work [...] I think if we could do*

*a better job of internally talking about what we did, then that could maybe allow business development to move further down the process. So at the minute this is where business development stops (points at first step of the process), and then all of a sudden it's like me or jarred have to do this. (Interviewee P)*

While the concern of giving business related advice will remain outside of the designers' expertise and role, documenting data and information on these matters from previous projects can help other departments such as business development improve their breadth of knowledge. This in turn can assist clients in managing this aspect of the process before getting the designers involved; saving resources, and potentially help creating better briefs.

*"So it needs somebody with a good knowledge of the UCD process and what we might be able to do for them, like the breadth of knowledge. So that actually ends up being a bit of an issue internally for PDR because our business development team is not really well trained in UCD." (Interviewee P)*

### **Generating the Right Methods**

For the UCD research team, deciding on what methods to use relies on different elements. It can either be a previously implemented method in a previous similar project or context, it could be a method that has been created and 'customized' for the specific needs of this project, or a method adopted from a different discipline. Naturally, in this scenario, the process relies on the academic and practical experience of the designer or design researchers involved.

*"I would think about the aim and what we are trying to get to, do we have any previous projects that might be applicable? Have we read about any methods that might be applicable? If none of that is, if there's no sort of existing knowledge base on what we do, we might go out and do a bit of research ourselves to try and find out whether somebody else has done similar projects or we might just make something up." (Interviewee P)*

Even after the choice of the specific method, getting feedback from other designers is important to achieve the most successful iteration possible. Clients' feedback is a crucial element in this process; their opinions, the budget limitations they have, and the risks they are willing to take play a role in the choices of methods (type, sample size, scale, data collection tools...) chosen for the specific project. Similarly, the knowledge and

experience of researchers outside the commercial design team is of high importance, and can add to the process value and outputs.

Similarly in the NPD process, making decisions on the choice of methods used for designing, prototyping, and testing, relies on an elaborate set of criteria (time, cost, difficulty of the project, technical details...). The time spent on choosing and applying these methods is a critical point in the allocation of budget and time.

*“Sometimes we fall into the trap because of what we have at our disposal, because we spend too much time designing the prototype and not designing the end thing.” (Interviewee O)*

Collecting data and learning from experience to generate transferrable knowledge, can be useful to reach an optimum number of iterations before the right method is found and used. Increasing effectiveness and decreasing repetitions are benefits that came out from testing documentation processes in other disciplines, such as nursing and software engineering (Falessi, 2006; Munyisia et al , 2011; Tang et al, 2005).

### ***Cost of repetition***

Cost is a consequence of the high number of iterations when narrowing down options. Both NPD and UCD designers and researchers believe that there is a chance to reduce the number of iterations to get the right results, and believe that previous experiences can help in achieving that. This reduction of iterations becomes more confusing when dealing with clients who are facing their own inter-departmental conflicts of interest; discussed further in the internal politics (Section 6.2.1.2); having to attend to these different conflicting requirements, and finding a middle ground to meet all the needs is time and money consuming.

*“Yeah it’s hard to say to a customer ‘you might have to pay for this four times before you get it right’. It’s like how long is the length of the string- kind of situation? And how good you want the product to be? What kind of compromises the client is really willing to accept?” (Interviewee O)*

*“All of those decisions get made at that stage. That gets kicked around internally, and gets sort of finalized, and that’s what we use to quote against, so we generate a quote off that. So without knowing which methods you’re going to use, you can’t*

*tell people how much it's going to cost, because obviously you don't know how much time you've got, so you've got to do that before the project starts."*  
(Interviewee P)

Going through similar processes, documenting, and reflecting can assist in finding patterns, and help designers in effectively achieving the needed results, which has been previously tested in software design (Falessi, 2006)

### **Data Quality**

Knowing what to expect and what can be delivered needs to be identified and cleared out at the beginning of the project. The better the expectations and capabilities are set, the more successful the project is and the easier it is to manage expectations.

Making process-related decisions rely on more than just the design's functionality and esthetics. Some matrices related to internal and external auditing assist in making the right decisions. Matrices such as the FMEA risk analysis are necessary for highly sensitive products, especially medically related ones. ISO is another auditing mechanism that design projects regularly go through and designers are expected to provide the adequate documents and information to keep track of all the necessary data the audit system requires. Similarly being able to produce academic quality information that would potentially be used for research production requires the rigour that commercial design does not necessarily require.

*"If they say it's too expensive and ask us to cut stuff out, then that stage repeats, and what needs to be clear in the second proposal, is what are they losing. Cause you can't just cut stuff out and then be like 'yeah we're going to produce equally as good outcomes, even though you're not taking our recommended process!'. So a good example is where I spoke earlier about workshops v/s interviews, we need to tell them, that 'we can make this cheaper if we do a workshop rather than interviews, but what might happen is that there might be bias, there might be group think'"* (Interviewee P)

*"It is a research project, but a commercial research project, and there are things that as a result of that happened differently than to how they would in a research context. So the ways in which we were able to recruit people, you'd be more cautious about that in a research project. The idea that we pay for participation to access markets is a bit tricky, from a research perspective, but it happens in the commercial, because you are driven, you have to deliver a goal by this certain time."* (Interview Q)

While rigour is the purpose of collecting all this data, rigour in reporting is not the main purpose of this process. Detailed data needs to be available for a rigorous processing of information.

## 6.2 ENGAGING IN RESEARCH

To grasp the potential of implementing a documentation process, it was crucial to understand the designers' willingness to engage and the difficulties in documenting and disseminating knowledge resulting from commercial work. Moreover, it is important to investigate what motivates or stops clients from engaging with PDR (as a consultancy within an academic institution), and how much are they willing to share with the wider community, any significant knowledge resulting from this commercial collaboration.

Table 6.2 below represents the themes and sub themes relevant to the designers' opinion on the matter and their perception of the client's attitude towards the process. The primary headings (clients and designers) represent the categories, and the second headings (willingness and difficulties) represent the overarching themes identified. Sub-themes are given in the columns under each heading. The sub-themes are distributed in a way that represents their categorization and how they relate to the themes. The themes (drivers and difficulties) will be discussed based on the relevant categories (clients and designers)

Engaging in Knowledge Dissemination					
Clients		Designers			
Drivers	Barriers	Drivers	Barriers		
			Engagement	PDR's context	Practicalities
The level appreciation and interest of engaging in research: production and sharing	Process versus output	Impact on development and learning from previous experiences	Managing resources and client's expectations	Management style and self-sustainability	Easier to look at the process as a whole
Clients' internal politics	Strategic decisions and output	Decision making based on experience	Academic v/s commercial frame of mind	Time and cost	Inability to remember details
	Costs	Interest in feeding back into research and nature of the design theory community	Lack of detailed information	Discipline and self-management	Not knowing WHAT and HOW much to record
		Keeping track		Impact on designers' careers	
		Institution's reputation		Motivation	
		Similarities between projects			

Table 6.2 – Results of phase C's interviews: Themes and subthemes arising from the 'Drivers and Barriers' of engaging in knowledge dissemination' discussion.



## 6.2.1 DRIVERS TO ENGAGE

### 6.2.1.1 *Designers and Design Research*

The willingness of designers to engage in any form of documentation or knowledge dissemination ranged from being neutral all the way to being on board. While NPD designers did not completely relate to the idea of theorizing and sharing research and its benefits for their career - potentially explained by the practice orientation - UCD designers, or designers with a research background (PhD) were fully on board and understanding the value in disseminating research from the projects. This could be explained by their in-depth engagement in design research through human centered research and studies they conduct on daily basis. Designers discussed multiple reasons why they would be on board for documenting their processes.

#### ***Learning From Previous Experience: Development, Decision Making, and Sharing Knowledge***

Interviewees pinpointed the positive impact of engaging in research on commercial and process development levels such as improving performance, cutting costs, and reducing processes times.

*“But if no body’s taking an academic approach to it, if nobody’s actually looking at the work and nobody is writing up that work, and showing it to a grand audience, we’ll never be able to share methods, we’re never going to be able to share like how we’ve come to outcomes [...] if it wasn’t for people doing that sort of thing, then I think learning and progression in particularly UCD, would have be a lot slower then it actually is.” (Interviewee P)*

Potential benefits to the engagement in capturing, documenting, learning, and disseminating knowledge from experiences can include but is not limited to:

- Speeding up the choice of the right prototyping method

*“And in this day and age, there’s an awful lot that we’re missing out on, because we don’t have the time to do that, especially when it comes to: how to prototype, when to prototype, iterative design, and testing of iterative design.” (Interviewee O)*

- Reducing time spent on the repeating research, choosing material and resources used

*“So practitioners are learning of other practitioners, you’re learning methods, learning new ways of approaching design projects [...] If someone has really thoroughly documented for example, a new method that they tried, and we’ve got a problem that fits in, that method would be suitable for, then that saves loads of time, because we’re not having to generate ways to gather that insight” (Interviewee P)*

Designers perceive the iterative activities and processes they go through, and feedback they get, as useful tools for future projects. If recorded, these activities could support future projects and reduce repetition, time and costs of re-learning. The same applies to mistakes and negative decisions in supporting future solutions and experiences, for other partners, designers or clients.

- Learning the ‘dos’ and ‘don’ts’ at any stage of the process.

*“And you can see how this applies to the thing before, if you come across a sticky problem, you can find how similar problems were solved before, and overcome it, because you can search it.” (Interviewee Q)*

*“But in terms of how we work on day to day bases, we’re not making our lives easier, because we’re not really sitting down and capturing and detailing and learning from the work we’re doing, we just don’t have that opportunity. If you’re good, you don’t make the same mistake twice, but it’s highly likely with all the commercial pressures that we are under and everything else, and all the rush, you do end up doing the mistakes, and not a nice streamlined, ever improving, ever purifying process of design.” (Interviewee O)*

*“A lot of decisions are made because we know from previous things we’ve done, that this is the right thing to do.” (Interviewee N)*

- Transferring knowledge

Designers perceive that by engaging in research dissemination-related activities, like keeping descriptive record of the data and information listed in the list above, can significantly improve the ability to transfer knowledge externally with industry or academia and internally on an organizational level

*“Not the rigourousness of the practice on that particular project, but in terms of our overall practice. So when I was doing the prototypes for a project, the tolerances on those parts in production, are 0.05mm and as I was prototyping them, I couldn’t achieve those tolerances. So we spent an awful lot of money vacuum-casting parts which in the end turned out to be useless, now I know that, my colleague knows that, but if we both go tomorrow, the new interns, when they come to do a project like that, they have no record of what went wrong, so they can go through exactly the same heartache.” (Interviewee O)*

PDR’s context (multiple areas of research under the same roof) and the potential overlap of their experiences can benefit from sharing such knowledge, primarily to learn of potential ways to execute the commercial project but also to seize any chance of potential collaboration or help from other teams

- Teaching new incomers:

The vast learning potential of knowledge sharing also applies to developing new staff skills within the design department. PDR welcomes a number of new designers and interns every year, and getting them on board of the project running at the time, or informing them of previous and current projects can be a difficult and time consuming task. The easy availability and access to this information in a comprehensive manner could potentially make this process easier.

- Distributing new roles

A systematic exchange of information and knowledge on an internal level could help with the difficulties of meeting and acquiring new clients. According to the interviewees, the roles within the process should be distributed between different departments in PDR. However, the limited depth or breadth of information on the projects limits some teams’ ability to confidently perform their roles.

*“So, yeah that takes a long time, but the value of that stage [business development] to us internally is very high, so we take a long time to do it, more the issue there is how few people are able to do it, and I think that’s training issue and confidence. So like I said, the business development team don’t have the confidence to do that stage, so instead, it ends up being the practitioners doing that stage [...]”(Interviewee P)*

- Knowledge from theory:

The idea that some decisions can emerge purely from experience or a brilliant moment of inspiration, detached from the process, came up during the interviews.

*“The difficulty is, is that the assumption is, is that the output is 100% consequence of the process, and it’s not all the time. Even if the process has lead to the product, there’s also chance and luck that comes in, and inspiration, that sometimes aren’t linked to the process.” (Interviewee O)*

*“I would say, largely we rely on experience of people doing the work. There’s no set way to approach a piece of product design” (Interviewee N)*

This perception can be contradicted by the argument that these moments of ‘inspiration’ come from the accumulated tacit and explicit knowledge and the high level of exposure to the design world, and not purely out of the blue. It has been argued that tacit knowledge is scripted and can be compared to cognitive models or frameworks people follow when they find themselves in a certain situation (Nonaka, 1991; Sternberg, 1994) and that knowledge is a result of processing and exchanging existing knowledge and skills (Hermans and Castiaux, 2016). In this case, tacit knowledge becomes so rooted in the person’s cognitive behavior that it seems completely natural (Ravetz, 1971) and cannot be linked to articulable knowledge.

This combination of learning efforts achieved through the documentation of all this knowledge and information, can help in improving and developing the processes that serve as incremental changes over time. The documentation can also contribute to the ability to externalize and explicitly share the knowledge, which as argued in chapter 5, can lead to more impactful outputs.

### ***Design Research Community and Interest in Giving Back***

Giving back to the research community was a value expressed by one of the designers with a PhD as an academic background, who believes that there is a need to disseminate and try to capture the value within the commercial work executed in PDR. They acknowledged different ways designers and design researchers benefited from knowledge created through basic or applied academic research, and especially research published by PDR. They expressed the value this information has on their career

development and ability to execute their work. Wanting to contribute to the creation of knowledge and research is driven by their acknowledgement of an existing spiral of new insights and information generated through their work.

*“So yeah I do see the importance of it, that being said, it’s a struggle on day-to-day basis. I am glad other people do that, but I don’t give as much back to the research world, as I would like to.” (Interviewee P)*

The lack of active engagement in research activity and dissemination so far can be related to the scale of the design theory community, its development, adaptation, and accessibility. Although design goes back hundreds of years, design research and theory has been evolving only for the past 70 years (Blessing & Chakrabati, 2009); therefore the scale and the way design research has adapted to the needs of relevant stakeholders, and the way it is presented, seems to be un-inviting for designers.

*“I think academia needs to change for us, commercial people, to be really able to push out lots of academic output, so they need to change what academia expects of designers, which is why at the start I mentioned IDEO’s blogs and method cards and those sort of things, because whilst it might not be considered true academia, they are sharing data for academics to write about” (Interviewee P)*

*“It’s tricky to have that research add value commercially, because not many people in the commercial design world read academic papers, so I guess if there’s a way of shouting about it, like sharing it in a less academic way.” (Interviewee N)*

It seems that although the intention of taking part in the production of new relevant knowledge does exist, PDR’s designers still find the way research is created and communicated a barrier to engage in it in an academic sense.

### **Reputation**

PDR’s commercial design team and researchers agreed on the benefits of engagement in knowledge creation and academic dissemination, with some uncertainty concerning the practical translation of such engagement.

PDR’s engagement in academic knowledge creation can be perceived as a positive attribute by some industries and commercial partners. The confidence that a level of reliable and impactful knowledge is created builds the clients’ trust in PDR’s designers’

skills. Decision-making supported by strong theoretical explanation helps in maintaining a trustful relationship with other stakeholders.

*“I guess yeah it reflects well on us as both like an academic establishment and in some ways commercial”(Interviewee N)*

*“You might save time in that, for example, maybe someone has done research to say you only need X amount of participants to... like the whole Nielsen’s thing, on having 5 to 8 participants in each study, well all of a sudden that scopes down your work, because clients are always like ‘well , why haven’t you asked a 100 people?’ and you can say to them ‘well A, money and B this guy who’s done this research that says 5 to 8 people for usability trials at formative stages, is enough’ and you get to demonstrate that research to them and they’re like ‘oh yes, fair enough’. So that’s a good thing.” (Interviewee P)*

*“And I guess we are seen externally as quite a, like forward thinking consultancy in terms of user centered, in the UK anyway, like a lot of companies I’ve worked for previously have spoken about PDR, in terms of being at the forefront of kind of user centered studies and stuff like that” (Interviewee N)*

PDR’s designers seem to be convinced that their affiliation with research skills and a research institution is an attractive factor for certain clients and a trigger for repeat business. The prospect of improving the quality and deliverability of these claims seems to be a push for designers and design researchers to take part and improve this process by engaging in a thorough documentation process.

### ***Similarities between projects***

When available, similarities between some projects; such as the type of clients, the type of products, the methods used to analyze the competition, the prototyping or any other stage in the NPD or UCD research processes, offer the potential to learn from previous experiences. These similarities can be extremely subtle, making it hard to detect and draw a line between these projects’ commonalities.

*“I am sure there is, it is really hard to evaluate because every project is, is completely different. Obviously there is going to be similarities between projects and things like that. Every client is different, every project is different, everyone is willing to spend more or less cash, and give you more or less time, and wants a different level of, like prototyping specifically, is expecting different things and expecting it to cost different amounts” (Interviewee N)*

*“That sort of thing is going to be anecdotal evidence to us, like we’ve done this process, the user say it’s much better, but still that’s qualitative anecdotal, and if we actually want to say we’re saving lives, we need to do a massive quant study on like comparative and that sort of thing, and follow up on the output.” (Interviewee P)*

Designers have the capability to filter through accumulated experiences and recognize where a current situation fits within other previous similar experiences (Cross, 2004; Lawson, 2004; Thomas & Carroll, 1979). To increase the potential detected patterns, accumulating systematically organized data and information on these processes can help build a critical sample of information, and easily draw a comparison and build a valid theory, potentially applicable in other similar scenarios.

### ***Keeping track***

Keeping detailed data when engaging with clients in commercial projects, helps in tracking decisions, and allocating responsibility and credit. It also allows anyone to enter the process at any stage and be adequately informed about the activities that have been taking place

*“So every project should be, could by its nature, accumulate a lot of data, and if you’ve got a design folder, you should have a design history tree of decisions that were made, why they were made, things that were changed, why they were changed” (Interviewee O)*

*“To keep a diary of what you did throughout your day, once you get into the flow, and once you know what you are writing, it’s only going to take minutes of your life, let’s face it, it’s not going to take a long times. For the benefits of; A-someone wanting to review your work and produce academic output, but also B-internal, for your own. Like there are lots of times where I’ve done projects and I’ve been like ‘oh, actually, we did something like that a couple of years ago, I am going to go back a pull out the data and have a look’, and you pull out the data, and you’re just like ‘ well, I’ve not documented it well enough, for me to remember specifically why I was doing it, specifically how I did it, what I did with that data to generate the results’, there has been times that that happened and for the 10 min it would’ve taken me to write a post about why I did it, how I did it, when I did , all of that sort of thing, yeah, I don’t buy into this thing ‘not enough time”(Interviewee P)*

*“So if I was cycling home, and I got knocked off the bike, and somebody had to pick up my work, everything about that process, up to that point, should be documented, so they can pick it up and keep working on it.” (Interviewee O)*

On top of its commercial importance, track record is necessary for research when it comes to intellectual property and claiming certain ideas, designs, or responsibilities of the work. In the REF submissions, details such as dates of publication, availability of the output in public domain, and ownership of the IP are key aspects of a submission.

*“Actually, do you know what, before you start working on this project, If I could’ve looked at those block pieces [documented processes], I could’ve immediately gone ‘actually no, in the public domain there is a light with a plastic box with a long laryngoscope on the end, through the process all these additional steps were involved, and the result of this project, although it looks the same, it embodies all of these steps that the initial product did not.’ So that helped me define that what I am submitting here, is the embodiment of these steps from this point of time, which is in the REF time frame.” (Interviewee Q)*

#### 6.2.1.2 Clients

Worries regarding the loss of competitive advantage lead to the perception that commercial clients do not see a benefit in the dissemination of knowledge from commercial activities. PDR’s designers’ direct experience with clients reflects a slightly different outlook on the matter.

*“I don’t think the clients, in the majority of cases would be particularly bothered whether the work generates an academic outcome as well as a commercial outcome.” (Interviewee O)*

*“So they actually like that, it’s a bit of a shame we’ve never done a paper about that work, cause like the guy who manages the project is more than happy for us to write a paper on it” (Interviewee P)*

#### **Appreciation**

Many clients’ main reason behind approaching and engaging with PDR is their appreciation of the knowledge generated from a university-based consultancy. The academic background and confidence in the knowledge-based decision making, gives clients the trust to pursue collaboration and repeat business.



Designers gave examples of situations where their academic knowledge helped them communicate to the clients that the decision made was the optimal one.

*“... Like for example Jakob Nielsen’s work on having 5 to 8 participants in each study, well all of a sudden that scopes down your work because clients are always like ‘well, why haven’t you asked a 100 people?’ and you can say to them ‘well A, money and B this guy who’s done this research, says 5 to 8 people for usability trials at formative stages is enough,’ and you get to demonstrate that research to them and they’re like ‘oh yes, fair enough’.” (Interviewee P)*

Commercial stakeholders see the impact of research and knowledge sharing on their internal development and progression. Some clients who started off by fully outsourcing the whole research and development to PDR went on to develop their in-house resources, allowing them to better manage and expand their commercial activity

*“Like client A came to us because they liked the idea of the rigour of a university, and that we are academics, and that we weren’t just some consultancy doing innovation, like we’re actually going to have backing to the work we did.” (Interviewee P)*

*“Some clients we work with care a lot about the process, and like the bigger more forward thinking clients we’ve worked with, they would interview us at the end and ask us what worked what didn’t work, how we think they operate, how we operate, can we learn anything from each other”(Interviewee N)*

The level of knowledge appreciation differs depending on the nature of the clients and of the relationship built between them and the consultancy over the years, including the knowledge of each others’ capabilities

*“You know, in many ways when we do that kind of work, we are trying to sell the fact that we’ve got people in UCD that are qualified that got access to these fantastic resources, all up-to-date thoughts on principles in academia and everything else, so we’re selling that to get them on board [...] Of course it also goes down to the way you manage the relationship” (Interviewee O)*

*“Small companies think the institution doesn’t have an understanding of the commercial work, having time frames that are not in sync with the commercial reality, being slow to deliver, and deliver things in academic terms which is not often what smaller companies want, large companies get it more. Larger companies either want to engage with the university and they understand the*

*value that university approach gives, or if they're confident you can deliver, they're confident.” (Interviewee Q)*

### **Internal politics**

Engaging in documenting information and sharing knowledge does require a consideration of the capabilities, involvement, and resources of the client. Any commercial entity formed of multiple departments will have specific functions to deal with different aspects of the design process, and this can inevitably create conflict of interest between departments. Finding the optimal meeting point between financial value, product development, image of the client, and value of knowledge exchange can cause a conflict between the involved stakeholders, consequently affecting the willingness to engage in knowledge sharing and documenting activities.

For instance, departments responsible for the R&D or health and safety are interested in detailed information behind the process (e.g. the details of the user study, health and safety requirements), while other financial or commercial departments might only be interested in the results and outputs with the lowest possible costs. These differences can create a different stance on the relevance of keeping a detailed level of information. Internal conflicts therefore can affect the knowledge management capacities

*“Like the client is obviously the company, but there are different teams within that company, who care more or less. So we work with the new product team. Now **the new product team doesn't care how we get there,** what they care about is that we have innovative solutions at the end. But they also have **customer insight team,** and that team does have, like they do see the work that is generated, so we got commissioned by the product team to do some work and they actively said to us ‘we don't want any reporting, we don't want anything, like we just want the outcomes at the end, like we don't care about the rest; anything you can do to cut down time and money, cut it out [...] after that, we presented the results, and **some of the people in the customers' insight team** were in the presentation, and they were like ‘have you got the data to back that up ?’ and we said ‘well no, cause, like it's just notes from workshop sessions, and it's post-it notes, and **we don't have anything** to send across, we don't have that nice package to send across to you because we don't have the budget to write up that package, **cause product team told us not to,** so we didn't quote for that’. so yeah, it can even be within the same company that they have different demands”(Interviewee P)*

Interestingly, the reasons acknowledged by PDR's designers concerning their and their clients' drivers to collect and share knowledge, comes into solid agreement with the available literature on the benefits of such knowledge management. Learning from

previous experience (Dosi et al., 1988; Lee and Choi, 2003; Marsh & Stock, 2003; Tsey, 2019), training and informing other stakeholders and improving processes (Edelson, 2002; Garud and Nayyar, 1994; Parrin et al., 2004), bridging gaps between academia and industry (Friedman, 2000; Kolb, 1984; Schon, 1999) were all elements the designers acknowledge as benefits to such processes. As such, the reasons why a documentation and dissemination of knowledge process has not been done in PDR and many other similar contexts are not of fundamental nature, making the possibilities of implementing a successful documentation process on an organizational level more likely if the difficulties are realized and tackled accordingly.

## **6.2.2 BARRIERS OF ENGAGING IN RESEARCH PRODUCTION ACTIVITIES**

When trying to engage in documenting processes designers and clients may face a range of difficulties. Barriers can vary from the type of work they are engaging in, to the context they belong to, the methods used to do so, combined with the relationships and the risks that come with it.

### **6.2.2.1 Designers**

#### **A) PDR's context**

#### ***Management style and self-sustainability: Time and cost (For designers and clients)***

On a managerial level, PDR's context as an enterprise with a flexible management style gives researchers the freedom to engage in their research of interest and apply for available and necessary funding. Furthermore this flexibility in management opens the door for more informal interactions and exchange of knowledge and expertise;

*"It takes a particular type of people to work at PDR, I mean a lot of people try it and they don't like it here [...] lots of freedom for individual but some people I think can't work under the amount of freedom, and there's no one telling you what to do a lot of time, and you get to the point where you run out of money, and not being paid enough money to cover you." (Interviewee Q)*

Similarly, for commercial designers the bottom-up management provides flexibility that some people are not capable to engage in. Too much freedom might reduce the

designers/ researchers' ability to focus and set their own deadlines by estimating the tasks and allocating the resources. This flexibility could potentially jeopardize involvement in research, and make it more complicated and less appealing to designers. Time and cost are two essential elements to factor in when engaging in an activity such as documentation, for both the clients and designers.

*"So that was, we cut on the reporting, we didn't cut on the methods, we cut on how we presented those outcomes of those methods. Cause even just, you know, writing a formal report and doing a power point presentation that is what, three days of work. That is a significant chunk, like 10% of the budget "(Interviewee P)*

*"But we don't have the time or resources to translate that into other stuff. Because we are commercial, you know, a large proportion of my time has to be on commercial work." (Interviewee O)*

*"My time is driven by cost, and I have to charge for all my time [...] Commercial world is so different than the academic world, I don't know, super fast pace and deadlines." (Interviewee N)*

*"I guess like for me, normally I have many projects at a time, so to tell you what I did today, it might be difficult, maybe not every day maybe every week, like steps or decisions. I would find it interesting, I would find tricky to make it work in terms of time." (Interviewee N)*

*"There is nothing directly subsidizing an individual to take research" (Interviewee Q)*

*"Like, academics sometimes have vast timelines to do things, because there's no budget constraint on it, it's more like 'ok, we want to produce a paper for a conference that is happening in November, and now it's February.' That is a vast timeline in the commercial world. While commercially I might have somebody say to me, I want something in a month, so that obviously affects the rigour of the work you're going to do (Interviewee P)*

It is clear from some statements that designers can underestimate the time and financial pressure researchers are under, and that designers and researchers share some similar constraints. In both fields some other sources of income acting as a safety net can therefore be useful. The idea of engaging in teaching activities as a subsidy to engage in research activities is a solution to the financial pressure. In PDR's context, teaching requires integration with other schools and faculties that need the set of skills PDR's designers and researchers might have to offer. Although such dynamics can provide

financial and networking opportunities to engage in more multidisciplinary research for both designers and researchers, the time remains a constraint.

### ***Impact on Career***

Some designers' perception of academic basic research activity being a 'dull' process is the driver behind their choice of a practice-based career. The less exciting nature of basic research activities is something that all 3 interviewed designers had in common (N, O and P). Aside from the nature of research, its impact on their career is another reason for designers' disinterest in writing and disseminating research.

*"But to be honest, as a professional designer, my worth in the market place of all the designers, isn't going to be influenced by anything than my commercial abilities. So it's not going to add anything to my portfolio if I say 'you know, I've designed this but I also took up these papers, or got my name on these papers!'. No employer is going to care." (Interviewee O)*

As opposed to researchers or practitioners in other disciplines (medicine, sports, health), a designer's number of publications or involvement in research dissemination does not increase their employability potential or salary in many cases. The years of experience, their previous employers, and their portfolios play a bigger role in their ability to score a job or a client. This can be linked to some designers' perception that design comes from experience and tacit knowledge, which cannot be transferred, learned or written in books.

*"I would say, largely we rely on experience of people doing the work. There's no set way to approach a piece of product design I would say" (Interviewee N)*

While some designers might believe that all the knowledge is purely from their own experience, this claim has been negated by previous research. Even when it comes to ideas and decisions sourced from previous experience, the accumulation of descriptive and reflective information can in fact build a base to avoid repetitions and build future projects. Some designers argue that the mere activity of practice is research and source of knowledge and theory; however, a lot of this 'experience' knowledge comes from explicit theory and knowledge residing in the long-term memory (Nonaka,1991 ; Friedman, 2008; Hermans and Castiaux, 2006, 2016)

There seems to be a dis-interest in engaging in research dissemination activity by designers. Research has shown that when the relevant stakeholders do not value or do not see the clear benefit of an activity, their resistance to implementing it will increase (Waddell and Sohal, 1998).

### ***Discipline, Motivation and Self- management***

Even in cases where designers potentially see the value of some steps of the documentation activity, maintaining the motivation to collect adequate data throughout the process and years later (when it is time to reap the results or impact of the project) seems like a difficult task, for similar reasons discussed in the earlier section on the 'impact on career'.

*"Documenting what we've done is a big deal. But how we can actually get that seamlessly integrated into our design process, it's not just creating the boundaries and the definition in what we're expected to do, but actually having the discipline to actually do it. [...] like the timesheets, you need to complete it by Monday because someone does the figures on Mondays. But at the minute there is no one controlling that." (Interviewee P)*

*"Time is an issue, motivation to do academic output, personally I don't find it the most fun thing to do. So when you could be practicing your sketching skills or you could be writing a paper, you go for, it takes a lot of motivation to do the less interesting things or less fun things cause they are interesting.(Interviewee P)*

The self-discipline it requires to regularly engage in the activity of collecting the relevant information and managing the whole process of documentation can be overwhelming. Along with other limitations e.g. time, cost, seeking profit, disinterest in research, and not seeing the direct benefit on their career, research dissemination and academic research engagement do not seem like a priority.

### ***B) Practicalities***

#### ***Not Knowing How and What to Record***

Having research and commercial teams merged within one institution; PDR, has driven designers to take part in basic academic research both directly and indirectly. Observations in PDR's environment showed that even though designers are not directly engaged in the production of basic research, they do assist researchers who are

conducting basic or applied research and producing traditional research outputs around commercial activities. Designers are generally brought on board to share data with researchers, discuss commercial details, and transfer their in-depth knowledge and reflection around the relevant projects due to their direct involvement in all the decisions and interactions made throughout the project.

One main reason designers hesitate to independently engage in producing research outputs is their perception of academic writing as ‘unattractive’ and the lack of confidence in their academic skills and needs as discussed in the literature (Shanahan et al., 2015) and Chapter 4.

*“I think academic writing is horrible. I don’t know whether convoluted is the right word, but it’s like, you read academic papers and they use overly technical terms, they use really like horrible short sentences. Like academic style writing is a particular style, and I would hate to have to write reports in that way for example” (Interviewee P)*

*“I don’t know what is classed as research, and what is translatable and what is worthwhile really.” (Interviewee O)*

The lack of confidence in the academic skills, and how to collect or produce rigorous data for basic research, what information to record, and how to document in terms of content, style and language, decrease the interest in getting involved and trigger uncertainty. This in turn leads to more time to achieve the desirable datasets, and higher costs; issues also faced in architecture decision rationale documentation (Tang et al, 2005), software engineering (Falessi, 2006) and nursing documentation (Munyisia, 2011).

*“I think the reason people think there isn’t enough time, is because they don’t know what they’re writing. And if you don’t know what you’re writing, as all PhD students know, it takes so much longer, cause you’re just stabbing in the dark.” (Interviewee P)*

*“Like I think academia needs to change for us, commercial people, to be really able to push out lots of academic output, so they need to change what academia expects of designers, which is why at the start I mentioned IDEO’s blogs and method cards and those sort of things, because whilst it might not be considered true academia, they are sharing data for academics to write about” (Interviewee P)*

*“That requires time and resources that you might not have, and ability to write” (Interviewee O)*

There is thus a need to assist designers in the process of documenting their commercial work, by providing easier and efficient tools. Such tools could include electronic methods, which proved to reduce time and repetition in the health sector (Munyisia, 2011), and a systematic and specific list of what needs to be registered to increase the efficiency and time requirements.

### ***Forgetting details***

Designers believe that documenting and reflecting on information in details requires a holistic vision of the whole process to determine the significant elements, which are worthy reflecting on and documenting.

*“But actually...so you need to be very disciplined to follow up on the products and recognize that, it may not produce academic output now, but a year or 5 or 10 years down the line, when that product gets released, that’s when you’ll be able to do the academic output to that (Interviewee P)*

*“Yeah because if it’s the process you’re interested in, you probably get a better overview when you finish a project, when it’s done. I think, I don’t know. It’s like hard to see the day to day activity, if the project is a year long, day to day, I couldn’t probably tell you which part of the process, I could tell you where I was on the chart, but cannot tell you which parts were important to the process and which ones weren’t.”(Interviewee N)*

The drawback of waiting until the end of the commercial process, to look back in retrospect and determine the important components relevant to any new knowledge might be problematic for three reasons:

- 1- Some projects can stretch over long periods of time, and retaining detailed information on activities with all the related information and necessary rigour can be difficult.
- 2- On many occasions, the value of the process or implemented knowledge is not realized until after the production of the output. Similarly links and parallels between a process and previous projects cannot be clearly detected early on. The links can therefore be drawn only after the accumulation of multiple case studies has taken place.
- 3- Choosing what activities and decisions to record after reflecting on the whole process, might reduce the willingness of designers to record failing decisions or



report unsuccessful activities, which is a problem already faced in practice and in academic research (Faneli, 2010; Dawson & Dawson, 2018)

As such, any documentation and reflection activity need to take place in the nearest convenient time after they occur in order to avoid loss of information.

### *C) Engagement*

#### ***Academic and Commercial mindset***

The differences between academic and commercial frames of mind (language, timeframes, writing style, rigour of the data collection, methods of analysis etc.) are a barrier for designers to engage in both interchangeably.

*“But I think I think it’s also a different frame of mind and different way of thinking about things, and it’s difficult to shift between those seamlessly. So in commercial obviously we’re very driven by timelines, we’re very driven by producing deliverables, by things like we go out there and we do research, but the research, like the analysis and stuff won’t be as detailed or as rigorous, which obviously when it comes to producing academic outputs based on that same work, like you might have to go back and re-do some of the analysis to provide the structure that academic papers are looking for, and provide the rigour that academic paper are looking for. So you have to sort of switch heads, like you have to put on your academic hat or your commercial hat, and change your approaches to work and it’s difficult to do that all within one job role.” (Interviewee P)*

This does not imply that engaging in producing traditional outputs of academic standards is impossible. However, achieving it might need to take place through a relatively gradual process, ideally starting from the education level to adopt research skills of inquiry and reflective practice as a tool for better designs (Feldon et al., 2015; Frayling, 1993; Fiedman, 2008; Kuh, 2008; Shanahan et al., 2015).

#### ***Managing clients and gathering enough data and rigour***

Differences between basic research and commercial R&D including ethics, sampling, and above all managing time, costs and clients’ expectations, make accumulating data less of a straightforward process to adopt. Scarce resources from industry are limited to particular commercially related objectives.

*"If I am aware that we're thinking of using it for academic output, then I might have to consider the way I am collecting the data, consider the way like I mentioned before, like analyzing and like the rigour that's involved in it. Like we can get good outputs for clients, at a lower level of rigour, like don't get me wrong, we'd like to be as rigorous as possible [...] I guess thinking about where it fits in the academic world, what actually is novel about it, as far as academia is concerned. Because in academia, that's what we're concerned about I guess, is adding new knowledge to the world, and actually, commercially, we're not necessarily...we're adding new knowledge to that company, but we might be using the same processes that we've used before for somebody else. So, actually, the academic side of it, it might not be so novel, yes it adds another case study to back up that these methods work or that sort of thing, but they might not actually be that much novel in it, or that much novel work in it. And understanding going in, about what may or may not be novel about this work, so then we can make sure that we're producing what you need to get academic output." (Interviewee P)*

Due to these limitations, the engagement between the consultancy and the client differs from one client to another. The collaboration could fall under one of three categories:

- Full assistance: which includes handling the whole project or experience from its beginning till the end, giving the consultancy more flexibility in terms of the data or the type of decisions made, clearly always referring to the client for feedback and final decision making. Under this type of collaboration, the management of the process is in the designers'/researchers' hands
- Minimal assistance: the client has a clear detailed brief of the end product. The designers' role is to simply execute using their existing skills and available technology, with some potential changes. The nature of this interaction limits the depth of knowledge exchange and transfer, and consequently the potential newly generated knowledge.
- Middle ground assistance: Services sought by clients are based on a generic brief and knowledge of the final output but not entirely pre-planned. The designers' role is then to invest existing knowledge and technology, complemented by research conducted for the purpose of developing and fulfilling the brief.

Differences in types of interactions between designers, clients and researchers lead to a variation in the granularity of data and information collected and kept.

The type of created knowledge varies and the granularity of documented data is thus not solely dependent on the designers. This in turn affects the ability to engage in a research production or disseminating activity linked to new knowledge, due to the data limitations.

#### 6.2.2.2 Clients

Although as an enterprise within a university PDR is fundamentally built on the knowledge economy model; it still engages in a variety of commercial activities, some of which are not driven by a collaborative stance. Clients seeking purely commercial services might refrain from engaging with PDR or if they did, they might not be interested in sharing data and disseminate any resulting knowledge due to the commercial risks it might entail.

#### **Process versus output**

When it comes to potentially disseminating new knowledge generated from commercial projects, there are IP and credit allocation concerns. When any work is published in the public domain, one of the ethical requirements is to give credit to all the parties and stakeholders involved in the creation of this work

Since clients' IP is usually associated with the output and not the processes or methods used to achieve the output, designers do not think that clients are concerned when it comes to sharing information on the process rather than the output itself; which can be done without necessarily involving the client's identity.

*"I mean there's always you have to be careful about IP and IP release, when I'm talking about academic outputs, I'm thinking more about writing about the process rather than the outcomes. Because the outcomes tend to be like IP, like we can't release that sort of thing [...] I don't think a building society will mind us saying we did a project with them about first time buyers, or like we're doing a project on user experience" (Interviewee P)*

*"It's not difficult to write paper and not give away whom you're working for. And actually, the methods' IP is ours not the client's. So as long as we don't give away who the client is, and even like most clients I don't think care if we talk about them, what they do care about is if we talk about the outcomes" (Interviewee P)*

*"I think the issue of IP only really relates to the artifact instead of the process. And a lot could be published academically, should be on the process rather than the outcome" (Interviewee O)*

Since it has been established in chapter 5 that rigour of a commercial design is in the process embodied in output; e.g. new processes, methods, tools, decisions etcetera;

keeping track of different activities and decisions and their sources is essential throughout the project, to avoid any breach of intellectual property.

### ***Strategic decision as output***

The type of resulting outputs from a commercial collaboration between industry and university in a consultancy context can vary between services, tangible products, and/or a set of strategic recommendations. According to the designers, the more specific the product is, the more likely the clients are to engage in sharing results. In scenarios where clients are seeking a set of strategic design recommendations, which will potentially inform multiple future decisions, they are less likely to share detailed information and knowledge.

*“Some clients though, have projects which are novel and they don’t want competitors to know what they’re working on. In cases where the result of a project is a whole strategy like with [client A], and it’s everything for all their future decisions, so these results even if one product is in the market, the results of the research shouldn’t be published” (Interviewee P)*

Outputs such as strategic recommendations influence future commercial products or services, and therefore have a long-term impact on the clients, which increases the value and level of confidentiality associated with them. PDR-led user studies that resulted in such strategies (examples cannot be mentioned because they carry commercially sensitive names and information) were the culmination of a long and rigorous research processes, and an in-depth understanding of the problems. Such projects resulted in sets of recommendations and a vision for potential future artifacts, some of which were transformed into actual artifacts executed by the NPD team.

The iterative process that any commercial project goes through, and the accumulation of these projects over time, merged with the new insights and acquired expertise (tacit and technical), build up towards better, more improved, and resourceful outputs (Dewey, 1958; Nonaka, 1991; Nonaka and Takeuchi, 1995; Hermans and Castiaux, 2006).

Keeping track of decisions and activities is a requirement to the audit system used in design (ISO), the ethical requirements, the client, and certainly to the design team to manage expectations and processes.

The learning process resulting from these different activities and their repetition is an implicit value acknowledged by almost all the interviewed designers/ design researchers. Different activities carried out throughout the design process (investigating material, involvement in social responsibility, form, engineering and other technical elements) result in a learning experience through knowledge exchange, research and trial and error, which will help reach an optimum level of repetition and wastage of resources, and create new knowledge and insights.

The aim is to potentially accumulate a database of design cases and sharable knowledge. The debate on how operationalized tacit knowledge can be is ongoing. The link between tacit knowledge and competitive advantage is a limitation to conducting research in organizations, due to the fear of surfacing this information and risking the competitive advantage (Ambrosini & Bowman, 2001). Accumulating data on case studies can be significantly helpful in acknowledging these links and externalizing new knowledge generated from the different types of commercial interactions.

### 6.3 OPPORTUNITIES: HOW TO TACKLE THE CONCERNS

Understanding the barriers and the drivers led to two conclusions: the first is that most of the barriers are not the result of lack of research value in non-traditional outputs or the fundamental disinterest of the two communities (research and industry) in capturing and sharing knowledge. The barriers are rather technical, and related to resources and skills. Another conclusion is that contrary to the general perception, some clients do value the capture of knowledge and sharing it and others encourage it, while a considerable number of clients are indifferent regarding any research dissemination. The barriers for the clients, similarly to designers, are technical and related to time, cost and most importantly, commercial sensitivity. Some of these technical barriers could be addressed through managing the implemented documentation tool and how data is used when it comes to disseminating knowledge, while other barriers are more strategic and tackling them has to do more with the designers' benefit from engaging in such activities e.g. impact on career.

***Concerns related to the writing skills, how and what information to record:*** The information any implemented documentation process is looking at collecting, is factual

information rather than processed data ready to be shared. The aim is to collect this data and reflect on it, making it ready for any future analysis or accessibility. The academic analytical and writing skills are therefore not essential at this stage. Writing in a reporting style is suitable for the designers and their skills.

Furthermore, writing every detail on the process is unrealistic and unnecessary. The designers will need assistance in knowing what to record and what information needs to be registered. The documentation framework will need to offer a set of leads to assist the designers in filtering information and recording the relevant ones, the next section (6.3.1 What to record) will discuss this information.

***Cost, time and forgetting details:*** Two main concerns for both clients and designers are the time and cost of engaging in any activity outside the commercial projects. In order for any documentation framework to consume the least time possible, the load of information recorded at a time has to be minimal and memorable for the designers. Recording information as they emerge or with a short lead time, can save the designers the time of remembering the details and at the same time reduce the accumulated information they have to write. Facing big data at a time could lead to an overwhelming load of information, turning the documentation activity into an 'undesirable assignment'. Avoiding repetition of data, by linking the necessary documents that already include this information (briefs, contracts, minutes...) will also save time and effort

***Commercial sensitivity:*** The accessibility of information has to be limited to people allowed access to commercial material, or other stakeholders after getting the commercial team's approval to access it. This should be insured through any platform used for the testing phase as well as any potential implemented platform, where sensitive data is not online and have limited accessibility.

***Self-motivation and self-management:*** Considering the commercial context, adding a new activity to designers' to-do list will not be on the top of their priorities. Developing a process, which reduces repetition of data entry to the minimum and is based on user-friendly platform, will be the first step to facilitate the adoption of the process.

***Difficulties in the NPD and UCD research process:*** Section 6.1.1 discussed the difficulties faced in a typical design process, and the stages where designers feel something could be done to reduce repetition. The iterative stages, which include multiple back and forth interactions with the clients or internally within the design and research team, need to be

addressed in order to learn how to reduce the cost and time of repetitions. This implies that the implemented documentation framework has to use these stages as a point of reflection and new knowledge capturing. In turn, the documentation offers enough data on multiple projects and case studies to generate theory or generalizable knowledge.

### **6.3.1 WHAT AND HOW TO RECORD**

Chapter 5 thoroughly discussed the different definitions and components of originality, rigour and significance, and ended with table 5.7 listing the type of information to be collected in order to try and capture the original, significant and rigorous knowledge in commercial outputs. The documentation of a project offers a comprehensive image of the output's progression, helping the involved stakeholders keep track of the work, draw the links, and disseminate and new valuable knowledge.

Using methods such as assigning people who's role is to document and collect information resulting from commercial projects is costly, time consuming, and will lack the input of the designers, which is necessary to build context.

Another potential method to collect and document this information is by requesting the required information from the designers in retrospect, when needed. This method will lead to a loss of details on the reflective process, and will require more time from the designers and effort to recall and recollect all the information.

Using only visual methods such as annotated portfolio might not be suitable in this context. Annotated portfolios are limited in terms of content, and do not capture the whole process, which is an essential element in the capturing rigour and detecting patterns between projects.

Seeing the progression of the brief and its evolution into an output, going through the research process implemented, helps in visualizing the analogy drawn at the end of chapter 5 (figure 5.1) between R&D and a basic research process. All this information needs to be collected in a manner that regards the designers and clients' concerns discussed in section 6.3 'How to Tackle the Concerns'.

The design process timelines (figure 6.1) appeared to be a logical starting point for any documentation activity that will take place. The chronological flow of information rather than the documentation based on types of activities, seemed to be an easier way to input information for multiple reasons:

- Due to the flow of input with the progression of the project, this method helps designers document information as they go, without having to go back and forth through the different themes and sections.
- More suitable to view and reflect on data as it occurs
- A time and contextual data input is necessary when trying to identify any potential newly surfacing knowledge of impact; time and context are two crucial attributes in identifying originality and significance.
- In a potential REF submission, having a visual flow of information can be of use to locate information; as a representation of rigorous data maintenance, as well as a time saving method for assessors to review an output.

The design and research processes were used as a base to distribute the information from table 5.7. Figure 6.2 (recreated in Figure 6.2.a) is a photograph of the paper prototype made as a representation of how a documentation framework could potentially look like. The prototype is then translated into a digital platform used for the testing phase (Chapter 7).



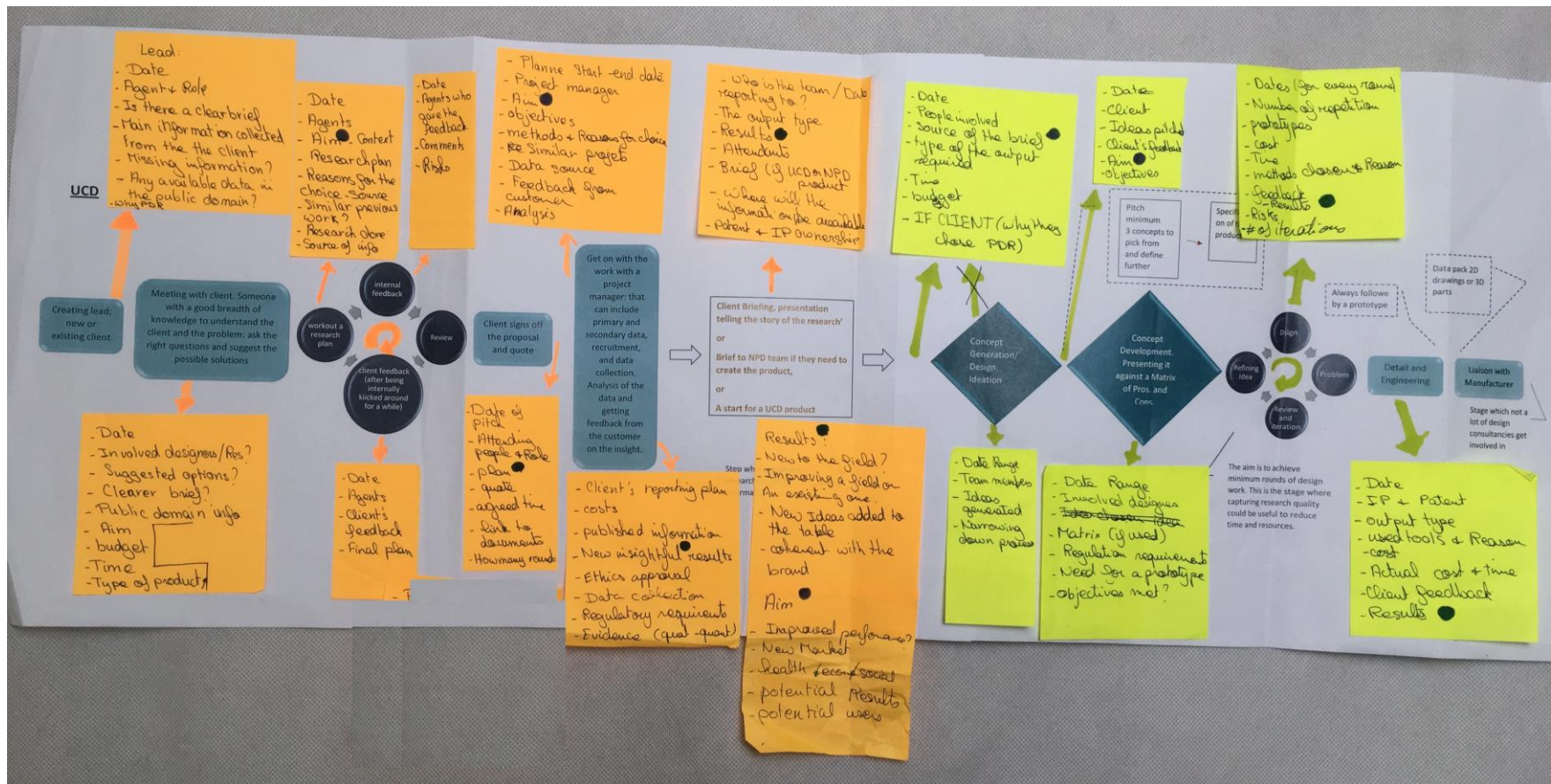
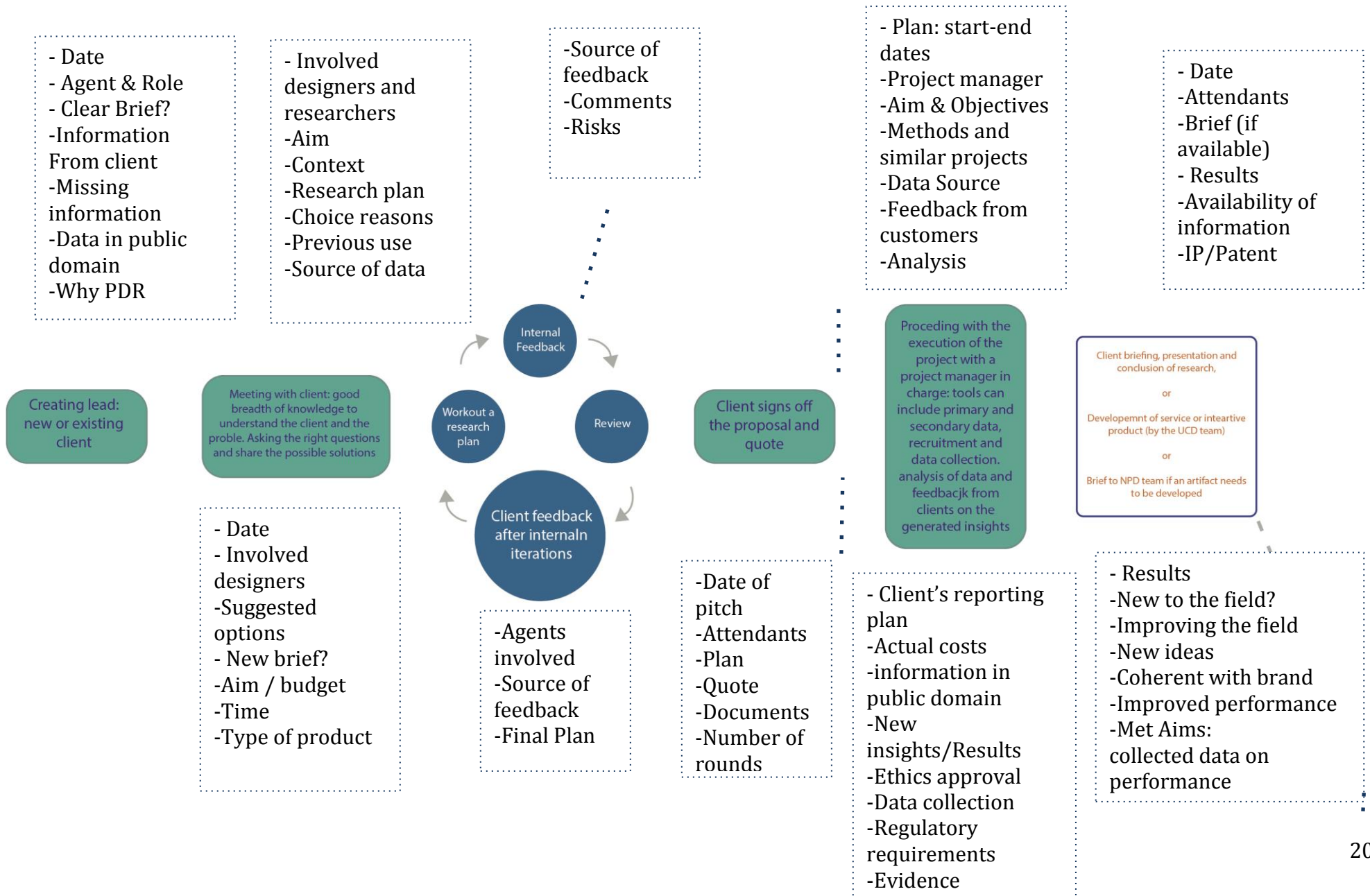


Figure 6.2 Paper prototype of documentation leads distributed on the UCD and NPD design processes



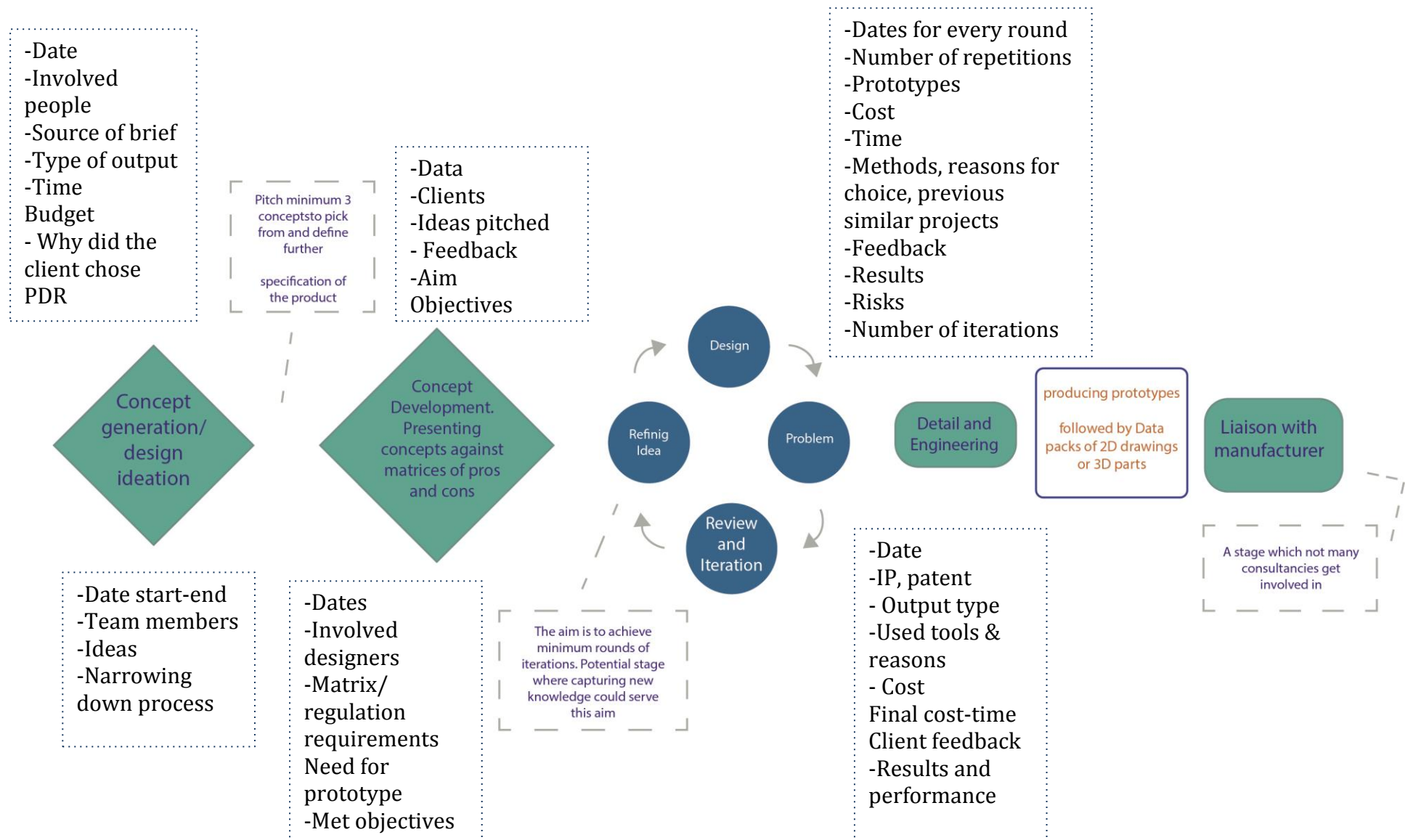


Figure 6.2.A Prototype 6.1 recreated

## 6.4 DOCUMENTING INFORMATION TO CAPTURE NEW KNOWLEDGE OF RESEARCH VALUE

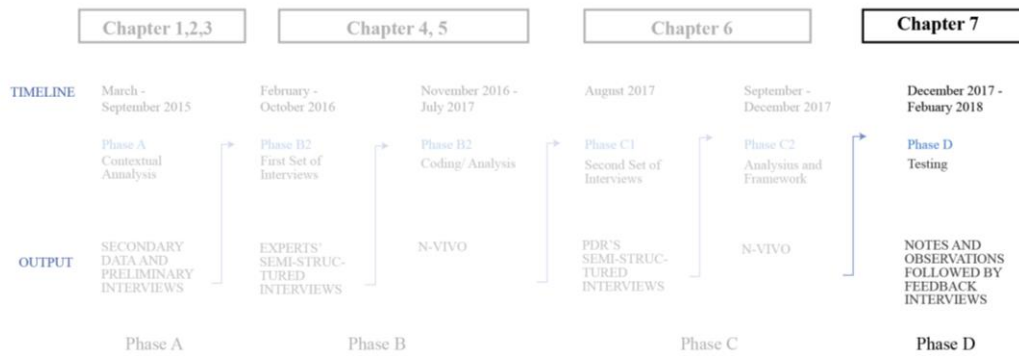
It became clear throughout chapters 5 and 6 that some information goes unrecorded during a commercial design project. While any existing information is scattered in different files, emails, and documents, other information and knowledge is not recorded or is of tacit knowledge and cannot be recorded explicitly.

The willingness of the commercial team to be part of an information-capturing process for the purpose of capturing and disseminating new knowledge of academic research quality, in order to transfer and spread its impact, is apparent.

Documenting design projects has the potential of reducing number of iterations in the process, accessibility to data, reflecting on the activities, clearer choice of methods, disseminating research, and training and development. However, the designers expressed some technical barriers to put such process into action. Chapter 6 discussed how to address these barriers in a documentation framework that could be implemented to achieve the benefits discussed in chapters 4 and 6.

The next chapter will use the theoretical documentation timeline created – Figure 6.1 and translate it into an interface that could be used by the designers in order to test the validity and practicality of the documentation process.

## 7 DOCUMENTATION FRAMEWORK AND TRIALS



### 7.1 DOCUMENTATION

Chapter 6 covered the value of reflective practice in understanding any new processed and learned knowledge from previous experience and reducing the loss of detailed information. Capturing processes' information with sufficient granularity over a long period of time adds more value to the operations running in PDR's commercial department, regardless of their potential as REF submissions.

The nature of this research and the time available does not provide the sufficient amount data necessary to validate the quality of information resulting from the documenting process. However, testing it over a limited period of time offers an idea on the quality of the process itself, and the possibility of its implementation over a longer period of time.

Chapter 6 ended with a prototype of what a documentation process could look like based on the UCD research and NPD design processes chapter 6 – section 6.1. This chapter will translate this prototype (Figure 6.2.a) into an interface that could be used by the designers in PDR to capture the necessary information.

#### 7.1.1 USERS

Since the commercial team is based on the two functions NPD and UCD, two designers representing both teams were chosen for the testing phase.

Designer 1 (D1): UCD Research Lead at the time of the testing phase. The designer has a recent academic background (graduated with a PhD). At the time, D1 has been working with PDR and as part of the UCD team for 5 years, hence the relevance and depth of knowledge in terms of processes, environment and clients.

Designer 2 (D2): Product design manager representing NPD with minimal involvement in academic research. At the time of testing, D2 has worked with PDR for 3 years.

### **7.1.2 CHOICE OF THE PLATFORM**

To test the potential of implementing a documentation process within the time and cost restricting commercial context, with the potential application in other similar commercial contexts, there was a need for an affordable, preferably free, and easy-to-use platform. After going through multiple options, and consulting the design team on available platforms they might be aware of, Trello (a web based project management application) was one of the suggestions that seemed most relevant in terms of cost, user friendliness and the sensitivity of the data that might be recorded. Some designers have also previously used Trello to manage projects; therefore, they are aware of its features and they would not be wasting time learning about its functionality. It is a free to use platform, and it has a large capacity to hold information as long as big files are hyperlinked rather than uploaded. This makes it a safer option in terms of storing sensitive commercial data, since any access to this information will require access to the university's server as well as the Trello account.

Trello's format also works very well for this testing phase, as it is formed of sections, which could serve as representation the design process stages.

Figure 7.1 below is an image of the initial set-up of Trello documentation process. The process is split into different stages (each stage is a card/ box). Each card holds a list of leads to the information required for that stage, based on the criteria identified and represented in the prototype of chapter 6 (Figure 6.2.a).

It is important to point out that at this stage Trello is used solely for testing purposes. If the documentation process proved to be valuable and led to the results hoped for, the platform might require reconsideration depending on the practical needs and results.



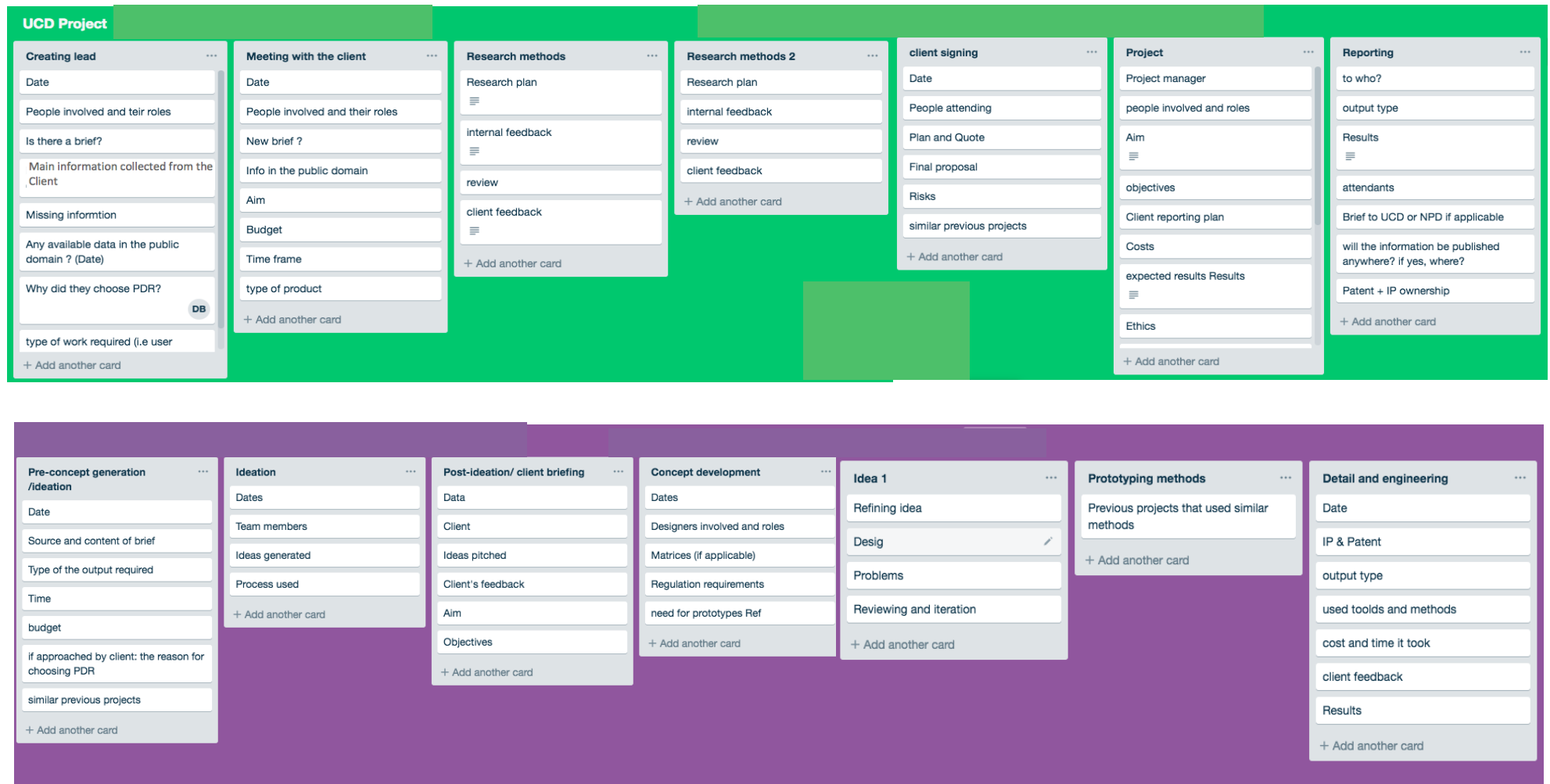


Figure 7.1 Documentation timeline including leads to assist the designers in documenting the necessary information

## 7.2 TESTING

The trial period was over two phases with designers D1 and D2. The timeline of the testing process is represented in Figure 7.2 below

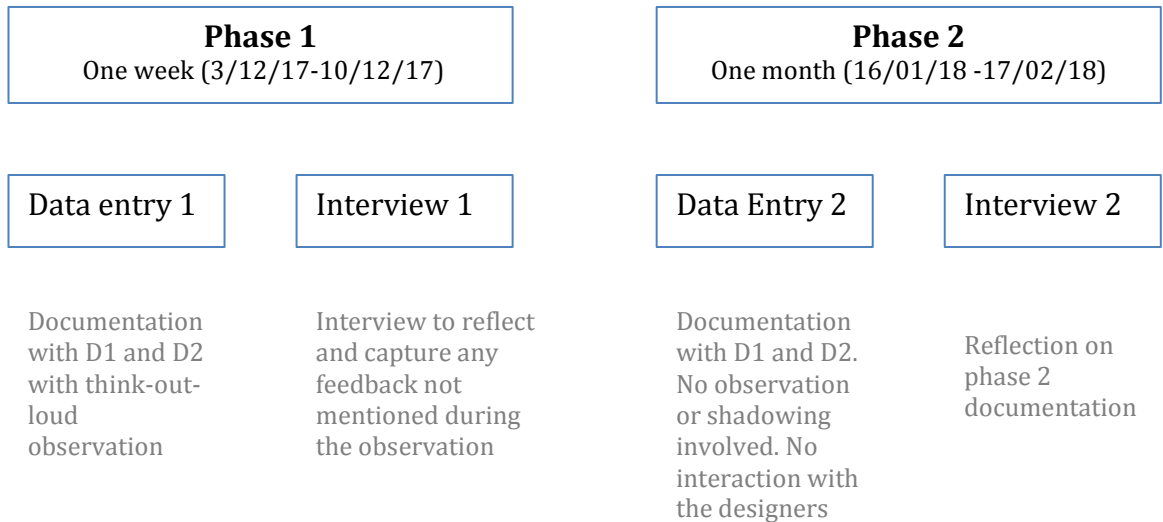


Figure 7.2 Timeline of the documentation testing process

### 7.2.1 PHASE ONE

#### 7.2.1.a Observations

During the first phase, the designers did not make entries every day. Over the one-week period, designer 1 made three different entries over three different days, and so did designer 2

**Designer 1** (three different entries)

**First entry** lasted 30 minutes, a new small-scale project had just started and D1 found it ideal to start this testing period with this project. The session could have potentially lasted less time had the researcher not been asking questions and the designer not explaining their train of thoughts. Since D1 knew a lot of details on how this project is going and its future stages, multiple cards (design process stages) on the Trello board were being filled even though the project had not reached that specific stage yet.



The process of retrieving information from different sources (emails, briefs, quotes, and design proposals from ISO folders) seemed easy and quick, mainly due to D1's recent and direct engagement in the project.

D1 was not always able to allocate ideas to the source in terms of people suggesting them due to the fact that these details were not registered at the time of the meetings. The importance of this information is in the source of data and information as well as the stakeholders involved in the research activity.

The designer did not go through the stages before starting to fill them up, which led to filling some information in the wrong cards, and later realizing that they belong to a different one. Going through the complete process once, was enough to solve this issue; a more thorough clarification of the stages would have been useful.

**Second entry** (18 minutes) and took place three days after the first one. This session was faster and involved fewer difficulties than the first one.

**Third entry** (5 minutes) took place four days after the second entry.

Some issues highlighted during the observations reflected the need for more efficiency in managing sensitive information and big data such as contracts, to avoid repetition and maintain the security, without consuming storage space. Which was solved by hyperlinking the files from the server.

#### **Designer 2** (three entries)

Designer 2 expressed the limited time they have during the testing period due to commercial obligations. To secure results from the testing phase, the observing researcher reminded D2 of the data entry sessions.

**First entry** (10 minutes) the session was effortless. Similarly to D1's experience, the process was fast and efficient. D2 added one research card to the NPD process, after struggling to find a location to record a stage involving competitor's product analysis by dismantling their product.

**Second entry** (40 minutes) the time was not entirely spent on data entry; the session involved explaining to the observing researcher about the two new projects being documented. The main observation in this session was regarding the exchange of information with clients. It was difficult to accumulate information from verbal

communication and emails exchanged with clients, since emails are generally scattered and it is time consuming to try and gather it all in one place.

**Third entry** (6 minutes) raised an important concern regarding documentation when multiple team members are involved. When multiple people are working on the same project, and a complex web of knowledge exchange is taking place, they all need to be filling different information in different stages/cards or sometimes the same stage but different roles. This issue can create duplication of information and confusion especially when multiple people are working on the same task. At the same time, if the entries are different, they could be a good way for all the team members to keep track of other colleagues' activities.

#### *7.2.1.b Feedback*

After one week of testing, the two designers were interviewed to discuss any feedback they did not mention during the documentation sessions.

Both designers were interviewed at the same time in order to optimize the feedback since there might be common comments or one user's feedback might trigger ideas for the other designer.

The below questions covered the topics discussed during the interview

- How was the frequency (helpful/not helpful) in remembering the information?
- The level of understanding the process and its value on a practical level
- What are the benefits and drawbacks?

The designers answered these questions and their feedback was focused on different themes. This interview's feedback along with the observations made during the documentation process, are discussed in this section.

#### ***Frequency of data entry***

The designers felt that depending on the number of projects taking place at the same time, and the number of days spent on each activity in a project, they needed to wait to finish the activity to update the information on it. Making an entry every other day would be less time consuming and more effective than engaging every day. D2 even suggested that entering information once a week could be enough, since some designers keep written notes of their activities, making it easier to remember the different details.

This leads to the belief that any documentation activity needs to take place fast enough to avoid any loss of specific relevant information, as well as minimize the load of information that needs to be entered, but not frequently enough to reduce the efficiency of the process.

### ***Struggles in understanding the process***

The process and leads for the information that need to be recorded became clearer after going through the whole timeline the first time. Going through the full process also helped in recognizing to which category each piece of information belongs.

The issue of understanding the process might have been the result of not going through the different steps of the process beforehand. Any documentation framework implemented in the future will require a training period for all the staff who will be using it or accessing its data.

### ***Understanding the value***

D1 saw real value in the reflective process involved in the documentation activity. Having acquired a lot of knowledge from papers written and published by PDR, D1 can see this as a very good opportunity as a source of information for future papers written by anyone, especially that the data will be available in a uniform and accessible space. D1 questioned whether the NPD team would have perceived the same value in reflective practice, to which D2 agreed but expressed their uncertainty regarding the value of this information for the rest of the NPD team.

Chapters 4 and 6 highlight the benefits and drivers of sharing and reflecting on information resulting from commercial design outputs. D1's reflections come into agreement with these benefits and value of reflecting on and sharing information. However, when it comes to the NPD representative D2, this value is still unclear. Although D2's opinion is not necessarily representative of all NPD designers, NPD's reliance on hard sciences (highly reliant on engineering and physics) leaves less space for subjective reflection. Furthermore, as suggested in the literature (Al-Hawamdeh, 2002; Navidi et al. 2016), when research on material, methods used, and process is rigourously recorded, it can save time in future similar cases and reduce the required research and evidence needed to support decisions, especially after accumulating enough case studies and examples. Furthermore this documentation will help in transferring any knowledge and technical skills to new designers or team members. Although the benefits are

theoretically understood by the designers, the value of this activity might only be experienced once they see a tangible time and effort reduction in future projects.

### ***Drawbacks of the process***

On a technical level, the two designers did not see many drawbacks except the repetition of some information, which might be redundant and time consuming. Another problem raised during the shadowing is how to capture information from meetings and long emails, and how multiple team members will manage data in the documentation process. Trello does not offer an option of automatically retrieving information from certain documents based on keywords. If available, this option could be added to the software used for documentation as a solution to collect relevant information from emails. Until then, although time consuming, the only solution is to manually enter the relevant information.

Since regular meetings and communication take place during every stage, the problem faced when multiple team-members are working on the same stage and therefore end up duplicating information, could be solved by assigning one team member to be in charge of the data entry.

### ***Suggestions for improvements***

- Splitting the 'project' card into multiple cards: In its current format, the timeline puts so much focus on the stage prior to signing with the client. The fact that any knowledge value lies within the R&D process, splitting the project card into smaller sections, and detailing the research methods in these sections will bring back the focus to the process. This split will also make the data entry clearer and easier to read through, allowing anyone to track each research or application method from its beginning till the end. Smaller sections help in drawing similarities between different methods and optimize them, as well as facilitating the accessibility to this sort of data to be used in other contexts or in creating academic content.

- Categorization: Creating different formats of the boards for different categories of the projects. The initial plan for the documentation process was that the information resulting from the documentation process would help in grouping different projects into different categories. However according to D1's first trial of the framework, they suggested that this categorization is pretty doable even before the completion of the

documentation, while more unknown categories can emerge after seeing patterns between different projects.

### 7.2.2 PHASE TWO

Following phase 1, a meeting was held with Prof. Andrew Walters (Director of Studies) and Jarred Evans (Director of PDR and commercial activities) to discuss the feedback from the first phase along with the plan for the next stage. After sharing Phase 1 observations and interview results, and showing that the process did not take a long time of the designers' daily activities, the researcher expressed the need for a second longer testing phase, in which some of Phase 1's feedback is tackled. In this phase the designers will decide when they want to make any entries without being reminded or being shadowed while they do so. The point of Phase 2 was to understand whether or not this documentation process can be implemented, and if so, whether the designers will commit to getting involved.

Phase 2 was approved and stretched over a one-month period (16<sup>th</sup> of January until the 17<sup>th</sup> of February) with the same two designers, D1 and D2 who participated in phase 1. In this phase the Trello boards were amended (when possible) based on some of the feedback given: explanations were made, some cards were split into multiple phases, and flexibility was given to remove/ add cards or stages.

#### 7.2.2.a *Observations*

The month period did not include as many entries as expected. D1 had made three entries on 3 three different projects. On the other hand, D2 made one single entry. Where D2's entries were more technical and factual, it was clear through some of those entries, that D1 used Trello and this documentation process as a reflection tool; below are few quotes from D1's reflective entries

*"Had we had a time to 'tell the story' of the user insight they would have bought into the changes better."*

*"Also due to the incremental development of the prototype we had to start to use Trello to create a to do list. We should do this from the start of the process and we should also share it with the client so they can see that when we send over development work for feedback they understand more fully what is defined and what is not (and thus understand what to feedback on)".*

#### 7.2.2.b *Feedback*

After the second documentation phase, an interview with the designers took place to understand their perception of how the longer more independent testing phase went, and the reason behind the fewer entries.

The designers did not see the need for more entries than the ones they have made. Information they have accumulated during that period was registered. During phase 2, D2's work was building up towards a trip to meet with a client; commercial activities taking place were limited.

The designers expressed that the start of a project is usually the most time consuming phase; building a strong base for the project and agreeing on a strategic plan and agreement with the clients; which builds towards a strong base for the collaboration (Hermans and Castiaux, 2006). And having a set template along with the flexibility to make changes was good change.

D1 preferred to enter data as it occurred. As it was expressed earlier, waiting for data to accumulate would have required more time and effort to record it. Meanwhile, D2 believed that with the notes taken and ability to remember the activities, there was no need to record right after the activities occurred.

During this phase, PDR's management introduced a time-keeping software to track the time spent on different activities. Engaging in time tracking task did not affect the designers' work, it saved them time from having to manually log in times; therefore, the two activities (time tracking and documenting) could potentially be merged together.

### 7.3 SUMMARY

The Trello framework used for this testing phase was a good representation of what a documentation process could potentially look like. Technically, a customized software built specifically for this purpose could better tackle some of the issues discussed in this chapter such as data sensitivity, and tracking scattered data from different locations and allocating it to the right fields. The overall response to this documentation activity was surprisingly positive. Designers acknowledged the benefits it could provide, yet were still

skeptical regarding some other benefits like producing research outputs and its impact on their career.

Testing this process helped in understanding the practicality of introducing a documentation framework to the designers' daily commercial activities. From an NPD point of view, it was still difficult to experience the value of the documented information on an academic level, turning the process into just another task on a long to-do list. While this is not a representation of every NPD designer, being more hard-sciences based, makes the NPD processes more factual and less subjective. Furthermore, in the PDR context, it is more likely that NPD designers are less engaged in academic research, and happen to have ended their academic engagement at a Masters level. On the other hand, from a UCD Research perspective the documentation process was seen as a beneficial opportunity for reflective practice, learning, and development. As opposed to NPD, the UCD designer had recently finished a PhD degree, putting them in a closer position to the academic frame of mind.

Understandably, if designers start seeing new knowledge being drawn from the documented material, the value they see in a documentation process will increase. One of the limitations is that the timeline of this research project (PhD) did not allow a long enough documentation period. A longer testing phase could allow time to collect enough data to experiment with its potential value in capturing new knowledge and disseminating research discussed earlier in this research (REF, publications, assessment, training material).

## 8 DISCUSSION

The purpose of this chapter is to discuss chapters 4 to 7 in relation to the Research Questions.

The Research questions are as follows:

**Research Question 1:** How best to recognize where commercial outputs can be characterized as research?

**Research Question 2:** Where a research characterization is met, how best to recognize and describe the research quality?

The aim of this research is to identify whether research value exists within commercial design projects and outputs produced in an academic context and how the quality of this research could be assessed.

This aim was achieved through understanding the challenges faced during the knowledge exchange and creation process between researchers and practitioners, and how these limitations can affect the creation of outputs relevant to both stakeholders. The next step was identifying whether this knowledge is of research value, and eventually how to assess the quality of this research.

Other benefits to the dissemination of any available research value from commercial designs produced in academic contexts were also recognized.

### 8.1 NEW KNOWLEDGE IN COMMERCIAL DESIGN

The focus on research assessment exercises, the difficulties in capturing research value in commercial processes and artifacts (Chapter 4- section 4.1.2), and the lack of academic outputs' impact on some practitioners' careers (section 6.2.2.1), limit some institutions involved in commercial collaborations from capturing and communicating new knowledge created in industry-university projects. PDR's activity nature falls within a university-industry collaboration context, making it prone to such limitations.

PDR was set up for external engagement and an important component of this is the financial contribution delivered by industrial collaborations. The push to create impact and generate new knowledge is driving PDR to reap new knowledge from its commercial collaborations.



As part of an academic institution, PDR recognizes the benefits of capturing any potential research value and its impact on the academic mission, research relevance, risk reduction as well as its commercial performance and credibility (Chapter 4 – Section 4.1.1.) which in turn supports the development and maintenance of trust and long term relationships (Chapter 4 - section 4.1.2); all of which are elements that affect its performance and skills as an organization and support collaborations' success through the continuous learning they bring to the table (Garcia et al., 2019; Hermans and Castiaux, 2006; March & Stock, 2003; Nonaka, 1991; Witt de Vries et al., 2018).

The university and consequently PDR's missions are increasingly emphasizing on collaboration projects, and knowledge and technology transfer activities between academia and practice. The explicit knowledge or 'spillovers' resulting from these commercial collaborations are currently being shared through publications about some of these projects. As important as these outputs are for PDR and the university, the important experience that contributes to the improvement of practice, and the role of tacit and explicit knowledge exchange, in learning, creating new knowledge and impacting the outputs is not being capitalized; an element also highlighted by the literature (Hermans and Castiaux, 2006; Nonaka & Takeuchi, 1995). This literature focuses on university-industry collaborative research aiming at producing traditional research outputs (Hermans and Castiaux, 2006). And in cases of commercial collaborations, the literature argues that new knowledge creation only happens in discovery projects (Hermans and Castiaux, 2016) or basic design research (Norman and Verganti, 2014). The literature on knowledge creation in consultancies' contexts such as PDR where R&D projects and UCD research are prevalent is limited (Philpott et al., 2011). Recognizing the new knowledge created from the daily interactions and activities of these commercial consultancy university-industry collaborations and its potential research value is crucial and lacks full understanding.

### **8.1.1 WHERE TO LOCATE NEW KNOWLEDGE**

Different types of research and collaborative processes act as sources of innovation i.e. exploitation, exploration, discovery projects, or human centered research, basic research (Hermans and Castiaux, 2016; Norman and Verganti, 2014). Norman and Verganti (2014) argue that research methods such as human centered research used in R&D processes,

do not lead to radical innovation and new understanding, and only contribute to incremental changes. On the other hand, Norman and Verganti (2014) do acknowledge the role of exploring existing products (tinkering) in potentially creating innovative meaning and radical innovation, but limit the role of design research tools such as UCD research to incremental innovation. However, if designers' tinkering with a product (using their knowledge and experience) can create new insights (Norman and Verganti, 2014), and users play a major role in creating meaning in an existing product; it seems that studying the user (by deploying both researchers and designers' knowledge), could be equally as informing in finding new meanings.

Furthermore, PDR's use of UCD research tools by designers and researchers is not limited to general R&D processes purely informing a pre-planned commercial output. PDR's deployment of design research tools and design thinking by designers with academic association, in informing strategic consultation services, attaches more rigour to the processes and results of UCD research. The purpose of employing UCD research tools in a context such as PDR is more generative and serves in exploring meaning. As such, it differs from the use of UCD in a general commercial context, and therefore, attaches new meanings to PDR's UCD research outputs.

Similarly, Hermans and Castiaux (2016) argue that exploitation projects where theoretical understandings and meanings are translated into practical opportunities (contributing to industries) do not aim and therefore will not result in new understandings. According to this literature, new radical innovations and understanding are only the result of basic research (Norman and Verganti, 2014) or exploration or discovery projects (Hermans and Castiaux, 2016). However, some literature still acknowledges that incremental knowledge in research can be as impactful as radical knowledge (Kasmire et al, 2012). This study's industry-university engagement activities varied between consulting services, collaborative research, applied research or PhD research, and therefore produced or contributed to the production of non-traditional outputs in one way or another. The interviewees chapter 4 - section 4.1 highlighted their agreement on benefits for the collaborations taking place between industry and universities agreeing with existing literature (Bettis and Hitt, 1995; Brundenius, Lundvall, and Sutz, 2009; Clark, 1998; Etzkowitz, 2003; Etzkowitz and Leydesdorff, 2000; Guimon and Agapitova, 2013; Tidd, Bessant and Pavitt, 2005; Wright et al., 2008; Zucker & Darby, 1996) and how capturing value and insights stemming from the interactions has been valuable to:

- 1) Develop and improve processes on a commercial and organizational level
- 2) Reduce risk and costs on the long term
- 3) Help in meeting regulatory and audits requirements
- 4) Sharing new knowledge with others in the organization they are part of, the general academic community, and industry.
- 5) Improve and learn

PDR's practitioners shared similar benefits they see within their interaction with industry and with PDR's researchers (Chapter 6 – Section 6.2.1.1.). However, one aspect that differentiates PDR from other types of university-industry collaborations (spin outs, collaborative research, patenting, etcetera) is that the interaction and knowledge exchange activities take place between three stakeholders: clients, designers and researchers. In some instances, the designer is at the same time the researcher (some user researchers are also interaction designers); while in other cases, designers and researchers are different people from different teams (NPD designers and user researchers or eco-design researchers). During some stages of PDR's collaborative commercial activity, designers are acting as a proxy for industry or clients. Although initial interactions with clients take place iteratively until a brief is decided, and then regularly for updates, feedback and reporting; most of the design or design research processes take place internally between designers or designers and researchers (as shown in Chapter 6 – Section 6.1 – Figure 6.1). PDR's structure therefore concentrates the knowledge exchange activity within the same organization for most of the process.

The effectiveness of specific (formal or informal managerial styles) in university-industry collaborations is not yet fully understood (Wit-de-Vries et al., 2018). PDR's bottom-up informal managerial style can support the flexibility required in some fast decision-making processes, and allows space for informal interactions between different functions of the consultancy. This dynamic allows more autonomy in managing the internal interactions and knowledge exchange and creation, thus offering more opportunities for multidisciplinary engagements. This autonomy opens the door for more flexibility in the type of commercial projects they accept and decline and the management of information and academic orientation (Perkmann and Walsh, 2008).

The multidisciplinary interaction taking place in contexts such as PDR is a critical aspect of Mode 2 knowledge creation, which is a precursor for development and production of a service or product (R&D). This knowledge thus broadens the engagement, applicability, and accessibility of outputs, and enriches exchanged and created knowledge (European Commission, 2010). It positively impacts the breadth and depth of exchanged knowledge, and impacts the quality of the outputs (Poggenpohl, 2015; Veryzer and Mozota, 2005).

The justification of what is innovative knowledge seems to be dependent on the processes' outputs and how they impact future developments of science and research (Dahlin, Behrens, 2005; Kelly, 2010; Koberg, 2003; Schoenmakers, 2010). Furthermore, according to the REF criteria for research assessment, original and significant knowledge is one that improves a field's knowledge or practice, even if it is of incremental nature. Therefore, when judging innovation and originality in knowledge rather than practice, incremental innovation is as valuable as radical innovation.

The impact of applying existing knowledge in a new industry leads to new understanding and development of that industry. Hermans and Castiaux (2016) do not take this into consideration, and rather argue that new knowledge is only created in exploration projects or discovery research projects, or when an exploitation project requires further knowledge, and therefore shifts into an exploratory project. Similarly, human centered design and user studies have a clear element of new added incremental understanding to a field, and sometimes radical, which is acknowledged in the REF definition of research.

As opposed to commercial design projects, one main aim for collaborative research is to create new knowledge and generate research excellence (Link and Scott 2005); generally measured by publications and conferences alongside the application opportunities of any created knowledge. In their research, Hermans and Castiaux (2006) explain the role of tacit and explicit knowledge flow in the creation of new knowledge. They subsequently generate a representation of the knowledge spiral; how new knowledge is created from exchange and transfer of tacit and explicit knowledge between industry and university partners. In their research Hermans and Castiaux (2006) equally highlight the importance of the daily interactions in generating further insights and opportunities for collaborations, and more long-term research based on trust. More recent research has also highlighted the value of trust and long-term university-industry relationships have on the knowledge and academic production (Witt-de-Vries et al., 2018; Garcia et al., 2019).

Figure 8.1 below is a representation of Herman and Castiaux (2006) knowledge creation process explained above

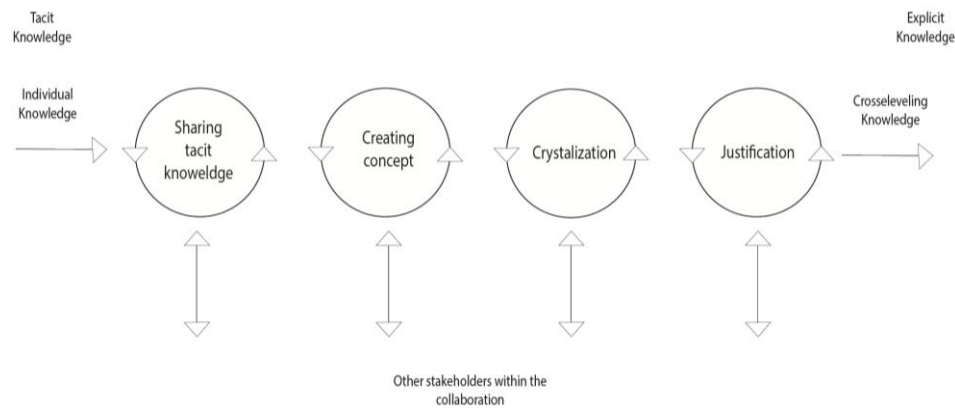


Figure 8.1 The knowledge creation process in collaborative research projects adapted from (Herman and Castiaux, 2006)

The interviews conducted throughout this research helped in understanding the dynamics of information flow within PDR. As understood by this research, the aim of commercial product design activities taking place in a context such as PDR, is to pour PDR's knowledge, experience, and technology into creating an output that delivers to the clients' needs in the form of a tangible product, service, or strategic plan.

The knowledge and technology vary between already existing, or newly explored for the purpose of the commercial project at hand, through R&D activity. Combining existing and newly generated information lead to a commercial output.

The identified similarities between an R&D process resulting in commercial outputs, and basic research process resulting in traditional research outputs are illustrated in chapter 5 – Section 5.3.1 – Figure 5.1. These similarities represent a parallel flow of information and a similar level of rigour in the formats (not the content) of the two processes. This comparison highlighting existing similarities in the flow of information therefore reflects an existing knowledge carried by their relative outputs.

Three types of commercial projects emerged from the interviews and were explained in chapter 6 - Section 6.2.2.1.C

Minimal assistance: Execution of a specific commercial brief or improvement of existing product, using existing knowledge or technologies. Designers rarely engage in an elaborate research process in this case.

Full assistance to the client: Clients have a very generic idea, an elaborate R&D process or applied research project is required, going through all the stages of design leading to strategic recommendations resulting from new knowledge, and/ or output: artifacts or services.

Middle ground assistance: Designers are approached with a generic brief with an idea of what the final output could potentially be. The concept is slightly underdeveloped and requires research to identify non-existent knowledge needed for the project. New knowledge merged with existing technology and knowledge exchange takes place between clients, designers and researchers, resulting in new outputs.

The different depths of processes taking place in PDR undergo different levels of knowledge exchange and undertaken investigations. Even minimal assistance activities can play a role in the creation of new understanding. Alongside the resulting commercial outputs, commercial activity taking place in PDR gives access to real life commercial issues and consequently the opportunities to turn experiences into a great value to academia and practitioners' 'knowledge portfolio'.

The accumulation of projects creates value through building up opportunities of case studies and finding patterns between processes, methods and outputs to capitalize and reflect on. This can assist both on internal and external levels. Internally, capturing knowledge and exchanging it can contribute to the development of commercial design on an organizational level: its processes, teams, and its different functions, as well as facilitate informal interactions between functions. Externally on a larger scale, extracting knowledge from commercial design processes assist in academic research dissemination and sharing knowledge with the larger community; through presenting publications and patents or commercial outputs that withhold the newly created insights.

Experts and practitioners who were involved in this research acknowledged the existence of significant knowledge and information within the daily interactions between researchers and practitioners. This information goes unnoticed, yet plays a big role in the generation of the final output. These interactions include:

- Exchange of knowledge (tacit or explicit) in two ways: during a formal meetings between clients, designers and researchers to discuss needs and potential routes to tackle the brief, or during informal discussions taking place between designers and researchers due to the existence of both roles under the same roof.
- Trial and error and iterative processes

- Prototyping and testing
- Engaging with users

These formal and informal exchanges are indeed highly valuable and significant to both researchers and designers in influencing the creation and processes of the final output. Additionally, interactions between researchers and designers take a more practice-informed form. While researchers' knowledge can be highly academic, PDR's research team and the nature of their work means that their knowledge can be contextualized within application. This in turn makes any interaction with designers more relevant, and the translation of the researchers' academic knowledge to applicable knowledge that designers could work with, becomes easier.

These interactions were also perceived as contributors to the generation of original insights, the understanding of recognized problems, the detection of new relevant issues, and the trial of combinations of existing knowledge (interdisciplinary practice). Therefore leading to more insights for commercial outputs as well as new gaps in research. The flexibility in management opens the space for such informal interactions and exchanges, causing an increase in opportunities for unintentional interactions leading to new insights.

Figure 8.2 below represents this flow and interaction of technology and knowledge in an NPD process, leading to the planned outputs and insights and knowledge generated along the way. Although this figure represents the NPD format of process (From chapter 6 – Figure 6.1), the same flow can apply to the UCD research and design process, or other types of R&D interactions. The different shapes in figure 8.2 are different stages of a design process in figure 6.1. The different colored flows represent different occasions where interactions, exchange of knowledge or experience, or reflection on multiple case studies took place, and led to new insights or resulting new knowledge that designers or researchers have acknowledged. The different shapes represent different phases of the design process. The colored lines represent comparisons, and knowledge and technology transfer between different projects that portray common aspects, leading to new insights. The black arrows represent communication, interactions and knowledge exchange (formal and informal) taking place in individual projects between designers or designers and researchers, leading to the new output or knowledge.

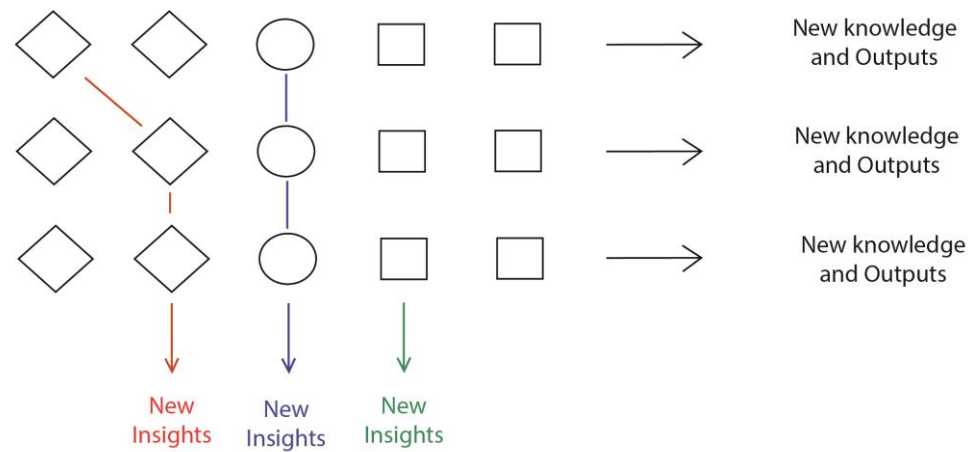


Figure 8.2 Flow of Knowledge leading to new insights and outputs in commercial projects.

The theory on understanding knowledge flow within university-industry collaborations and more specifically in a commercial design context has not been extensively explored. However, there is literature that explains explicit knowledge creation and research value through exchange of tacit and explicit knowledge in different contexts: university-industry collaborative research (Hermans and Casiaux, 2006); knowledge creation in different types of R&D processes (Hermans and Casiaux, 2016); and design research processes (Norman and Verganti, 2014). All of which have been found to overlap in some aspects with the generated framework in Figure 8.2 and support the theory of the existence of research value within some commercial outputs.

Existing parallels have been found between this theoretical framework (Figure 8.1) and the framework generated from the research conducted in this thesis (Figure 8.2). Whilst the process' motivation (in a design consultancy in a university setup versus other R&D processes) and consequently its resulting outputs' nature differ, the nature and flow of knowledge involved in the processes are similar, and explicit knowledge is thus shown to be created from an interactive process of tacit and existing explicit knowledge. Furthermore the benefits assigned to the spillover knowledge and insights indirectly generated throughout the process are similarly recognized.

An important difference between these two frameworks is however the motivation of the collaboration. The new knowledge exploration aim of a collaborative research implies that the processes driving the collaborative research are rigourously built to support academic research outputs. On the other hand, an NPD project conducted in PDR is



mostly commercially driven, and thus its processes are affected by the final motivation, and can lack the academic rigour that construct research as defined by the REF.

It is therefore not the case that a commercial artifact produced in PDR will clearly evidence research value. PDR's purpose as a contributor to two of the three pillars of an entrepreneurial university; applied research and university-industry commercial interactions implies that its activity cannot shift to purely generating research and academic value. Furthermore, because the external driver for the commercial product development is atypical to academic research, it appears that there is more value in exploring the research value and quality potential within the process. Therefore, making a change in how processes are managed is vital in order to benefit from the knowledge exchange taking place in a commercial design process.

This research therefore argues that NPD and UCD R&D processes involve interactions between stakeholders, and a process of knowledge exchange and transfer leading to new insights and potential new knowledge of research quality. Furthermore, some commercial projects involve an R&D process elaborate enough to offer new knowledge; incremental and radical, that will consequently influence the understanding and practice surrounding design, contributing to the body of work tackling the knowledge creation in: university-industry collaborative work (Hermans and Castiaux, 2006), R&D (Hermans and Castiaux, 2016), and design research (Norman and Verganti, 2014).

In this thesis, the definition of research was adopted from the REF guidance; "a process of investigation, leading to new insights, effectively shared" (REF, 2019a).

What lacks from the new knowledge and insights created in a commercial design consultancy context to be acknowledged as research, appears to be the systematic process that these exchanges go through, and the extent and relevance of these new insights to the broader practice and possibly academic communities.

It was observed that instead of reflecting on the final output (artifact) and find potential material to support the existence of any research value, it would be more effective to track projects as they happen through a documentation process. This way not only allows the capture of necessary new knowledge and research value in the final output, but also offers the opportunity of capturing any spillover insight resulting from daily exchange of knowledge.

## 8.2 DOCUMENTATION FOR RESEARCH DISSEMINATION

While documentation aimed at improving processes, learning from performed activities and sharing information is common in certain fields such as sports, nursing and engineering (Falessi, 2006; Munyisia, 2011; Tang et al, 2005), so far design documentation takes place with the objective of tracking processes and deliverables (Al-Ashaab et al., 2011; Brown, 2006; Falessi, 2006; Munyisia et al, 2011; Tang et al, 2005; Gaver & Bowers, 2012), and in some cases is argued to limit creativity (Collado-Ruiz & Ostad-Ahmad-Ghorabi, 2010). Tsey et al. (2019) argued the importance of tracking research projects over a long period of time in order to assess it and realize its impact; however, the research assessment they tackle in their research is of anthropological nature, and does not reflect a commercial setting. That said; the importance of time to collect enough data and reflect an output's impact has been also highlighted in this research (Section 4.2.1.2). Systematic wide spread documentation processes taking place in the commercial design sector in order to generate research impact and case studies are rare. Furthermore, the analysis that took place in chapter 6, showed that as NPD processes are managed right now, the knowledge value of the daily interactions that take place as part of the process are not obvious. The importance of the reflective nature of UCD research and development activities is not equally perceived in NPD processes.

### 8.2.1 FEASIBILITY OF DOCUMENTATION

The resistance to engage in an activity if it does not impact one's career (Waddell and Sohal, 1998) and the limitations identified in the research in section 6.2.2.1, mainly time and cost of taking part of such practice were major concerns in terms of the designers' willingness to participate. Nevertheless, designers saw the value in giving back to the research community they gained their knowledge from, but do not necessarily feel part of. Designers also saw the value of research conducted in PDR, the existing and created knowledge, and being part of an academic institution as a driver for the reputation and attractive component for some clients, especially big enterprises, to seek PDR's services. Designers who were previously/ have recently engaged in research practice (PhD, and conducting research) were more appreciative of the value of any data collection and reflective practice for internal development of practice and external academic

collaboration. Industrial designers (NPD) did not clearly see the practical value on an academic level, while agreeing with the benefit documentation could have on improving processes.

These limitations perceived by NPD designers could be natural since the lack of recent involvement in research activities had caused a sense of detachment from it and its role in their practice. It is also linked to the less reflective nature of the NPD process as opposed to UCD research projects identified in chapter 7 – Section 7.2.1.b.

An interesting result from phase C's interviews (Chapter 6 – Section 6.2.1.2) was the fact that many clients are on board or even encourage to share knowledge. However some limitations such as the type of the output might affect this willingness to share. As opposed to single commercial outputs, the more strategic the output is, the less likely the client is to agree to share it in the public domain.

The unclear value of performing the documentation activity had in turn affected their motivation in getting seriously engaged in the process. This result is consistent with the literature on resistance to adopt behaviors and activities when the value is not clear for the stakeholder (Waddell and Sohal, 1998).

Any implemented documentation process had to address the technical reasons limiting the designers' motivation to engage in the documentation practice: time, cost, what and how to write. Phase C showed that creating and sharing knowledge, requires capturing originality, rigour and significance criteria where designers can slowly but consistently record and reflect on information stemming from their commercial projects.

The data should be recorded gradually and observed over a long period of time, and not done when needed in retrospect; which has been the case until today and has caused difficulties in data loss and time costs. The designers expressed the attractiveness of the research element for some clients. The designers therefore see a great potential for this documentation process in improving attracting more collaboration. The designers' reflection also highlighted the documentation's contribution to the business development team's knowledge, and ability to take part in developing and maintaining relationships. The documentation will also support other research functions within the consultancy to increase contributions, trust, and engagement; all of which are essential elements for knowledge creation and academic production in a flexible managerial environment (Witt de-Vries, 2018).

The right documentation framework had to 1) fit within the context of PDR, 2) achieve the objective of capturing knowledge contributing to the creation of the final output and 3) help in validating the argument of existing research value in a commercial output. In order to achieve these objectives, the documentation process had to incorporate the REF research criteria for non-traditional outputs identified in chapter 5, and adopted as a base of assessing research quality in this thesis (Chapter 5 – Section 5.3).

### 8.3 RESEARCH VALUE AND QUALITY CHARACTERISTICS

One of the main barriers in disseminating knowledge and research value is the ability to evaluate its existence in the first place. In order to locate any existing research and knowledge value, this study relied on the REF three main research assessment criteria: originality, significance, and rigour. Using the REF criteria made sense since the foundation of this research was the possibility of extending PDR's contributions to the REF, as well as the fact that the REF is a national reference to research quality evaluation. While the REF does provide guidance into what forms an original, significant and rigorous research output could take: digital, physical, chemical, these criteria do not detail what elements constitutes an original, rigorous and significant commercial output. Furthermore, the criteria do not specify the necessary benchmark to be achieved, for an output to be considered original, rigorous and significant.

The multiple limitations faced by staff throughout the REF process and the difficulties in different evaluation stages have raised questions and claims of subjectivity within both the submission process and the evaluation. Going through the REF and trying to succeed at it, means playing by its rules. If achieving the aimed scores is more attainable through traditional outputs submissions, due to the clearer interpretation of originality, significance and rigour, then academic and research institutions might understandably aim at putting more weight on this type of submissions.

This is where the gap was found. How is it possible to translate descriptions and a research evaluation process that seem to be created for the written word, and apply them to non-traditional outputs. More specifically, how could these criteria be applied to commercially driven outputs, which face more barriers due to the non-academic external

motivations and needs driving them, as opposed to some other types of non-traditional outputs.

### 8.3.1 ORIGINALITY, SIGNIFICANCE AND RIGOUR IN COMMERCIAL OUTPUTS

The blurred boundaries between basic research and R&D (Kusha & Thelwall, 2015), and similarities highlighted in the interviews, led to the direct comparison established in chapter 5- Figure 5.1. Similarly, the areas of knowledge creation identified in this research were compared to an existing knowledge exchange and creation model (Hermanns and Castiaux, 2006) in section 8.1.1. Those similarities combined with the concentration of research value within the process which is embodied in the commercial output, implied that originality, rigour and significance could be found within the R&D process embodied in a commercial output (whether it is an artifact, service or a strategic plan created for the client), and reflected in the output itself.

Interviews, external examiner's feedback on potential REF submissions and the REF guidance, resulted in assigning different components that could form each one of the criteria: originality significance, and rigour in a non-traditional output, and which can be used as a guidance to characterize already existing and future projects that are likely to have any potential assessable research quality. Being able to identify these components within an output or a process leading to that output, can highlight a potential existence of research value.

Finding a close relationship and highlighting the similarities between commercial design process, R&D and traditional research process meant that these components established for the non-traditional outputs could be translated into criteria relevant to commercial design outputs.

This specification of elements defining originality, rigour and significance listed below. Their translation into practical clues to what components need to be looked for across the criteria table 5.7, can be used to characterize commercial outputs into ones that could have research value, and others that are purely commercially valuable.

**Originality** is linked to the components (problem, material, methods, business model), the relationship between existing components: (management, relationships, connections), the point of reference (stakeholders' point of view).

The debate regarding originality stemming from incremental innovation is ongoing. However, the analysis and further understanding of the original components in commercial outputs, and their link to innovation within R&D, led to the conclusion that incremental innovation in commercial R&D processes play a role in creating original and significant outputs.

This comes in agreement with the notion that while disruptive innovation alone might not directly lead to economic impact; often incremental changes are needed in order to translate and improve the performance characteristic of a disruptive invention to have an economic or social impact (Globerman and Lybecker, 2014; Norman and Verganti, 2014). Exploitation is understood as the use of existing knowledge and technology to create a new application or innovation (Hermans and Castiaux, 2016). By creating novelty that did not exist before, even if it does not achieve new knowledge produced through basic research or discovery, it can still create original outputs, which can impact learning and development.

Documenting and tracking incremental changes; new used material, changes in interaction between processes, small interactions and exchange of knowledge and expertise will allow the reflection on how these changes impacted the output. As such, being able to link the occurring changes to the results, can offer the chance to prove that the innovation or originality is not a result of a complete chance, but an output of critical, analytical and justified process.

**Significance** is about reflecting how the output impacts the understanding or development of a practice. Significance has three dimensions: extent (magnitude), reach (audience) and relevance (context), and is heavily reliant on the justification of the stakeholders to whom this influence is indeed relevant and of value.

Compared to figure 8.1, significance could be linked to the justification stage, where knowledge and elements that contributed to the development process have shown to be effective by successfully leading to an impactful end-result. An example could be the use of a new material in a product and how it revolutionized the environmental standards surrounding that output, or how the systematic use of a certain process adopted from another discipline, has opened up chances to reach a new group of users. All this impact requires the justification through its positioning within any existing literature, and justification from the receiving end: e.g. the users through feedback or reviews, or academics through publications or peer review, or practitioners through design awards.

As such, the attribution of different insights, knowledge, newly adopted processes, methods, or material to the practical impact of an output can reflect significance. Furthermore, reflecting how the new unplanned insights resulting from an accumulation of projects and case studies, can inform another project or product, is also significant new knowledge. Reflecting on how the new output or a specific process will be carried out in the future as a result of new knowledge or insights learned during a process, can be of research value embedded within an output.

**Rigour** is linked to processes (methods, processes, failure) and their components (validity, time, reputation, data type).

Rigour is a critical attribute that differentiates research aimed at exploring new knowledge in the academic sense, versus research to understand (e.g. R&D or user studies), which aims at discovering certain features to help develop an output. This does not imply that research aiming at understanding (i.e. R&D, UCD research, and market studies) does not lead to new insights that could revolutionize how things are and could be done. However, what specializes academic research of excellent value are the characteristics of its data and process. As described in the literature (Chapter 2 – Section 2.5.1.1), a research process has to be empirical (based on experience and observations), analytical and following a logical process, cyclical starting with a problem and ending with more opportunities, and following a systematic methodical process using credible data. Rigour is essential for impact to be reflected as research significance, and innovation to be attributed to research originality. Being able to describe that a systematic process has been followed is essential. Having a descriptive proof of data, information, and knowledge that has been exchanged (formally or informally), along with a reflection of the way this information fed into the output, can serve as concrete data and methodical process. All these elements if not actively registered and reflected, can be lost and therefore deflates the rigour of the process.

Figure 8.3 below represents where originality, significance and rigour could be located within the design process, if the right data is collected. The design process presented in this figure is based on the NPD process identified in chapter 6- Section 6.1. Input includes any existing knowledge, technology, material and methods that go into a design process. The box surrounding the process is PDR's environment, management and communication. The circle is the iterative process and methods used in developing/

testing a product. Insights represent any new knowledge learned from one or a group of projects.

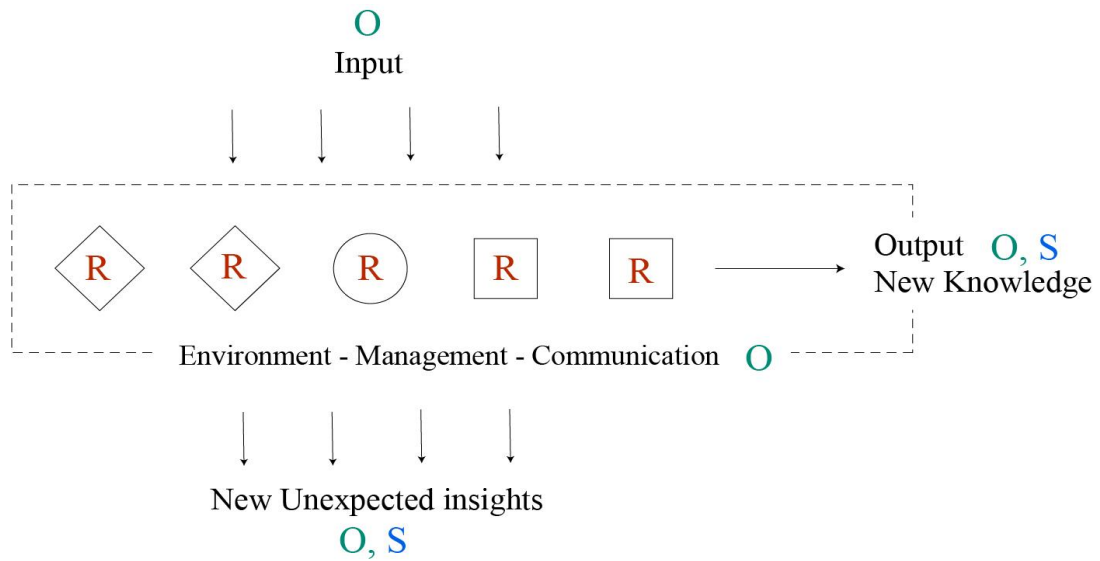


Figure 8.3 Where Originality, Rigour and Significance are located within a design process

The way the REF measures the quality of research by identifying the level of influence the research output has on its field, and its position as a point of reference are represented in table 4.3 in chapter 4. The quality measures indicate that for an output to be classified as a research output, it has to feature originality rigour and significance, and for these criteria to at least meet the minimum requirements (1\*) to be nationally recognized up to 4\* to be considered as world leading.

To achieve the minimum requirement on the rigour level, an output has to carry the basic measures of rigorous data validity and methodical processing of this data. The level of rigour is not negotiable, and systematically defines whether an output meets the definition of research or not.

Furthermore, to showcase originality, the output has to at least show an incremental improvement based on “existing methods and practices” (REF, 2019 b, p. 39). And to prove significance, the processes carried need to have had a minor influence on the general know-how of the field of practice.

Therefore a commercial output or process where research value has been recognized, has to firstly have enough supporting evidence that rigour is met. Furthermore, this value needs to showcase a minimum level of incremental knowledge which complements existing practice, technology, or knowledge with useful added value. From there, any



proof of contributions exceeding that level can only contribute to greater recognition of the quality of this output.

Accumulating case studies, reflecting, and learning are important to maintain relationship and repeat business, feeding into a spiral of exchange and creation of new knowledge and technology.

Accumulating data over a period of time and learning by doing can help in generating and assessing the impact of the knowledge and the outputs, and requires an extensive quantity and quality of collected data and case studies (Tsey, 2019)

As such the role of the implemented documentation process is to secure the benchmark of minimum requirements, by collecting information on the activities that took place and reflected the evolution of the brief, which results in an output. This data will be used as evidence to argue that this output has at least influenced the current status of the field: improving the existing know-hows in the design practice through showcasing the new insights or incremental created knowledge.

## 8.4 APPLICATION

Testing a documentation process that tackled the technical barriers opened up the opportunity to validate the predicted applicability of the documentation process, and potentially contribute to the argument on the practical value of this activity.

As perceived by this research, a lacking element so far, is the impact of research outputs on practitioners' career and professional development, which is affecting their motivation to systematically document these processes. This lack of relevance is the inability of designers or practitioners to submit to the REF, or for their professional advancement to be affected by their research contribution. Although some designers feel the need to give back to the research community, they do not particularly feel that they belong to this research community. As such, a worthwhile avenue of exploration would be to understand what would make this documentation process and consequently any resulting research value of excellent quality relevant to the designers.

The research, development, and testing of the documentation process took place in the context of PDR. The organizational structure of PDR; relatively flexible bottom-up managerial style dictates specific conditions and a level of flexibility within which this process has been tested, and some alterations would still be required for an effective

implementation of the documentation activity. Any implementation of a documentation process outside the context of PDR might require other alterations if the organizational structure differs.

In scenarios such as spin-outs within a university, where the aim is to commercialize knowledge and research, using those spin-outs as a tool for knowledge transfer is rather a complex matter. The development and success of spin-outs, and their use for knowledge transfer is dependent on a list of factors. These factors vary between the research capacities, the necessary support offered by the university and related bodies, or the innovation environment surrounding the spin out (Beraza, Garmendia, Rodríguez and Castellanos, 2015). While spin-outs share the benefit of processes improvement with contexts such as PDR, the barriers faced within spin-outs might differ due to the differences in their relationship nature with the university, the level of independence or control it implements, financial safety-net it provides, and the prioritization of knowledge commercialization versus knowledge creation and sharing.

The documentation framework can also be applied in similar contexts (consultancy within a university) but different fields such as business consulting and management, sports and health education where observation, documentation and reflection already take place. Similarly, to commercial design, management and business solutions consulting follow a variation of the double diamonds process. The application of a similar documentation process could be implemented, however in this case outputs take more the form of a set of strategic suggestions. Therefore, the commercial sensitivity risks are high, and the documentation framework needs to take this data sensitivity into consideration.

In sports, documenting activities, filming, analyzing and reflecting on footage of athletes, has been the lead way of feedback in improving processes and developing the necessary tools for a long time (Dowrick 1991 in Hughes & Franks 1997). A form of registering and reflecting on information already takes place. As such, documenting can be a similarly useful tool, but it has to incorporate the needs of a heavily visual data.

The application of a documentation and research dissemination framework is thus reliant on more strategic and managerial decisions related to the general objectives of the entity implementing it. In the case where research and research dissemination is part of the mission of the organization, implementing a similar documentation framework is

relevant, however, it requires more intervention and alteration of the process, according to the needs of practitioners who will be engaging with it.

## 8.5 ANSWERING THE RESEARCH QUESTIONS

*How best to recognize where commercial outputs can be characterized as research?*

The discussion of this research refers to the originality, significance and rigour components of research quality assessment, and applies them to the investigation into commercially derived output. The research found that commercial work can be evaluated against each of the factors, and therefore provides a positive answer to the existence of research value within commercial outputs.

The study showed that the commercial output's processes and a traditional research process do show a high level of similarities in terms of processes and methods. Furthermore, a detailed understanding of the design process offered opportunities to uncover originality, rigour and significance that meet the definition of research, and outputs (particularly artifacts) resulting from these processes embody all these criteria and therefore represent that research value.

Generally, the approaches and communication of rigour in methods and tools used in commercial versus academic research might differ. PDR's context within an academic institution implies that an exchange of existing knowledge and technology is taking place between designers, clients and researchers. This spiral of knowledge exchange is leading to new knowledge even if it was not initially established for academic purposes. Furthermore, the research processes these stakeholders undergo are taking place in a context that enables rigour, which is likely to hold up against academic rigour. In turn, these processes of exchange of knowledge and R&D leading to incremental information, directly and indirectly impact the newly created knowledge of potential excellent research value, building on the literature presented by Hermans and Castiaux (2006), Hermans and Castiaux (2016), (Norman and Verganti, 2014), and presented in Figure 8.2. Moreover, originality is found in both the R&D process and the output. The implementation of new components, which form part of the input generating the final design, or the employment of innovative and new relationship and connections between

already existing components, are ways in which originality is fed into the design process or output. Furthermore, incremental changes introduced to the processes, organizational structure, the design environment etcetera, appear to have an impact on the nature of the output generated, and influence the originality of the output and the knowledge it carries for some of the involved stakeholders.

Significance of the added knowledge and improvement of skills appeared to stem from an output as well as the process embodied in the output. The extent (local, national, and international) and the economic, social, political breadth of impact an output could have on a field and/or its stakeholders reflect the level of significant knowledge that could stem from a commercial design and its process. The reach of this commercial output or its process, and the stakeholders who adopt this commercial design process or output, similarly reflect its significant research value.

*Where a research characterization is met, how best to recognize and describe the research quality?*

The new knowledge resulting from the commercial process and represented in Figure 8.2 has a vast potential of being of excellent research quality.

Having a clear and elaborate research evaluation criterion such as originality, rigour and significance can increase the possibility of detecting and evaluating any existing research value. This could be achieved by uncovering components that characterize originality, rigor and significance in the artifact and the process as represented in figure 8.3.

For the output to be considered of significant research quality, there is a need to prove that the process or the output have impacted existing knowledge or technology used in design, and pushed it a step further. This development could influence how the organization improved its process, or how other practitioners beyond that organization have adopted this change. This influence and change could be as radical as fundamentally affecting the area of practice or the theory around it, making it a research of greater quality.

Furthermore, there is an opportunity of increasing the potential captured and disseminated knowledge beyond the limits of a single project or output. The right flow of information is critical to the extraction of factors that make up originality, rigour and significance, and therefore rate research quality.

Building up a portfolio of projects that can converge in many aspects, can lead to new research insights of high quality. This will be possible through a documentation process, flexible enough to suit commercial environments, yet systematically implemented within the organization as part of its strategic mission, in order to detect and disseminate any existing new knowledge of high impact and quality.

## **9 CONCLUSION AND RECOMMENDATIONS**

This research adopted a grounded action method to study the potential availability of research and knowledge value within commercial design outputs, and if existent, how to capture the research quality, resulting in a set of primary and secondary theoretical and practical contributions to knowledge.

### **9.1 PRIMARY CONTRIBUTIONS TO KNOWLEDGE**

#### **9.1.1 IDENTIFICATION OF THE POTENTIAL FOR RESEARCH VALUE IN COMMERCIAL OUTPUTS**

There is a high potential for knowledge creation and research value within commercial outputs. There are existing similarities between commercial processes and basic research processes. These similarities along with the parallels between commercial design processes and an existing knowledge creation spiral in industry- universities collaborative research (Hermans and Castiaux, 2006), highlighted the presence of knowledge being created during a commercial process taking place in a university-based consultancy. This knowledge, if it meets the originality, rigour and significance research standards, could be of research value even if it is of incremental nature (Hermans and Castiaux, 2016; Norman and Verganti, 2014).

#### **9.1.2 ORIGINALITY, SIGNIFICANCE AND RIGOUR; A JUSTIFICATION THAT NEW KNOWLEDGE IS OF RESEARCH VALUE**

The thesis identified a list of elements that support the application of the three research criteria (originality, rigour and significance) on commercial design outputs. If found within certain standards in the output or the process leading to it, this list of elements can help characterize commercially driven outputs with potential research quality. The elements forming originality, significance and rigour need to be identified in order to articulate research value in commercial designs.

Originality is identified in the REF as an element of innovative contribution and added value to the existing field of knowledge and practice. Since there is no body of literature to compare the commercial output to it, originality can be identified in a commercial

process through its components (problem, material, methods, business model), the relationship between existing components: (management, relationships, connections), and the point of reference (stakeholders' point of view, justification from designers, clients and researchers).

Significance is understood as the extent to which the output can influence the body of knowledge. In commercial outputs, impact on a practical level plays a role in determining that significance. A commercial output's significance, could be measures by the extent (magnitude or depth), reach (audience or breadth of expansion) and relevance (context).

Rigour in REF is linked to the systematic methods and processes used in the research process. In commercial design, this systematic methods and rigour is equally as important, and would be identified in the tools used (methods, processes, failure and iterations) and their source (validity, time, reputation, data type).

### **9.1.3 DOCUMENTATION TO CAPTURE RESEARCH IMPACT AND QUALITY**

A documentation process was built on a conceptual framework to capture research quality that makes explicit where research value exists, and provides a mechanism to capture that evidence of quality.

The documentation process was developed to capture and disseminate knowledge in commercial projects over a long period of time allowing reflection on design activities to learn and capture impact of the outputs in what could potentially have academic and practical implications. The documentation process is partly based on the set of barriers and drivers available in the literature review and resulting from the interviews. The framework reflects one finding of this research: the limitations are mostly technical, and related to resources and skills, rather than a lack of research value in non-traditional outputs, or the fundamental disinterest of the two communities (research and industry) in capturing and sharing knowledge.

The documentation process is also reliant on the list of elements that define the three REF research criteria: originality, rigour and significance. The implementation of this documentation process or any variation of it is affected by how the process and the designers' motivation are managed. Testing showed that for a successful implementation of a documentation process, designers need an element of gradual introduction to the process within their daily tasks over a period of time, rather than a sudden

implementation. Furthermore the documentation process needs to be explained, and its benefits need to be introduced. Going through this process needs to also have an impact on the practitioners' careers to give them a reason and motivation to take part of it. Documenting the commercial processes needs to be introduced as part of the strategic plan of the organization, and implemented over an extended period of time.

## **9.2 SECONDARY CONTRIBUTIONS TO KNOWLEDGE**

### **9.2.1 ASSISTING IN DETERMINING RESPONSIBILITY FOR RESEARCH**

The main changes introduced to the REF 2020 guidelines post-Stern review are associated with impact and eligibility for submissions. The former regarding impact being linked to the increasing importance of impact represented by the 25% weighing, and the fact that impact is linked to the institution where research was conducted. And the latter regarding the HEI's responsibility to identify staff with significant responsibility for research. Both REF new guidelines impose on HEI the need to develop a process that would help them recognize staff responsible for research based on the type of research output they produce, and the average length of time they invest in producing research outputs, while tracking the impact of their work. This research proposes a documentation framework developed based on the research assessment criteria: originality, rigor and significance. This documentation strategy can be used by HEIs to identify: 1) when practice meets the needs/definition of research; 2) who is performing practice that meets that definition; and 3) for what proportion of their time are they expected to perform the right types of practice and at the requisite quality.

A pilot implementation of the framework would allow for a retrospective evaluation of where individuals have performed a significant responsibility to research, even if they did not recognise it. This might in future lead to new understanding of who is expected to spend a significant proportion of their time undertaking research, and therefore being submitted to the REF. Further, it may lead to new understandings regarding the links and overlaps between research and knowledge exchange activity.

### **9.2.2 POTENTIAL FOR APPLICATION IN OTHER CONTEXTS**

This research offers an approach to capture research quality that can be applied to other disciplines.



Interviews conducted for this research with experts from multiple fields resulted in shared limitations in identifying research within industry-university collaborations relevant to their fields; the needs to identify research value is common between commercial design and non-traditional outputs-producing fields. The elements forming originality, rigour and significance criteria resulted from interviews done with the group of experts belonging to multiple industries, as such their implementation in other fields is feasible.

This resulting documentation strategy can therefore be implemented in the contexts of the fields that were interviewed in this research. The flexibility and potential alterations of the technicalities of the originality, rigour and significance elements and the documentation framework serve the ability to transplant this documentation process into another area of university-industry collaboration.

### **9.2.3 A GREATER REFLECTION AND LEARNING WITHIN THE DESIGN PROCESS.**

The documentation of commercial design activities assists in locating research value and knowledge in commercial outputs and R&D processes. This collection of information therefore contributing to the consultancy's own commercial development, improvement of processes, staff skills' development, and increasing the commercial power and the research capacity of PDR and the academic institution as a whole. Consequently, such knowledge creation serves both institutions' strategic plans and aims on a bigger scale.

Documenting can also help in capturing spill over and unforeseen insights and opportunities for collaborations and research, by being able to visualise and compare all the projects including all their data and involved processes. As such, the impact of the created knowledge stretches beyond its significance on the specific area of inquiry of this research and its contextual setting (Tsey, 2019).

### **9.2.4 COMMERCIAL LIMITATIONS TO THE ENGAGEMENT IN DOCUMENTATION**

The implementation of a documentation framework, and knowledge dissemination that might consume a commercial body's resources, no matter how effectively done, can raise questions around the risks, cost, and time. Sharing commercial data presents its own sensitivities, which clients and designers are not ready to jeopardize.

Sharing commercial outputs as a REF submission, or in the public domain has already proven to be highly scrutinized by universities. This could be due to the commercial sensitivities, difficulties in reflecting the value within such outputs, and worries regarding the evaluation process.

Documentation processes that assist in collecting the necessary data to prove research quality are not easy to implement. Commercial management in organizations similar to PDR, or any other university department dealing with commercial activities, are not always supportive of such documentation and dissemination activities. Spending commercial teams' time on documenting and reflecting is not seen as a priority, unless there is a proof that the commercial benefits outweigh the costs.

#### **9.2.5 POTENTIAL FOR IMPROVEMENT IN WRITING SUBMISSIONS' MATERIAL**

In a comparison of top scoring institutions and the least successful ones, few noticeable distinctions were made. Top submissions almost always had a story-telling format, and a persuasive writing style. They did not resort to simply stating facts surrounding the research underpinning the outputs, and how the respective output meets the originality, rigor, and significance criteria. The submitted descriptions were of the contextual setting leading to the output and in many cases, the background and interests of the author/curator/designer of the output. It appears that the appeal of story telling is allowing the reviewer to relate on an emotional level. During their observations of impact case studies assessment, Watermeyer and Hedgecoe (2016) suggested that the writing style could impact the assessment; and that the result of the assessment might no longer purely reflect the output and research quality, and rather become a result of "window-dressing" the submissions.

### **9.3 RECOMMENDATIONS**

Today, information and data on PDR's different commercial projects do not get systematically recorded and organized in a manner that is useful for describing research quality. Information is scattered, visually and content wise, limiting the ability to capture any existing research value and consequently assess its quality. Additionally some knowledge goes unrecognized and ends up being relearned and re-generated in other

projects, lengthening the process of learning and development, and knowledge transfer, and causing additional costs.

### **9.3.1 RECOMMENDATIONS FOR PDR - IF THEY WISH TO CAPTURE RESEARCH QUALITY FROM COMMERCIALY DESIGNED OUTPUTS**

PDR needs to organize and systematically implement a documentation process where all the information generated during a commercial process and exchanged between designers and researchers is readily and clearly available. This availability of data is useful for the designers to reflect on and researchers to refer to as case studies and real life examples, which brings another advantage to research production at PDR.

PDR's well-documented commercial processes to generate material and assist:

- In capturing exchanged information and knowledge between designers, research, and clients,
- In creating rigorous data and portfolios to develop stronger REF submissions,
- In collecting enough data to highlight rigour, originality and significance within the commercial outputs,
- New designers in easily finding already accessible and visually understandable material to learn from, and to develop training material for staff,
- In reducing the possibility of repeating the same mistakes, and speeding up the learning process,
- Designers in using the generated material, reflect on it and use it as a development tool for internal processes,
- Business development staff to this material to further understand the design process, learn about existing and ongoing projects, and increase the breadth and depth of their commercial design knowledge, therefore taking full control and reducing the time of the first stage of the design process,
- A tool for other departments within PDR to learn about the different projects running in the commercial department, to learn about existing opportunities for collaboration or initiating any potential ones,
- Material for any potential teaching activity or collaboration taking place between PDR and other schools such as Cardiff School of Arts and Design,
- In creating case studies as teaching material in the event of PDR collaborating in the teaching process in one or more of the university's schools and faculties.

Designers in PDR can use this available information and the regular reflections to share with team members, and work on ways to improve and speed up the processes and reduce costs.

### **9.3.2 RECOMMENDATIONS FOR PDR'S MANAGEMENT**

One of the aims of this study was capitalizing on any existing research value. The importance of the research production activity in PDR's role as part of an academic institution, and finding ways to constantly maintain its contributions to the academic mission, is a concern for PDR's management. As such developing and implementing a different kind of data capture can offer opportunities and additional values within PDR's commercial activities. Management plays a big role in implementing such changes and introducing new processes as part of its involvement in the general research activity in PDR. Managerial control focusing on the way tasks should be performed can increase clarity, therefore supporting employees in their performance, which are elements linked to more trust and better task performance (Verburg et al., 2018; Wit-de-Vries et al., 2018).

In order to reap the opportunities that this documentation process can offer, the management has an important role in encouraging development and motivation. By turning such process into an essential element of the organizational culture and activities, management could reduce the resistance to change or introduction of any new process.

### **9.3.3 RECOMMENDATIONS FOR THE UNIVERSITY**

The value of this knowledge goes beyond REF submissions and internal development. The value in capturing and sharing new knowledge is in its impact on the university's research production and education of the future professionals aim. This research and the resulting research assessment criteria and documentation process offers an opportunity to achieve this aim. As such, the university can benefit from implementing a form of this documentation process to provide case studies for teaching material, and opportunities for researchers from different disciplines to interact and generate potential multidisciplinary research collaboration. The university could also use a similar documentation framework to create its guidelines and implement a process of assessing

responsibility to the REF, and eventually identify people who are not on academic contracts, but still have significant responsibility for research.

As discussed in chapter 8 – Section 8.3.1, part of the difficulties in implementing a documentation framework is how designers or practitioners can feel distant from the research community. Not seeing a tangible impact of research production on their career can affect their drive to invest time and effort in documenting their work. The university could play a role by offering opportunities to motivate designers and practitioners to take a research route for a career development based on the research contribution and research quality associated with their names.

## 9.4 LIMITATIONS

Phase B of this research involved a set of 13 interviews from a variety of fields, which informed chapters 4 and 5 and answered the first part of the research question. The snowball effect used in recruiting the interviewees might have led to people who are logistically close to each other or involved in the same area of research, therefore narrowing down the scope of opinions and consequently the results. A higher number of interviewees from a broader variety of fields for Phase B, might have increased the number of opinions regarding the different themes, and broadened the applications opportunities of the outcomes of this research.

Some of the interviewees' experiences with the REF process may have dictated their opinion on the matter. If some experts received negative REF results in comparison to other work they perceive of lower quality to theirs, or received feedback that they perceived as unfair, this could have an effect on their opinions, consequently creating bias in their response. The bias surrounding their opinion might have skewed their points of view in one way or the other, therefore affecting the data and the resulting themes.

The documentation process trial was enough to confirm the feasibility and practicality of such process, proving that the preconception of it being costly or time consuming is not necessarily accurate. A longer documentation period could help generate enough data and information on multiple projects and case studies, which could be used to create examples of knowledge creation and generate case studies. A longer testing period could help to assess the quality of the resulting information, which would assist in giving

practitioners more examples of the value of this knowledge and research and its impact on their work.

## 9.5 FUTURE RESEARCH

The documentation process is partially reliant on the three criteria of originality, rigour and significance and the elements listed under each one of them in chapter 5. A further elaborate definition of these criteria, and the development of sub-elements under the existing definitions, can improve the potential of the documentation framework as well as the evaluation of any research value existing in commercial projects.

A longer period of documentation needs to be done to evaluate the resulting data and its quality, in order to validate the documentation process and help in improving it. A step further after collecting enough data is developing potential REF submissions using this data, and subjecting them to evaluation by an external examiner. This longer testing period can take place in iteration and feed into the development of more detailed definition of originality, rigour and significance discussed above.

Implementing the documentation framework (with the necessary changes) in other similar contexts in design, but also in other industries such as sports, management and arts can be the next step forward. The documentation process has potential in improving practice in other industries, as well as creating opportunities to capture and share new knowledge.

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## **APPENDIX 1 PHASE B'S INTERVIEW QUESTIONS**

### **Interviewee H- 3/2/2016**

- From your work on the REF submissions, what are your thoughts on the REF as an evaluation process?
- REF criteria and the 300 words characteristics?
- Knowledge exchange between stakeholders (academia/ industry)
- Communicating artifacts and traditional research?

### **Interviewee E - 9/2/2016**

- What is the flow of projects submitted for evaluation such as REF?
- At what stages are other stakeholders (mainly commercial partners) involved?
- What role do research and academic rigourousness play in your commercial projects?
- How do you choose your commercial partners?
- What role do design awards play in your work and in providing proof of research?
- How does your involvement in academic research improve you commercial capabilities and your ability to attract funding for further research?
- How do you identify originality, rigour and significance within your work ?
- How do your partners react to communicating the work you've done with them with the academic community but also the industry?

### **Interviewee I- 3/3/2016**

- Your opinion on the REF process in general, its criteria and its evaluation based on this criteria ?
- The effect of the REF on an institutional level
- Do you feel that there are other elements that affect the evaluation process other than the published set of criteria?
- How does the university choose the staff members that will be submitting and what affects the choice of the submissions?
- How is that choice affecting the submissions of what is called non-traditional research outputs (from PDR and CSAD)?

#### **Interviewee D - 4/4/2016**

- Can you explain to me the steps you go through in a collaborative project (one which have been submitted to the REF)
- What do you feel is the most important thing you are getting out of this collaboration? And what does PDR get from it?
- How does winning the award affect you on a practical level, and academic level? - How do you as a practitioner feel about these awards?
- How involved are you academic publications and work and the submissions to the REF?
- What's the importance of the research element for you?
- How do you think, in the medical field, originality perceived and monitored on a practical and academic level ?
- How do you define rigour, significance and originality within your work?

#### **Interviewee A - 21/4/2016 and Interviewee B - 3/5/2016**

- Explain to me the link between your studies (PhD) and the work you are currently doing.
- What's the added value of research in general and your research background in your field?
- What do you feel is the most important thing about merging design and academia?
- How does winning awards affect you on a practical level, and academic level?
- How do you think , in your field, originality , significance and rigour are perceived and monitored on a practical and academic level ?

#### **Interviewee G - 3/5/2016**

- Do you think what you communicate is addresses more to academics or clients/commercial ?
- How does that influence how you write about research or about commercial work?
- What do you think are main factors or boxes you need to tick when you're writing any piece to reach your target audience?
- What do you think is the most important factor a possible client might want to see in a portfolio , and that might affect their decision positively/ negatively ?
- How do you show how this or that project is significant/rigorous / original ?

#### **Interviewee J- 3/6/2016**

- Tell me briefly about your role in the REF submission process
- Due to the nature of the work done within this department, do you feel some of the work you do in collaboration with industry feeds into the submissions to the REF?
- How do you reflect the impact of such outputs?
- Do you think there is a strategy in terms of the administrative side of submissions (number of submissions and choice)
- What do you think about the evaluation criteria and the process in general?
- How do you reflect originality, significance and rigour within your submissions?
- What's your experience with commercial or industry people?
- How is research affected by the way it is communicated within academia but also to practitioners?

**Interviewee C - 28/6/2016**

- How important is the research element within the NPD process, and commercial design in general?
- What are the differences (other than the explicit written and abstract) between traditional and non-traditional research output?
- What do you think of situations when the problem that actually ends up being solved is not the same as the one the research was set to answer in the first place? And how does that affect the trajectory of the research?
- What are your thoughts on the REF criteria and evaluation process concerning non-traditional outputs, and its challenges?
- Are the research factors (originality, rigour and significance) clearly understood within non-traditional outputs?
- How do you think this criteria (O, R and S) are perceived by commercial stakeholder or by the industry?
- Do you think commercial stakeholders are interested in the research aspect or output of the process?
- Do you feel that certain aspects of the design process as opposed to traditional research go more towards that customized rather than the generalizable, as expected from most traditional research outputs?
- What are your thoughts on communicating research and what it represents in terms of knowledge including tacit knowledge (on an internal and external level)?

### **Interview F - 30/6/2016**

- What are your views on the overlapping grounds between academia and non-traditional outputs?
- How do you look at the REF process in terms of criteria and evaluation , and how do the non-traditional outputs differ in terms of O, R and S?
- How do you transmit the way you see O, S and R in a non-traditional output to a panel that might not see it the same way, only through that 300 words ?
- How do designers and artist perceive academic work and how involved are they?
- How beneficial is the research work to practice and how the practitioners' involvement or the lack of it affects it negatively or positively?

### **Interview M - 20/9/2016**

- Can you further explain to me further about the non-traditional outputs you mentioned during you symposium talk?
- What differences can you pinpoint between traditional journal papers and ones resulting from applied practice in sports sciences in terms of REF submissions?  
and the 300 words accompanying non-traditional submissions,
- What's your field's experience in terms of REF, its criteria and the evaluation process, especially for non-traditional outputs? Is there a direction towards a change within that area ?
- How do you identify O, R and significance ?
- Are practitioners interested in engaging in the academic or research side of the work ?
- How do you think the communication play a role in bridging the gap between academia and practice?
- Are the criteria (O, R and S) relevant to practice the same way it is relevant to academia?

### **Interviewee L - 10/10/2016**

- What differences can you pinpoint between academia and practice?
- Common points between traditional journal papers and ones resulting from applied practice in sports sciences in terms of REF submissions? How do you personally look at practice work and demonstrate that this is a result of a rigorous research process?

- How much similarities are there between the different aspects of your fields, that allow generalizability of research in one to the others?
- Are practitioners interested in engaging in the academic or research side of the work?
- How do you think communication plays a role in bridging the gap between academia and practice?
- Your opinion on the effect of organizational environment on internal and external communication.
- What's your field's experience in terms of REF, its criteria and the evaluation process (its level of objectivity) especially for non-traditional outputs? And is there a direction towards a change within that area ?
- How do you identify O, R and significance?
- Are the criteria relevant to academia (i.e O, R and S ) as relevant to the practical world ?

**Interviewee K - 12/10/2016**

From your experience in working with the industry, with large applied research projects with many different large industrial companies, how valuable is the overlap of industry and research?

What are the limitations of this overlap?

-When we talk applied research, was it more in R&D or more to improve processes?-Do you think that the three criteria of originality, rigour and significance are relevant to commercial stakeholders?

- How is this criteria perceived from an academic perspective?
- What are the major limitations in the evaluation process such as REF?
- How is /should the communication be from academia to industry and the other way around ?

## **APPENDIX 2 PHASE C'S INTERVIEW QUESTIONS**

### **Interviewee O - 21/8/2017**

- Are you involved or would you be interested in getting involved in academic research, and why/why not?
- How do the clients react to any sharing or publications of the/some of the commercial work?
- How do you think you can benefit from the commercial work and your own previous experience?
- How beneficial is communication, both on an internal or external level ?
- Is there a value for originality, rigour and significance in the commercial work you produce, and if yes, how do you identify them?
- Take me through a rough flow of activities in a typical UCD project
- Which stages do you feel you face problems with, or that can be improved by learning from experience?
- How do you think documenting work is currently managed and how do you think it should have been?

### **Interviewee N - 24/8/2017**

- What difference do you think academic outputs make to you or any other practitioner? And what pushes them/you to get involved?
- Take me through a rough flow of activities in a typical UCD project
- Which stages do you feel you face problems with, or that can be improved by learning from experience?
- How do you think documenting work is currently managed and how do you think it should have been?
- Is there a value for originality, rigour and significance in the commercial work you produce, and if yes, how do you identify them?
- Information sharing: values and limitations?

### **Interviewee P - 29/8/2017**



- Do you see value in academic research within your work? And in producing academic research from the commercial work you do?
- What can be the constraint to such an activity?
- What are the benefits of such an activity on an internal and external level?
- Take me through a rough flow of activities in a typical UCD project
- Which stages do you feel you face problems with, or that can be improved by learning from experience?
- How do you think documenting work is currently managed and how do you think it should have been?
- Is there a value for originality, rigour and significance in the commercial work you produce, and if yes, how do you identify them?
- Information sharing: values and limitations?

**Interviewee Q - 30/8/2017**

- REF: who's submissible, under what contract, and what does it depend on, can the submitting person be different than the person who did the work (especially with commercial work) ?
- What's the submission process and who makes the internal decisions ?
- What is PDR's position within Cardiff Met?
- How does that position affect PDR's attractiveness to clients?
- How are originality, significance and rigour perceived?
- communication and information sharing : limitations and benefits on an internal and external level?

## APPENDIX 3 APPLICATION FOR ETHICS APPROVAL

When undertaking a research or enterprise project, Cardiff Met staff and students are obliged to complete this form in order that the ethics implications of that project may be considered.

**If the project requires ethics approval from an external agency (e.g., NHS),** you will not need to seek additional ethics approval from Cardiff Met. You should however complete Part One of this form and attach a copy of your ethics letter(s) of approval in order that your School has a record of the project.

The document ***Guidelines for obtaining ethics approval*** will help you complete this form. It is available from the [Cardiff Met website](#). The School or Unit in which you are based may also have produced some guidance documents, please consult your supervisor or School Ethics Coordinator.

Once you have completed the form, sign the declaration and forward to the appropriate person(s) in your School or Unit.

### PLEASE NOTE:

**Participant recruitment or data collection MUST NOT commence until ethics approval has been obtained.**

### PART ONE

Name of applicant:	Dana Al Batlouni
Supervisor (if student project):	Dr Huw Millward
School / Unit:	PDR
Student number (if applicable):	20050064
Programme enrolled on (if applicable):	PhD
Project Title:	Challenges Of Capturing Research Outcomes
Expected start date of data collection:	Within A Commercial Design Consultancy. 15/01/2016

Approximate duration of data collection:	12 months
Funding Body (if applicable):	Internally funded PhD project
Other researcher(s) working on the project:	No
Will the study involve NHS patients or staff?	No
Will the study involve taking samples of human origin from participants?	No

Does your project fall entirely within one of the following categories:

Paper based, involving only documents in the public domain	No
Laboratory based, not involving human participants or human tissue samples	No
Practice based not involving human participants (eg curatorial, practice audit)	No
Compulsory projects in professional practice (eg Initial Teacher Education)	No
A project for which external approval has been obtained (e.g., NHS)	No

If you have answered YES to any of these questions, expand on your answer in the non-technical summary. No further information regarding your project is required.

If you have answered NO to all of these questions, you must complete Part 2 of this form

In no more than 150 words, give a non-technical summary of the project

[Click here to enter text.](#)

**DECLARATION:**

**I confirm that this project conforms with the Cardiff Met Research Governance Framework**

Signature of the applicant:

Date: 08/12/2015

**FOR STUDENT PROJECTS ONLY**

Name of supervisor:

Date: 08/12/2015

Dr Huw Millard

Dr. Andrew Walters

Dr. Joanna Hare

Signature of supervisor:

**Research Ethics Committee use only**

Decision reached:

Project approved ☒

Project approved in principle ☐

Decision deferred ☐

Project not approved ☐

Project rejected ☐

Project reference number: [Click here to enter text.](#)

Name: Huw Millward

Date: 01/02/2015

Signature:

Details of any conditions upon which approval is dependant:

[Click here to enter text.](#)

## PART TWO

### A RESEARCH DESIGN

A1 Will you be using an approved protocol in your project?

No

A2 If yes, please state the name and code of the approved protocol to be used<sup>4</sup>

[Click here to enter text.](#)

A3 Describe the research design to be used in your project

A mixed methods research perspective will be adopted for this inductive exploratory research.

Below the methods that will be used to gather qualitative and quantitative data :

- Contextual observation in PDR and Cardiff School of Art and Design.
- Review and analysis of PDR's different design projects and award winning designs.
- Review and thematic analysis of the REF submissions.
- Informal preliminary interviews followed by semi-structured interviews with:  
experts in PDR and CSAD design research teams;

external designers and practice-based researchers;

external parties who were involved in the REF submissions process.

Interviewing the same person more than one time might be key

In the formulation of the framework and re-evaluating and sharing the findings.

A4 Will the project involve deceptive or covert research?

No

A5 If yes, give a rationale for the use of deceptive or covert research

[Click here to enter text.](#)

A6 Will the project have security sensitive implications?

No

A7 If yes, please explain what they are and the measures that are proposed to address them

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<sup>4</sup> An Approved Protocol is one which has been approved by Cardiff Met to be used under supervision of designated members of staff; a list of approved protocols can be found on the Cardiff Met website [here](#)

[Click here to enter text.](#)

## **B PREVIOUS EXPERIENCE**

**B1** What previous experience of research involving human participants relevant to this project do you have?

I conducted interviews with international alumni for my Msc in International Business Management degree thesis at Cardiff School Of Management.

I conducted a series of Interviews with employers in Cardiff as part of Research project on the effect of digital literacy on employability (in collaboration with Sarah Williams FHEA, Project manager of the Digital Literacy Project)

## **B2 Student project only**

What previous experience of research involving human participants relevant to this project does your supervisor have?

[Click here to enter text.](#)

## **C POTENTIAL RISKS**

**C1** What potential risks do you foresee?

The research does not have any health or safety risks on the participants or the researcher.

Participants will include staff from PDR and Cardiff Metropolitan University's other schools, as well as external participants from a different universities and consultancies.

Risk of the large amount of data gathered being mishandled

**C2** How will you deal with the potential risks?

Participants will be given the choice of anonymity and confidentiality .

The risk of the data gathered being mishandled is addressed through adherence to Cardiff Met's ethical procedures, with the appropriate levels of data storage and data security.

The research relies heavily on internal participants - it is estimated that 80% of the data lies within PDR. This reduces the risk that the researcher is unable to access the appropriate data.

The research will not seek any sensitive data from any internal and/or external

participant.

The risk of the large amount of data gathered being mishandled is addressed through adherence to Cardiff Met's ethical procedures, with the appropriate levels of data storage and data security.

In addition, all participants will be informed of their right not to participate or to cease participation at any time without penalty.

When submitting your application you **MUST** attach a copy of the following:

- All information sheets
- Consent/assent form(s)

An exemplar information sheet and participant consent form are available from the Research section of the Cardiff Met website.



## **APPENDIX 4 PARTICIPANT INFORMATION SHEET**

### **Challenges of Capturing Research Output from Enterprise-Led Design**

#### **Activities**

##### **Participant Information Sheet**

##### **Background**

I am a PhD research student at the International Centre for Design & Research (PDR), which is based within Cardiff Metropolitan University. PDR undertakes a wide range of academic research and commercial design activities – my project is interested in evaluating how enterprise-led design activities can deliver research outputs, predominantly in terms of product design artifacts. The research project is looking at defining, capturing and disseminating enterprise-led research outputs, outcomes and impact. The aim is to develop and deploy a framework within a commercial design environment that can effectively communicate emerging research outcomes.

##### **Project summary**

I am evaluating the potential for design outputs and artifacts to contribute to academic research, and as a new way of understanding design research. This project looks into how design activities can be shown to meet the criteria for academic research, namely: originality, rigour and significance. The research gathers information on the commercial product design process, and the possibility of capturing the research elements within it. The research aims to develop a framework for capturing, analysing and disseminating research outcomes from the design process on two levels:

1. To improve internal communications between academic and commercial disciplines;
2. External publications highlighting the originality, rigour and significance (and impact) of specific product design projects.

This research investigates a range of available projects (international design awards, REF2014 submissions) in order to produce a list of criteria that can serve as a foundation for this framework.

The research will examine researchers/designers/practitioners' opinions regarding the criteria, and the ability to measure an output's research potential and background.

## **What is involved?**

This PhD project seeks input and feedback from a range of participants who have knowledge of the design process. You have been asked to participate because of your experience and expertise within academia, commercial design and/or practice-based design. I hope your involvement can add value to my research; I will endeavour to share the findings of my research with participants at the appropriate stages of my PhD. The primary research method will be the semi-structured interview. Following initial contact and preliminary agreement to proceed, this could take the form of:

- telephone-based interviews;
- Skype Interviews;
- interviews held at Cardiff Met or the interviewees' premises;
- interviews at design events (such as conferences).

In addition, participants may be invited to contribute to this research project through web-based surveys, workshops and focus groups (where appropriate).

You will only be asked questions about your perceptions and understanding about how the product design process can facilitate research outputs. The questions could be directed towards documents in the public domain (e.g. research papers/submissions), together with your views on the subjective assessment of what constitutes 'quality' research.

## **Project risks**

I am not seeking to collect any personally-sensitive or commercially-confidential data. This research is only concerned with your thoughts and opinions regarding the interface between academic research and the product design process.

We do not think that there are any significant risks associated with this study. However, if you do feel that any of the questions are inappropriate then you can stop at any time. Furthermore, you can change your mind and withdraw from the study at any time – we will completely respect your decision.

## **How we protect your privacy**

All the information that you provide will be held in confidence. Your personal details (e.g. signed consent forms) will be kept in a secure location. No personal details will be

revealed in the PhD or associated publications – all information and quotes will be anonymised. When I have finished the study and analysed all the information, all personal details will be removed from the set of research documents.

**Contact Details**

Dana Al Batlouni

Researcher, PDR

TEL: +44 (0) 29 2020 5964

EMAIL: [dabatlouni@pdronline.co.uk](mailto:dabatlouni@pdronline.co.uk)

## APPENDIX 5 PARTICIPANT CONSENT FORM

### Participant consent form

PDR

Cardiff Metropolitan University

Ethics Reference Number:

Participant name:

Title of Project:

Name of Researcher: Dana Al Batlouni.

### Participant to complete this section: Please initial each box.

1. I confirm that I have read and understood the information sheet for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily
2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason
3. I agree to take part in the above study.
4. I agree to the interview being audio recorded

☐☐☐☐

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Signature of Participant

Date

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Name of person taking consent

Date

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Signature of person taking consent