

THE BENEFITS AND LIMITS OF INVESTIGATIVE DESIGNING

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ABSTRACT

This paper discusses the role of designing in the research process in the sector of Art and Design, sometimes referred to as practice-based research, with particular focus on the imperatives of PhD studies. It points to the vagueness of terms used, and defines its key terms including 'investigative designing' which is taken to be an act of systematic designing set within a research study, intended to generate reliable new knowledge, and where methods and outcomes are open to scrutiny.

To set the topic in context, reference is made to previous debates, and descriptions are given of a range of designing and researching activities. These form the basis for a description of several identified categories of investigative designing, illuminated by examples of such work. Thus the paper maps out where designing may be helpful and valid in a research study dependent on how it is set in a research context.

KEYWORDS

PhD-research, practice-based research, investigative designing, design, research methods

1. INTRODUCTION

This paper contributes to debates about the use of design practice when conducted as part of a research process, and attempts to establish some limits on the validity of such practice as a research method, particularly in PhD studies. To set this discussion in context, we make clear our position on the nature and purpose of PhD study, and provide some practical examples of research investigations drawn either from the literature or from our personal experiences.

Design is here set in the traditions of the Art & Design sector comprising broad subject specialisms such as spatial, two- and three-dimensional design, and applied arts and crafts. In this sector, a number of terms are used to indicate the use of creative design practice within a research context. Terms used include practice-based research, practice-led research, research through practice, or practice-as-research, though there are many others. It is reported that the many terms used are vague and are used interchangeably (Niedderer & Stokes, 2007). For clarity, we eschew all these terms and confine our discussion to what we define below as 'investigative designing'.

This vagueness about the use of practice is particularly problematic for the area of PhD study. The following discussion therefore limits its scope to PhD studies in Design in the context of current UK regulations. Several authors have reported problems or varying positions on research and practice, for example: Durling (2002) provides some historical background to the growth of PhD studies; Durling, Friedman & Gutherson (2003) debate the practice-based PhD; Langrish (2000) gives clear guidance on the role of design practice within PhD research; Durling & Friedman (2003) discuss best practices in the PhD in design; and Niedderer (2007a) provides foundational work on knowledge in research as well as case studies on designing and making within PhD study (Niedderer, Harrison & Johns 2006).

In this paper, we aim to address persisting confusions about the nature and purpose of doctoral awards which may stem from the relative newness of research in the Art & Design sector, the lack of trained professional researchers, and to some extent a plethora of terms that are ill defined. We aim to draw together some of the above mentioned approaches to obtain more clarity for the use of creative practice in PhD research by establishing the boundaries for what designing can and cannot contribute to research.

2. DEFINITIONS

Often there are many different terms used interchangeably in discussions of design practice, doctoral studies, and related to the nature and purpose of research. It is therefore important that for clarity we carefully define and justify the terms used in the context of this paper as follows.

Designing is taken to mean: "the entirety of all design activities" (Hubka & Eder, 2005). In choosing the term 'designing' rather than 'design' they state that:

"The advantage of the word 'designing' lies in its general intelligibility, even if it sounds unusual, for example as a metaphor. In addition, this word is widely used internationally, it is understood in the defined context in Germanic, Romance and Slavic languages."

In the art & design sector, designing has characteristics that include speculating on possibilities for modified or new artefacts, systems and environments, and modelling what is required in the mind, symbolically, graphically and in three-dimensional forms. In this context, designing is a conceptual activity and a process of ideation which is usually expressed through drawing, making, model making, or prototyping etc. and which leads to proposals in 2D or 3D form. However, designing is not homogeneous, and the number of definitions quickly expands to meet the desires of a wide range of protagonists. This diversity of approaches to design process is summed up as follows:

"Designing as a process is more or less creative. This usually includes: intuitive, iterative, recursive, opportunistic, innovative, ingenious, unpredictable, refined, striking, novel, reflective, searching for elegance, beauty, etc." (Hubka & Eder, 2005)

Investigative Designing is taken to mean: the act of designing, set wholly within a research study for the generation of new knowledge. Used in this sense, designing may be said to be forensic (from Latin *forensis* 'in open court, public'), where the process of designing denotes the application of systematic methods and techniques intended to explicate reliable new knowledge, and where crucially the process is transparent and open to the scrutiny of others. It follows that, for such designing to be valid, it would have to meet the norms of appropriate research methods rather than design practice methods. These criteria will be developed below.

Research is taken to mean: a formal, systematic, and rigorous process of inquiry (Fawcett 1999: 1-25; OED 1996), the purpose of which is to gain new knowledge or understanding (AHRC 2007). This knowledge or understanding is usually expected to be generalisable or transferable: in other words, it should be possible for the research to be made explicit such that others may benefit from it. It is therefore usually linked to the generation of principles or theory building whereby theory can be defined as a set of concepts and propositions, which is generated and/or tested through research (Fawcett, *ibid.*). The meaning of research can

be further defined by identifying what does not count as research. For example research for the UK Research Assessment Exercise (RAE):

“excludes routine testing and routine analysis of materials, components and processes such as for the maintenance of national standards, as distinct from the development of new analytical techniques. It also excludes the development of teaching materials that do not embody original research.” (RAE 2005)

PhD is taken to mean: a training in research methods which enables the candidate to undertake independent work as a professional researcher. The course of study may be seen as an apprenticeship in generic and specific research methods suitable to the subject. Such research may or may not be focused on creative design practice, but will necessarily be focused on the development of research skills. A PhD is not awarded for design practice. In these respects our view is substantially the same as Langrish (2000). To provide a context for the following discussion about the use of investigative designing in PhD research, we discuss the conventions and requirements of PhD research.

Perhaps much of the present confusion about the role of design practice in research stems from Regulation 3.7 of the original Council for National Academic Awards (Langrish 2000: 304) research degree regulations which were implemented at the time of the setting up of the British Polytechnics. This regulation stated:

“In appropriate cases the Council may approve a programme leading to the presentation of a thesis accompanied by material in other than written form”

Langrish (ibid.) explains:

"PhDs in Art and Design were discussed extensively in the 1980s and a consensus was arrived at by the Council for National Academic Awards (CNAA) Art and Design Research Degrees Committee which controlled PhDs in the Art College and Polytechnic sector. This committee invented the regulations for PhDs which involved 'the candidates own creative work'."

"Being aware that PhDs for practice were not allowed, the CNAA regulations made no use of this dreaded word. Instead, they came up with the phrase, 'the candidate's own creative work' which could form part of the submission. The word requirement for the written thesis was reduced but it was made clear that the written and creative parts together must add up to an addition to knowledge. Any suggestion that the written thesis was 'theory' and the creative work was 'practice' would never have been accepted by the CNAA Research Degrees Committee for Art and Design of which I was a member. Notions of '60% theory and 40% practice' belong in the dustbin of MA educational history."

In discussing the 'practice-based' doctorate, Green & Powell (2005: 103) note that the debate is still ongoing (and manifest in some Universities' regulations) as to whether:

“a Practice-Based Doctorate can be awarded solely on the basis of the production of creative work(s) – assessed by knowledgeable peers who are experienced in the field and who can therefore pass judgment on whether or not the work(s) is worthy of note as excellent in respect of the criteria operating in that field and as contributing to knowledge itself.”

It seems clear however that the original intention of CNAA was for there to be an integration of designing within an accepted research framework, where the candidate's own work might form the basis of data collection or reflection. In the PhD this does not absolve the candidate from adopting appropriate research methods distinct from design practice, nor of explicating the work in written form.

We must also make clear that we speak of PhD study, not of doctorates generally. There are many kinds of doctorate within the sector including several forms of professional doctorate which are aimed at the development of professional creative practice (for example DDes or DArts). These may be quite different to the research doctorate, the PhD. Both degrees have a research agenda, though the difference between PhD and professional doctorate has been expressed as the intention to produce a professional researcher in the former, and a researching professional in the latter (Green & Powell 2005: 45, 54, 86).

3. THREE POSITIONS

Debates about the use of creative practice in research often polarise into two views: that all design practice is research, or that there is no overlap between design practice and research. A third position with growing influence acknowledges the importance of design practice as a means of investigation for and within research (Niedderer 2004; Rust, Whiteley & Wilson 1999). While being a general problem in research, it becomes an imperative in doctoral studies to determine whether designing is possible as part of a PhD research process, and if it is, then what limits may shape its use.

We attempt to differentiate between primary design activities and primary research activities. Within each activity we describe various extents of inquiry, before concentrating on the third position above, the use of creative design practice within a PhD research study.

3.1 DESIGNING

There is a wide range of designing. Design practice is usually thought of as creative, but the extent of creativity employed varies between contexts. At one extreme, designing may be seen as the application of prior professional knowledge to a particular problem where little creativity is required because the application of professional skills takes priority. For example, a junior designer working on revised company stationery and following a corporate style manual, would be applying his professional knowledge within given rules, and with little scope for individual creative endeavour beyond the rules of the style manual. There is also no intention to derive new knowledge from this activity beyond what the individual gains.

Another example would be a junior designer working under the guidance of a senior and more experienced colleague, with limited scope for creativity or inquiry. In architectural practice, though the headlines may be grabbed by the more innovative stars of the profession, much work comprises extensions to and refurbishments of existing buildings, again working within a supervisory and regulatory structure where professional competence often takes precedent over creativity. Though it seems rarely recognised, much designing is like this. Within this limited kind of routine designing it will be appreciated that there is no requirement for research activity and no intention to undertake research. We conclude therefore that there are forms of designing where there is no research.

Let us now consider another extreme, a top professional designer who, though working commercially, extends the boundaries of what has been done before, and influences other designers. Similarly, designers might develop certain practices or naturally investigate certain questions through practical developmental work. One such example is the British designer James Dyson who problematised vacuum cleaners in a new way, and applied an existing technology in a new class of products. He claims to have made 5127 prototypes of his bagless cleaner before getting it into production (Dyson). Designing and making seemed to have played a significant part in this design and development process.

In a cognate subject such as engineering, designing and making have long been a natural part of research and development work in materials and structures. Creative processes such as designing and prototyping have been subsumed under scientific working methods but not explicitly acknowledged as a form of method for research in their own right. In industrial design PhDs, particularly with rapid prototyping, several studies have reported designing as part of a process of robust inquiry (for example Evans 2002). In crafts, we are working with the Argentium Project (Niedderer, Harrison, & Johns 2006) where designing and making are intrinsic to exploring creative possibilities of a new alloy of silver with unique properties. There are many examples of designers working in ways where designing forms part of the investigation, and where there is an intention to learn and abstract some new and transmissible knowledge from the process of designing and/or making. So in this context, designing may be seen as a valuable part of some research activities in design and related disciplines, and it is used already in some PhD studies.

3.2 RESEARCHING

There is a wide range of research too. Research activity overlaps with design activity where there is investigation. At its simplest this may be the kind of personal investigation that any reasonably competent and inquisitive designer might undertake. This may be manifest in several ways. For example, a potter might produce test firings or experiment with new glaze

formulations, a furniture designer might try a new machine process, or a graphic designer might explore an illustrative effect that they have not used before. This kind of investigative activity is normal, to a lesser or greater extent, for academics and practitioners in all design specialisms. In this context, professional practice is best characterised by the gaining of local, implicit knowledge which benefits the individual practitioner but is not necessarily new for others. It is knowledge gained primarily for oneself in personal design practice, and is not made widely available for scrutiny by others. This might therefore be termed research with a small r.

At another extreme, big R researching may be seen as highly systematic, aimed at deriving explicit knowledge from the world and, significantly, disseminating it widely for other scholars to scrutinise and possibly to follow. It is expected that this knowledge is new for the whole of the research community and not just for the individual researcher. Examples of this latter case include empiricist traditions of design science and have typically provided robust data that other scholars and practitioners may use in the development or better understanding of design practice. Most conventional research, even in design, does not require designing to be undertaken. In much research, designing may not be appropriate as a means for eliciting new knowledge, for example: technological developments in materials and processes; surveys of user attitudes; production of anthropometric data; evaluation of existing products; or studies in material culture. Sometimes designing is tangentially present, for instance in studies of designers or design teams actually engaged in creative practice, where the research intention is to gain understanding of design thinking (an example is Cross, Dorst & Roozenburg 1992).

3.3 RELATING DESIGNING AND RESEARCHING

Having looked at both researching and designing, we have suggested that within research there is a diversity of design and research activity, ranging from various forms of designing that may be acknowledged to produce new knowledge or understanding formally or informally, to more formal systematic research that is widely published but where there may be no designing either directly or tangentially. Within this range of research activity, some work may be suitable for personal professional development within an academic setting, or for purposes of research assessment including funding bodies. Indeed, the Arts & Humanities Research Council (AHRC 2007) will accept a wide range of design inquiry from the local and tacit, to the systematic and published. The requirements for the RAE are similarly broad, encouraging all forms of assessable output and only limiting this to those outputs "that have entered the public domain during the publication period".

However, as we have seen, PhD study is qualitatively different in the respect that it has to demonstrate that the candidate has served an apprenticeship in the practice of research. The thesis minimally and unambiguously must: establish prior art through an extensive literature review; detail the research questions; demonstrate the methods used to answer those questions, and their validity; explain what new knowledge was gained; and discuss the limitations of the work. The candidate also has the duty to provide an enduring record, usually in the form of a written thesis which may be published. These are not generally constraints on professional researchers, though the best research is often explicit about some, if not most, of these imperatives. It follows that if the PhD candidate is to undergo and demonstrate the acquisition of deep research skills, the requirements are more tightly bounded than is required for more general research, and therefore the range of suitable activity (which may include designing) is consequently limited.

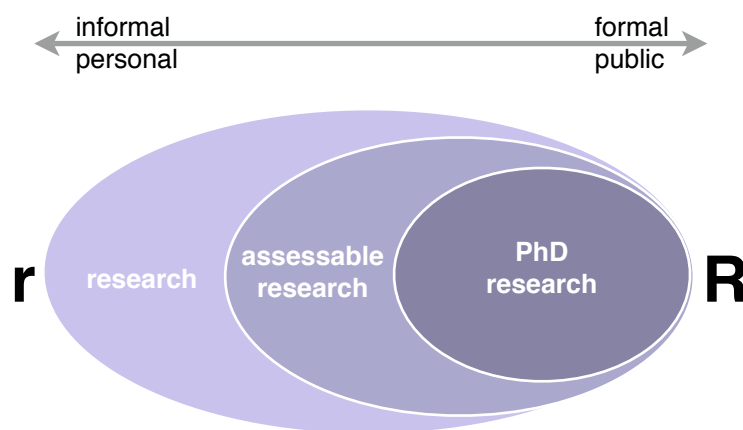


Fig. 1: Range of research practices

These competing claims on research may be visualised as overlapping areas of activity, where research spans from the informal and personal to the more formal and published (See fig. 1). It may be seen that in moving from what we term small r research (informal and personal) to big R research (formal and published) a subset of work is admissible for research assessment, and an even more constrained subset will be available for PhD studies.

It is against this background that we attempt to establish some boundaries on how designing might be used within a research process, its benefits and any limits to its use.

4. DESIGNING IN RESEARCH

There are many research traditions. Some studies require quantitative methods, while other studies best derive robust data from qualitative studies. There are benefits and disbenefits to all methods, and the skilled researcher attempts to select the method that has validity for the particular inquiry. That is, the most appropriate methods should be chosen to extract the

data required to be worked upon. Sometimes this will require observational methods, sometimes statistical techniques, or at other times an interpretive framework. Some research aims to be replicable, some does not. Some research makes claims for general truths, while other research may be focused on specific cases with more bounded claims.

However, all research should be set within some methodological framework that assures other scholars of the robustness and provenance of the methods employed. Usually, within a given subject area there are research norms. Observations of designers engaged in creative activity may, for example, be subject to well established social science methods. A designer engaged in making an intervention might utilise action research methods. Attempts to elicit users' views of new products might be explored through focus groups. A researcher trying to understand the lived experience of users might adopt a phenomenological position. Studies of peoples' perceptions or attitudes might be conducted from a range of psychology perspectives.

In longstanding research areas, the methods themselves come under some scrutiny and may attract adherents as well as detractors, some of them very vocal in offering evidence that a method is defective in some way. One of the present authors, in making assessment of a particular questionnaire instrument as part of his PhD studies, had to assess some 40 detailed critiques of the instrument (for and against) before deciding in favour of the instrument in the context in which he was using it. The limits of reliability of the instrument were well understood by this point, and an informed judgement could be made. At the same time he noticed several PhD theses all using a similar instrument for which a search showed no validation at all: these candidates will have had no idea about the robustness of the instrument at the core of their study. A careful researcher must take account of validity and reliability of the methods used. In some subjects, this leads to considerable testing.

In design research, there is an increasing desire to use designing. However, as in the examples above, designing cannot be used as a research method without regard to the methodological framework within which it is set, and an acceptance that there will be limits to what reliable information may be extracted from these methods.

There are two basic modes of designing within research. The first mode relates to observation of others designing: this is subject to a range of objective measures set within established protocols, and seems unproblematic.

The second mode relates to research where one's own design work forms the basis for the research: this is considerably more problematic in terms of objectivity and validity and is often referred to as reflective practice based on Schön (1983) and his followers. Here, we do

not engage with the term 'reflective practice' largely because reflection may or may not be rigorous, depending on how it is operationalised, but also because modes of reflection are implicit in any research methods. Instead, we suggest and investigate a number of broad categories of designing in the context of research through an analysis of examples, and we consider the benefits and any limits there may be to the validity or reliability of such designing.

We next turn our attention to suggesting several broad categories where designing may be considered in a research context, together with benefits and any limits there may be to the validity or reliability of such designing.

We have identified five categories of investigative designing as follows.

4.1 DESIGNING TO TEST

The making of prototypes and test pieces for testing and improvement and development of artefacts is a traditional method widely used, for example in engineering studies, where it has possibly been used for over one hundred years. Within Design PhDs there are also examples where designing within the research process would be helpful in deriving new knowledge, and unexceptional as method.

One such example is the PhD study by Evans (2002) where the focus of the study was in the development of professional practice, with the aim of evaluating and facilitating the integration of emerging rapid prototyping techniques into the industrial design process. The intention was to provide guidance to designers on the benefits and disbenefits of rapid prototyping, and the fit of the new technology with designers' traditional ways of working. Evans discusses the challenges of the researcher moving from a professional practitioner approach to an inquiring academic approach, and is cognizant of the imperatives of PhD study. He articulates an action research approach and provides several case studies of developmental work where the designing is set in a clear methodological frame. The designing has the purpose of providing artefacts for practical and objective evaluation where the technology rather than the design quality is the principal focus. As an approach this seems to be unexceptional and has a long history.

3.3 DESIGNING QUICK AND DIRTY

There will be times where an intervention is made that is intended more in the nature of a local probe than research that leads to generalisable findings. An example from the cognate area of ergonomics will serve to illustrate this point.

An ergonomist may be called to a manufacturing company to make suggestions about improving a process in part of the factory. She observes people working, and makes suggestions for improving a particular artefact (for example a production machine) to make it easier for operatives to use, and also suggests changes to related production methods. The modifications are made to the machine, and staff are re-trained in a new production method. A little time later, the ergonomist returns to the plant, conducts a further assessment and agrees with management that there are clear improvements in efficiency, and staff report that they are happier with their new roles. Such a success story could be written up as a case study and published. This is similar to many interventions that a designer might make in the course of professional design practice or as a researching designer, sometimes known as quick and dirty methods.

What can be claimed is that, within the scope of the project and the limited means for research, an intervention was made that led to improvement. What cannot be claimed is that repeating the same intervention in **any** factory would necessarily lead to the same improvement, if any. It may not even be claimed that the same intervention in the same kind of factory would be as successful, as there may be variables in the environment or in staff attitudes that indicate that the particular case may not be generalisable.

While the above is a concrete example, there is much work conducted by designers in perhaps less concrete situations such as cultural probes, design and emotion, and user perceptions and attitudes. All of these areas of inquiry, to a lesser or greater extent, will be concerned with issues of the robustness of the data gathered and whether these can be generalised to other cases or more widely. Some work may generalise, but certainly in the context of PhD research, claims of generalisable findings from particular cases would have to be defended.

4.3 DESIGNING AS DEMONSTRATION

Rather than concluding in a designed artefact, some doctoral studies may conclude at the stage of producing a specification for an improved artefact.

For example, let us consider a case where the researcher has identified a number of features of a product which, if incorporated into a design, would lead to product improvement and better user satisfaction. Let us take as a given that the research is valid, and the specification is the product of a line of robust inquiry which demonstrates research competence suitable for the award of PhD.

The candidate might, as an additional aide to visualising the possibilities for product improvement arising from the specification, choose to operationalise the specification in the form of a conjectural design. This would not be an 'ideal' product, or the **only** possible manifestation of the specification, but would have the sole purpose of demonstrating that the specification could have practical outcomes. The thesis argument would not rely upon this artefact, which might not progress beyond a conceptual stage, and would not for example be tested with users. For example, Durling, Cross & Johnson (1996) describe a learning style study intended to be instantiated within a computer aided learning interface: while various papers deal with the theoretical basis of the study and a resulting design specification, the related PhD thesis provided a sketched conceptualisation as it might appear on screen. It should be noted however that this is one of possibly many such instantiations of the specification. It cannot be claimed as the 'best' solution, or even an improved solution, since there is no evidence to support this view (it not having been tested). It may however be viewed as a demonstration that it is feasible for the specification to be used by a designer to produce an artefact embodying all or some of the specification. Under these circumstances no claim can be made for the artefact as an ideal solution. As a demonstration, the artefact proves nothing objective. It does however utilise designing skills to provide a vision of how such a specification might be instantiated, and provides one example of such a design that might yet be subjected to rigorous further examination.

It follows that the PhD would not be awarded for the conceptualisation or production of the artefact, but would be awarded for the evidence of process that led to the production of the specification.

4.4 DESIGNING AS IDEAL

Much product development aims to improve products in some way, perhaps in regard to user benefits or improved product features. In 4.3 above, the specification is instantiated in an artefact that is a demonstration of feasibility, and is not afterwards tested in any way.

Let us next consider the position where the artefact *is* tested. For example, a classic way of conducting such user centred research might be to:

- identify a product for improvement
- elicit the views of users and determine the deficits of the product
- draw up a specification for an improved product
- design a new product from the specification
- make a working prototype of the improved product
- elicit the views of the same or a similar set of users with the prototype, and determine what improvements have been gained in the new design.

A carefully constructed assessment of this kind appears to have the potential to tell us much about: the extent to which we have developed a better product; may demonstrate the practicality of any theory, guideline or specification under consideration; or validate the work for example by user testing.

Let us take an actual example. Guimaraes (2006) was concerned with assessing a product development self-report instrument (the Kano model) as a tool for designers to design inclusively. He used a mixed methodology comprising laboratory style interviews with representative samples of elderly users, the results of which were subject to both quantitative and qualitative analyses. The study utilised the activity of potato peeling as a common task, and assessed users' attitudes towards functional and other features of a traditional peeler and an inclusively designed peeler both in manufacture.

Early in the study the question arose of whether the student would engage in designing a better product to address any deficiencies that might be found in existing products. The candidate was a mid career academic with a history of designing professionally. Nevertheless, the skill of the designer was considered to be problematic in creating a new and improved product to any specification which would be an outcome of the study. If a new design were subsequently assessed by users as 'improved' this would be taken at face value to indicate the success of both the approach and the particular design. But what if the user assessment indicated no improvement, or that the new design was rated worse than the original control peeler?

A significant aspect of research design is the elimination of extraneous variables for which there are inadequate controls and which may severely affect the significance of any results. Such a situation may be attributed to variability in skills of designing, arising either from the competence of the individual designer, or simply because of the normal vagaries of outcomes of designing by an individual. Even very skilled designers will not necessarily produce top grade designs every time. We conclude therefore that any designing intended to produce an idealised product is capable of eliciting user reports of improvement, but is equally capable of producing the reverse. Methodologically this is problematic for research design, as whatever the result, we may not be certain to what to attribute the improvement. This has to be considered carefully in the research design.

In this particular study, rather than designing anything the approach was a rigorous analysis of the validity of the Kano model in identifying product features that could aid a designer in designing a better product. Designing any improved product was therefore considered to be a post-doctoral activity.

4.5 DESIGNING AS CREATIVE EXPLORATION

Designing as creative exploration is perhaps the strongest way of using creative practice within research, and the way that is both most desired and most debated. By designing as creative exploration we mean the working through of a research problem through designing. This may include, variously, ideation, drawing, prototyping, etc. Using designing in this way is useful where it is necessary to gain insight into the complexity of a situation, phenomenon or process, where scientific reduction is unable to provide a sufficiently rich or coherent picture of the subject being investigated. We have identified two different modes of using designing as creative exploration. One may be described as analytical, the other as synthetic.

Designing as an analytical tool was used for example by Niedderer (2004, 2007b) where she explored, through designing, a deeper understanding of the concept of function. The aim of the research was to understand how function could be used to create awareness of interaction with the object, and of social interaction through the object. While existing literature provided an understanding of the concept of function per se, designing was used to investigate experimentally the translation of the concept into the reality of artefacts, and interaction with and through these artefacts. The investigation consisted of designing and making a number of drinking vessels according to a pre-determined conceptual framework. The framework was based on five aspects of function (from "The Thing", Heidegger 2000).

Each aspect of function was explored with regard to causing mindfulness. Through designing and making three drinking vessels, the relevant aspect of function was gradually made dysfunctional. The stages of 'functional', 'semi-functional' and 'dysfunctional' in each set of vessels were achieved through a disruption of the relevant aspects of function. In those vessels which were 'semi-functional' (i.e. at the boundary between functional and dysfunctional) it was still possible to 'compensate' for the disruption of function through interaction with the object. For example, in the case of the functional aspect of holding liquid, the dysfunctional vessel has many holes and therefore does not hold and cannot be made to hold liquid any longer (Fig. 2). In contrast, the semi-functional vessel has only five holes, which can be covered with the fingertips of one hand. Thus the function can be restored through interaction. This requirement for interaction was shown to raise awareness and reflection. The outcome of the practice in terms of artefacts was a series of 5 [groups of 3] drinking vessels of conceptual-experimental character, some of which served as examples for the comparative testing in the thesis.

The outcome of the designing for the research process was a record of the design process which provided important knowledge of the relationship of function and interaction, and about creating awareness of this interaction. In this way, the analysis through designing made a contribution to the conceptual understanding of function and its translation into artefacts with particular functional characteristics. The study thus provided insights into the potential and the limits of using function within design. This knowledge also helped develop some tentative design guidelines as a contribution to design practice.



Figure 2: Designing as analytical tool

Designing as a synthetic process can be observed in another example which concerns both the technical and conceptual development of design.

In scientific development of a new material, scientific data may provide certain expectations for the possibilities of the use of the new material. However, use in practice may show different results because of the complex interdependence of all the different factors. In the specific case of the new material Argentium™ Sterling Silver (Niedderer, Harrison & Johns 2006) exploration of the material through designing has demonstrated superior qualities to standard Sterling Silver which could not have been predicted from the scientific data alone, for example in the use of laser welding.

In turn, these findings, arising from exploration of a combination of the new material with the new technology, offered new avenues for designing in silver. In comparison with the traditional joining technique of soldering, laser welding heats the material less and consequently, work-hardened thin material can be used. These changes offer an opportunity of light-weight, durable, production-oriented silverware in a way not previously possible. Also, using thin material requires a different construction of joints (e.g. face-to-face/overlapping joints rather than edge to edge) which affords silver design a new aesthetic (Fig. 3). Taking all these findings together could fundamentally change silverware design and the social and cultural perception of silverware.



Fig. 3: Jointing of Argentium Sterling Silver

In both examples of using designing as creative exploration within research, designing has been used within a predetermined research framework, within which the creative aspect of designing has been brought to bear. This way of using designing within research is therefore not illustration or demonstration, nor is it necessarily about testing any concept or theory, but essentially it utilises designing to reveal new avenues and opportunities for development, and to gain new insights and understanding.

5. CONCLUSION

We have argued that the use of designing may be helpful in research in some cases, but not in others. Where it is helpful, designing forms a part of the research process leading to the production of new knowledge. In due course, we have tried to map out in which instances the use of designing may be helpful because there are many terms that note this use, but due to their vagueness they are often unhelpful.

In this paper we have used the term 'investigative designing' and we have defined the term as an act of systematic designing set within a research study intended to generate reliable new knowledge, and which is open to scrutiny. We have also set the context for such designing within the constraints of PhD study and its imperative to demonstrate research competence as well as making an original contribution to knowledge. PhD research is shown to operate within a subset of all research, and any designing must be set within an appropriate methodological frame.

We have identified and described five categories of designing within PhD study which, to a lesser or greater extent, may assist in generating new knowledge and its dissemination. However, there may be more categories. We therefore see this paper as conjectural and as having the purpose of promoting debate so that others may become more aware of the

issues raised, and hopefully contribute both to refining the listed categories and extending the range of applicability of designing within research.

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