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Positioning creative, three dimensional design practice and understanding its role and value in university health research and development projects

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Abstract

The success or failure of new product innovations depend upon many, complex and often competing demands. These range from market conditions, availability of technology, psychology of consumer acceptance to the fundamental reasons for a particular product or technology existing in the first instance. The role of universities in this mix can compound success or failure issues further. Where there may be a desire and ambition to improve the quality of life of a population through new scientific or clinical discovery, often translating those discoveries to real world application is challenging.

The Wilson report, commissioned by the UK Government, 'A Review of Business–University Collaboration' highlights some of the issues universities and industry face and states that "There is no simple model for interaction; the diverse business needs and diversity of supply from universities leads to complexity in relationships" (Wilson, 2012). Based on the experiences of the authors of this paper and through a number of short health research and product development case studies this paper presents and discusses a theoretical model developed to help build greater understanding and demonstrate the value of design practices value in university and industry collaborations. It identifies 3D designs value through targeted activity towards successful outcomes and discusses how those projects have run in university research setting.

Keywords: Device design, strategic design, innovation, design approaches, multidisciplinary

Introduction

Many academic disciplines play key roles in defining and delivering research that leads to new product innovation. However, a silo based culture of many institutions can create disciplinary specific 'voids' between project focus, objectives, capabilities and methodology that can hinder multidisciplinary activity. This paper proposes that three dimensional (3D) design practice, for its part, is capable of helping to reach across those disciplinary voids at many stages of the new product innovation pathway because it has '…become used or practiced at working in multi and interdisciplinary ways than many other disciplines' (Reed, 2013). The authors argue, like many before them, that design is a very powerful tool in realising end products. However, in order to do so more effectively in academic / institutional settings, and to bring them to successful, industrial application outcomes, all stakeholders need to better understand how and where 3D design practice place their effort, not only to deliver products based on 'others' research, but as a means of helping to identify opportunities and shape and direct the research itself. To this end a model has been developed to progress that discussion that aims be used as a tool to help to identify, describe and position how and where 3D design can be used over the 'potential whole new product development pathway'.

Positioning 3D design practice - a theoretical model

In this paper four short case studies are described that involve real word, complete or in progress projects. Each can be said to map onto 'categories of activity' of the proposed theoretical model (see Figure 1.). The model is divided into categories A to C over the life of a given design project. Understandably there may be resistance to the idea of categorising creative effort; this has been done here purely to facilitate communication and each category is not intended as mutually exclusive, rather, any one may be undertaken separately or together, over the duration of a project.

The following briefly describes the categories identified in the model, highlighting both the type of work undertaken and the reasons for which the work is undertaken.

Describing the model components

Case study 1 - Proof of concept, 'Infant Non-invasive Ventilation' (NIV)

In the activity Category A 'Seeding (POC/P)' (Proof of Concept / Principle)) we place work effort that aims to prove a design concept or principle. This is done to build evidence in support of further funded development effort and secondly to assist the design team in building enough specialist knowledge, through practice, in the specific topic area. This is important in a university setting, where design may be engaged in subjects as diverse and specialist as the physical sciences, psychology, clinical practice or engineering, to name a few. Given the diversity of types of engagement across many specialist topic areas, building knowledge in the design research team is essential to successful outcomes. Undertaking work here not only provides confidence within the team, it offers funders tangible evidence of the potential impact the work might have. Indeed, more and more research council funding is caveated with the requirement for transfer to application, beyond a more traditional academic quest for new knowledge generation. For example, in a recent Engineering and Physical Sciences Research Council (EPSRC) funding call the following statement is made;

> 'Applications to this call should bring a creative and multidisciplinary approach to one of the four grand challenge areas, and should also clearly identify how the proposed research and collaborations have been designed to shorten the pathways to translation and/or clinical adoption.'

Further though, this stage of work provides an environment for identifying opportunities that are either core to the original design brief or defines new opportunities arising from the line of enquiry.

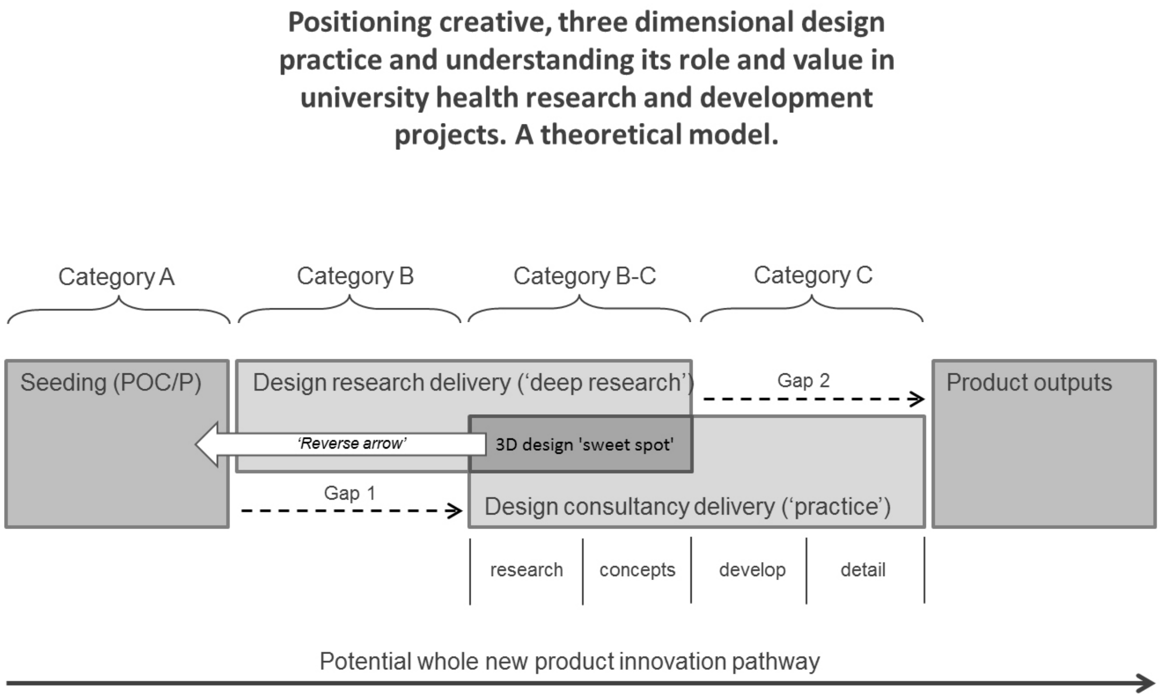

Figure 1: Mapping categories of practice, theoretical model

Projects in this 'Category A' can be illustrated in part by the NIV case study. NIV is a clinical therapy proven to increase health and quality of life in adults and children where respiratory difficulties manifest as a result of a wide range of medical conditions. Often a face mask is required to deliver the therapy. In children, current ventilation mask provision is said to be inadequate, and compliance poor as a result of a physical 'poor fit' between a mask and the patients face. When a poor fit is evident, often it can result in highly invasive, distressing and expensive alternative therapies such as tracheostomy.

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The project 'idea' aimed to bring the latest, low cost 3D scanning technologies together with the latest, low cost 3D printing technologies to provide customised face masks for infants (a particularly problematic group in terms of mask fit) in a customised, 'near patient manufacture' approach to solving the problem. However, in order to secure funding to undertake that work the project team needed (at least) to demonstrate not only that better fitting masks produced in this way improve performance (and thus compliance and improvements in quality of life), but that a robust method for testing the principle was possible.

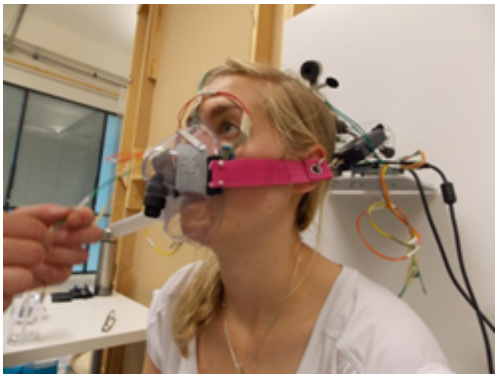

Figure 2: Developing and prototyping the NIV experiment.

In order to secure funding the multidisciplinary team (paediatric clinicians, engineers and designers) was guided by the 3D design contingent in the development of both proof of concept for the methods of 3D scan and 3D printing but also in the 'creative' design of proof of principle testing methods that showed the proposed scheme to work. In a sense, the design effort was focused on technical success through 3D practice to determine and prototype the actual test method. Crucially, it was that effort that made a significant contribution to the success of subsequent funding bid as the multidisciplinary team could see and have confidence in the proposed technical evaluation methods. Arguably, once an experimental test process (and preliminary data) is incorporated into a funding bid it gives the funder confidence that research outcomes are testable and deliverable.

Case study 2 - 'Future Bathroom'

The second category we identify (Category B), 'Design research delivery ('deep research') involves deeper social or cultural research that may traditionally be associated with academic activity, that is to say, the development of new knowledge (as the output of the study) in a given field rather than (but not exclusively) a product output.

This can be exemplified by the example of the 'Future Bathroom' project, an EPSRC funded study with two main aims. Firstly, the project was tasked with developing a robust methodology for fostering co-design dialogue between designers, researchers and older people, with age related health conditions which lead to disability and frailty. In essence, the project asked 'what should we

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be designing?' Secondly, it aimed to develop a range of innovative bathroom product prototypes that were sensitive to the problems of living with disability.

The first objective was met through the development of a variety of creative insight building methods. These included the recruitment and training of older participants who undertook aspects of the research on behalf of the design team acting as 'community researchers'. A challenge for the design team was that the designers tended to be younger or middle aged males, whereas the target group (in this case) tended to be older females. It is understandable that there may have been reluctance in some of the older respondents to share intimate toileting or bathing habits. On the basis of the richer insights gained through the 'community researchers' method, the design team developed a number of early concept ideas for products that may address identified challenges. Rather than producing written or visual descriptions of these concepts, the 3D team set about making the concepts on the understanding that they were 'sacrificial' in nature, i.e. they were not intended to move through to development or detail design, they were 'throw away' ideas to stimulate discussion. In this way the design team were able to manifest all stakeholders' ideas and to present them in a way that asked 'what if we did it like this?' This method proved successful because it placed the lay persons and specialists in the 'same space', with each concept forming a foundation for further discussion.

Figure 3. An aspect of the future bathrooms project involving building new insights and methodologies through stakeholder workshops and 'community researchers'

Case study 3 – Profiling beds

A third category of activity, 'Category C' in Figure 1, involves the deployment of design practice skills, skills in aesthetic treatment, ergonomics, CAD and manufacturing for example. This type of industrially focused design is more commonly associated with design consultancy activity and generically runs through a number of phases of work from *research*, concept development, design development and detail design for production. The word research is italicised above as, depending on the nature and the scale of the commissioned works, the research can be limited in scope, often highly focused on a specific topic or skill set area and can lack the depth and breadth of enquiry offered by the 'Category B' example. This type of work often asks 'how can we solve this given (narrower) problem?' (mechanically or otherwise) rather than ask, 'what should we be designing?'

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This can be illustrated by an example of the Profiling Bed, a commercially commissioned piece of healthcare furniture design. In this project the design team were tasked with solving existing product range mechanical failure and user comfort issues for beds that articulate from lying to sitting up modes and resulting user postures.

The research phases of this study were highly focused on aspects of the client's manufacturing capability, ergonomics and the development of new mechanical systems to overcome existing product failure issues. The project then progressed through concepts to development and eventually detailing for manufacture.

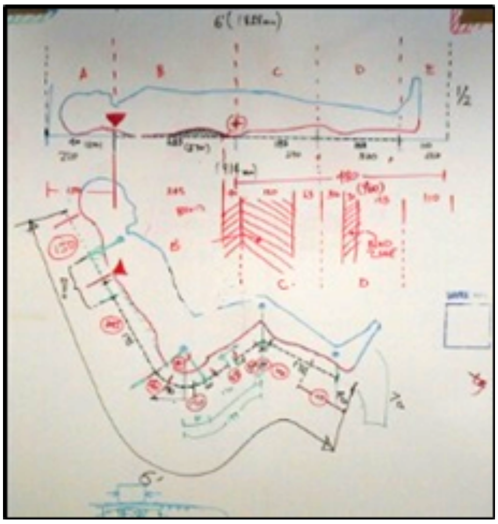

Figure 4. Sketch development to understand human ergonomic ranges for profiling beds.

Category B-C activity and the 'Reverse arrow'

In the categories of activity described so far there are similarities in terms of what is done. In particular, the research and concept phases of the 'Category C' work overlap with the 'deep research' offered by 'Category B' activity (albeit to a lesser extent in terms of research depth and breadth). For this reason we propose the model (Figure 1.) include a Category B-C because this can be seen as activity that exists in both categories of activity and can be very similar in nature in terms of skills and deliverable. For example, the concept development phases of the Future Bathroom project involved the designing and making of physical artefacts, based on insights gained from the project's first methodological objective. The 'Category B' research was indeed 'deep' in comparison to 'Category C' activity but in addition the artefacts, being 'sacrificial' in nature, were used as part of the methodology for building insight about stakeholder use and preference, to further enhance and inform the enquiry.

Whilst both categories involve research and concepts, they do not exclude development and detail for volume production (but those are more commonly associated with Category C activity) and as such use complementary skills and knowledge. In this respect the 'Category B-C' can be

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viewed as a ‘sweet spot’ for three dimension design in a research setting as it capitalises on the core practice based assets manifest within the discipline.

Further, we consider how this creative, 3D practice ‘sweet spot' may be capitalised upon in ‘Category A’ type activity. This is described by the ‘reverse arrow’ (Figure 1.). In this model we have illustrated a number of arguably recognisable, albeit generic descriptions and examples of categories of 3D design practice. However, we propose that a significant advantage Universities and other institutions could capitalise on when aiming to convert other disciplinary aims and achieve high quality research that translates to industrial application (impact), is to deploy the skills and expertise evident in the discipline of 3D design much further toward the beginning of the process. Effectively this would require taking 'sweet spot' skills and capability and applying them in what we have defined as the 'Category A'. This is a proven strategy that has yielded many examples of success. Through the application of creative 3D design practice the design team have succeeded in partnering and obtaining significant research funding awards focused on subsequent category B to C development.

Case study 4 - 'Head Up' (encompassing category A to C activity)

A final short case study illustrates one example of deploying 3D design across the whole new product innovation pathway. The Head Up project involved Category A (Seeding), Category B, (Deep research), Category B-C (example of concepts as sacrificial, insight eliciting tools) and Category C (development and detail for manufacture) activity.

The design challenge in this project was to invent, develop and design for production a new type of neck orthosis for people with Motor Neurone Disease (MND), a progressive and dehabilitating disease that involves muscle wasting. As the condition affects the muscles of the neck the weight of the head can cause extreme posture, eating, breathing and communication problems as well as severe discomfort. As is the case with NIV, current device provision does not meet user requirements with prescribed neck orthosis being (largely) designed for either ‘light’ support or for full head and neck immobilisation. Through early (pre-award, Category A) all stakeholder workshops it had been identified that neither was fit for purpose and compliance very poor. However, a solution to the problem was not known and therefore funding was not forthcoming.

In this study and new product development pathway the design team undertook work to build knowledge about the condition and to conceptualise, through physical modelling, potential solutions. The work was undertaken prior to the significant NIHR, i4i (National Institute for Health Research, Invention for Innovation) award. The project did receive small amounts of funding to conduct early studies and conduct early solution modelling, but the team needed significant multidisciplinary funding to deliver a full and comprehensive piece of work. As such the pre award activity can be said to fall within ‘Category A (POC/P)’ of the proposed model.

On the basis of specialist clinical knowledge, early stage proof of concept development modelling demonstrating the aims and a clear and transparent multidisciplinary delivery model the project was successful in securing funding. This enabled the team to undertake 'Category B' deep research involving further end users, carers and clinician co-design workshops, and to apply those deeper insights to proposed solutions through 'Category B-C' activity and further develop emerging device designs through to production (Category C).

Figure 5. One of the development models of the Head Up neck orthosis for people with MND.

Gaps in the model

In the model we identify two distinct gaps. The first Gap 1 exists between category 'A' and 'B-C', the second between 'B-C' and 'Product outputs'. These are intended to denote two distinct disadvantages when working either in compartmentalised or siloed ways. To create new product designs that achieve success 3D design needs to be involved, if not responsible, for 'deep research'. Conducting Proof of concept work (Category A) without richer and deeper understanding of the problem sets (achievable through category B) leaves design outcomes lacking (hence gap 1).

Similarly, in the case of the future bathrooms project, we can see that a 'gap' exists in terms of bridging from the concept outcomes work to actual product in market. This project met its two primary objectives, i.e. it succeeded in developing new research methods and in the creation of a number of product concepts, but (to date) falls short of new product innovations developed to a stage that can actually benefit the end users and intended consumers.

Conclusions

In the proposed theoretical model we identify a number of categories of activity that illustrate the role and value of 3D design when it engages (in these cases in a university setting) in aspects of the whole new product development process and across many other, non-design, specialist areas. One interpretation, and criticism, of design is that it is all too often applied toward the end of the new product development cycle (the later stages of the Category C for example), to package solutions or to embellish products. Often however, examples of other ways it can and has been used are not forthcoming, or are at least less well understood. The authors' premise in this work is

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based on real examples of design projects in health and offer, for discussion, the following tangible and evidencible benefits.

In 'Category A', design has identified opportunities for research direction, lead bodies of research, design thinking has helped/enabled multidisciplinary and laypersons teams to define problems, brought together enabling technology systems, facilitated scientific validation and designed experiment prototyping (as opposed to prototype experiments). Crucially it has built evidence and insight that informs future funded programs.

In the area we define as 'Category B', 3D design has developed ways and means of asking and answering 'what we should be designing?' and working in this area has 'invented' new solutions that have led to real innovation because it has been able to get closer to the problems than it can if it only works in category B to C. Design has been able, in these examples, to manifest ideas to help communicate concepts in tangible ways that lend confidence to future investors. We have shown how the 'sweet spot' for 3D design (B-C, in this institutional setting) can be applied at the very early stages (Category A) but also how the skills and expertise evident within the discipline can convert, in realistic ways, ideas into manufacturable end products that benefit all stakeholders.

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