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Understanding and classifying the role of design demonstrators in scientific exploration

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ABSTRACT

This paper describes the development of a model for classifying the different type of 'design demonstrator' that might be used in translating scientific activity from the laboratory to the market. Two detailed case studies are described in which designers worked closely with scientists. In one of the projects, the scientists were seeking to commercialise their research. In the other, the research was at an early stage and the scientists had not considered commercialisation. Different types of physical artefact produced in these collaborative projects were analysed to identify the extent to which they might contribute to science, technology, application or market. Evidence indicates that demonstrators might fulfil multiple purposes and that the translation from science to market is more complicated than is often shown in linear models. An original classification of the role of demonstrators through this journey is provided.

1. Introduction

There is evidence to suggest that the early involvement of industrial design expertise in the development of new technology can improve its potential for future application (e.g. Kotler and Rath 1984, Lorenz 1994, Black and Baker 1987, Roy 1999, Gemser and Leenders 2001, Hertenstein et al., 2001). These studies report explicitly on the development of technology in industrial settings, which is characteristically driven by commercial goals. However, despite compelling evidence for the value of designers in industry, there has been surprisingly little work exploring the potential impact that design might have on scientific research in academia.

There need to explore this in more detail is both important and timely due to the growing emphasis placed on 'impact' of research in the UK[1], EU (Fisher et al., 2009) and internationally. In the UK for example, the government spends in the region of £2.5bn on R&D (ONS 2012), but is acknowledged as being weak in translating its strong science base into innovative companies or products (Livesey et al. 2006). The well-known term 'valley of death' is often used to describe the difficulty of progressing scientific discovery from laboratory to market. This concept was first coined by Merryfield (1995), referring to the transfer of agricultural technologies to the third world but has since been adopted as a metaphor to describe the hurdle that exists between primary research and the commercialisation of new products (Markham et al. 2010). Increasingly, the 'valley of death' is used to refer to a resource gap in moving ideas from laboratory to market. The 2005 Cox Review noted that "technology that is not carried through into improved systems or successful products is opportunity wasted" (Cox 2005).

A common explanation for this is a "cultural gap" between the scientists, whose mission is to understand fundamental principles and the more commercially oriented development specialists, whose goal is to introduce new products (Markham 2002). One route to addressing this issue is to "manifest the discovery as a product"; designers are noted as providing a key 'interface' role (Boren et al. 2012) to enable this.

However, although much is known about the role of design in industry, little is known about the potential role that designers can play in supporting the development of new science in an academic setting as a route to bridging this valley-of-death.

The 2007 Sainsbury Review highlighted how "the use of design helps scientists to develop commercial applications for their work while it is still at the research stage or at the outset of the technology transfer process" (Sainsbury 2007, p151). Evidence for this assertion came from a pilot scheme, run in partnership between the Design Council, the Engineering and Physical Sciences Research Council (EPSRC) and University College London Ventures to bring design consultancies into scientific research (Design Council, 2006). A follow-on study conducted in 2009 saw a number of consultancies paired with Technology Transfer Offices (TTOs) from several of the UK's leading universities (Design Council, 2009). These consultancies provided design mentoring to scientific

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[1] http://www.epsrc.ac.uk/funding/howtoapply/preparing/impactguidance/

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teams. Participants in these studies reported several benefits of working with designers. In both the 2006 and 2009, the participating scientists were already seeking to commercialise the results of their work, and so had conceptually already started to cross the valley-of-death.

Rust (2004, 2007) has also commented on the potential benefits and barriers to designers working with scientists and discusses how these barriers might be overcome. Such benefits of engaging designers in the scientific process include: Speeding up the process of commercialisation; Bringing a perspective of potential users and the market place; Raising awareness of future applications; Making scientists aware of the process of commercialisation; Helping to communicate ideas between research collaborators and potential investors in an exciting and credible way; Visualising scenarios of use. Prototyping for quick testing of ideas; Producing artefacts to aid understanding and stimulate ideas; and Assisting with communication and dissemination of research. However, the data set supporting these assertions is not clear and so their validity cannot be easily evaluated.

Building on these themes, Driver et al., 2011 conducted a study in which designers worked closely with scientists to identify the critical contributions that designers might make. These included: Prototyping for quick testing of ideas; Challenging scientists' perceptions; Applying scientists' underlying theories; Creating artefacts to aid understanding and stimulate ideas; Assisting with communication and dissemination of research; Visualising scenarios of use; Creating technology demonstrators; Producing devices/processes/spaces to enhance scientists' research capability; and Performing user and market research to enhance the commercial potential of the outputs of scientific research.

A common theme running through the findings from Rust, Driver and the Design Council is the role of designers in creating visualisations, prototypes and tangible artefacts which serve to support communication, build understanding and enable testing of ideas.

But, despite these initial observations, there is little empirical evidence on the specific role that design demonstrators might play in supporting the transition of scientific activity towards commercialisation. Thus, this research seeks to address the question: *what are the roles of 'design demonstrators' in supporting the transfer of technology from the laboratory to the market?*

This research is motivated by a deep knowledge of the skills and abilities of the designers on behalf of the research team and a belief/hypothesis that there would be significant benefits should designers be more systematically and involved in scientific activity.

This paper is structured as follows:

- Firstly, there is a short review of literature relating to 'boundary objects', or artefacts which help mediate in the boundary between actors with different perspectives, knowledge, skills, locations or status in social systems. This highlights the potential for designers as creators of visual objects and demonstrates that no prior work has explicitly studied this phenomenon in the progression of scientific activity towards commercialisation.
- Next, standard models that describe the progression of science from lab to market are presented. The rationale here is that typically, demonstrators are viewed as technological prototypes which are close to market. By considering the broader development space, it is possible to explore the potential for other types of demonstrator. Specifically, this section explains the choice of the 'Science, Technology, Application, Market' (STAM) model which is used as a basis for analysis of case data, in order to position the various types of design demonstrator produced in the case studies.
- This is followed by an overview of an empirical study in which designers worked along scientists with the express intention of supporting the translation of technology towards application or market.
- Two case studies are then described in more detail in which the nature of the design demonstrators produced is explored.
- Finally, the paper will present an original classification of design demonstrators, built from insights generated from the case studies and literature.

2. Demonstrators, prototypes and boundary objects

Artefacts as mediators between actors in a social system have long been discussed as 'boundary objects'. Star (1989) and Star and Griesemer (1989) are accredited with first describing this concept, in the context of scientific collaborations, between scientists with disparate knowledge domains. They described 'boundary objects' as *"(…) an analytic concept of those scientific objects which both inhabit several intersecting social worlds (…) and satisfy the informational requirements of each of them. … they have different meanings in different social worlds but their structure is common enough to more than one world to make them recognizable, a means of translation."* (Star and Griesemer, 1989: 393).

This basic concept has subsequently been adopted in scholarly discourses in a wide range of disciplines, including: organisational studies (e.g. Zeiss and Groenwegen, 2009); engineering (Henderson 1991); and New Product Development (Carlile 2002). Other terminology has also been adopted, including 'intermediary objects' (Vinck 2009, 2012) which act as translators or mediators between actors in an actor-network system. Ewenstein and Whyte (2009) discuss visual representations in architectural design as epistemic (or knowledge) objects which are 'abstract in nature; objects of enquiry and pursuit … characterised by lack of completeness' (p. 9). Common to all of these is the notion that boundary objects can assist in creating common knowledge among individuals in dispersed design teams and across boundaries (Carlile 2002, 2004).

In engineering, it is especially in the field of innovation, new product development and design that this concept is discussed. Henderson (1991, 1998) adopted this concept in an ethnographic study of design activities, recognising that the world of designers is inherently visual and related to material experiences. For designers, sketches, drawings and other visual representations are *"the building blocks of technological design and production … Moreover, because they are developed and used through interaction, these visual representations act as the means for organising the design to production process, hence serving as a social glue between individuals and between groups"* (Henderson, 1991: 449). Henderson established that design meetings typically centre around, on and through these visual representations.

Bechky (2003) and Siedel et al. (2014) both determined that not all objects are effective in spanning boundaries. For example, Bechky (2003) claimed that some objects (e.g. CAD drawings) may not facilitate the creation of 'common ground' between actors, especially where the language expectations of participants is very different. Siedel et al. (2014) note that prototypes "did not always help teams coordinate their interdependent work" (p700) and as a result, they describe the notions of concept 'coherence', where concepts generate shared understanding, and concept 'disunity' reflecting a lack of common understanding.

It has been claimed that objects are most effective at facilitating communication when they are generated collaboratively (Terwiesch and Loch, 2004) where prototypes help to mediate between the different objectives and motivations. Bogers and Horst