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Main Article:

Methodological Innovation in Practice-Based Design Doctorates

Joyce S. R. Yee

School of Design, Northumbria University
Newcastle Upon Tyne NE1 8ST, UNITED KINGDOM
joyce.yee@northumbria.ac.uk

Abstract

This article presents a selective review of recent design PhDs that identify and analyse the methodological innovation that is occurring in the field, in order to inform future provision of research training. Six recently completed design PhDs are used to highlight possible philosophical and practical models that can be adopted by future PhD students in design. Four characteristics were found in design PhD methodology: innovations in the format and structure of the thesis, a pick-and-mix approach to research design, situating practice in the inquiry, and the validation of visual analysis. The article concludes by offering suggestions on how research training can be improved. By being aware of recent methodological innovations in the field, design educators will be better informed when developing resources for future design doctoral candidates and assisting supervision teams in developing a more informed and flexible approach to practice-based research.

Keywords: methodological innovation; design research methods; PhD research training; approaches to design research

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1. Introduction

Over the last 10 years, the United Kingdom has seen an increased interest in design PhDs. For example, the number of design PhDs awarded in the UK has more than doubled (Fisher, Christer, & Mottram, 2006) in the last 2 decades. In addition, the emergence of a number of major international conferences dedicated to doctoral research (see Buchanan, Doorden, Justice, & Margolin, 1998; Durling & Friedman, 2000; Durling & Sugiyama,

2003) reflects the growing interest in the nature of research and practice of the field (Durling, 2000). These seminal conferences provided a platform for educators to share their diverse experiences and insights on challenges arising from the development of design doctoral programmes. Most of the early discussions at these events centred on the purpose of design PhDs and how doctoral education will benefit the discipline, which then naturally progressed to discussions that focused on exploring the methodologies, structures, and processes particular to design PhDs.

In recent years, it has been observed that a more established typology of design methodologies have been developed, employed, and validated as acceptable forms of research methodology for doctoral research. These methodologies have ranged from hybrid methodology, which employs a mixture of qualitative and quantitative methods, to more practice-based methodology, achieved through critical design projects such as examples shown by Seago and Dunne (1999) and Mazé and Redström (2007). Saikaly (2005) describes this practice-based type of inquiry as a “designerly mode of inquiry,” distinct from the well-established science and humanities research approach.

Training provision for PhD design students is generally based on a generic university-wide programme, where science and humanities methodologies are dominant. However, there have been a few examples of where subject specific training has been developed successfully. One of the earliest research training programmes for art and design in the UK was set up by Birmingham City University. The Research Training Initiative (RTI), set up in 1995, “seeks to encourage debate about research skills, methods and approaches; and supports researchers, research students and research supervisors through the publication of PhD case studies, methodological papers and reviews” (as stated in the [RTI](#) Web site). A more recent, multi-university initiative is the Design Advanced Research Training (DART) project, set up in 2005 to address concerns about the adequacy of available doctoral training for design. It was funded by the AHRC and involved seven UK higher education institutions. Despite these different initiatives around research training in design, research and knowledge around supervision in art and design remains fragmented, particularly in the case of practice-based research (Frayling, 1993), while existing literature on practice-based research degrees is aimed at helping supervisors manage their students (Newbury, 1996) rather than informing supervisors of the range of research methods available to their students.

2. Design Research Frameworks

If we are to look closely at the range of subject and purpose covered in design PhDs, it might be useful to review them in the context of different research design frameworks discussed over the years. One of the more widely-used frameworks is Frayling’s classification (1993) of art and design research (adapted from Herbert Read’s works, especially his 1943 book, *Education Through Art*), which identifies three main types of research projects: (a) research into practice, (b) research through practice, and (c) research for the purpose of practice.

Research into practice refers to research where art or design practice is the object of the study. Research through practice refers to research where art or design practice is the vehicle of the research, and a means to communicate the result. And finally, research for the purpose of practice aims to communicate the research embodied in a piece of design. I would argue that these types of research are not mutually exclusive. For example, Pedgley's (1999) PhD was to study designers' attention to materials and manufacturing processes (a study into the design processes) by designing and prototyping an innovative polymer acoustic guitar (through the practice). While Hillier's (2006) PhD uses typographic practice as part of the research process to identify, design, and test the readability and legibility issues of a new typeface.

Frayling's analysis of art and design research activity seems to cover all design research possibilities. In comparison, Cross (1999, pp. 6) offers a design research taxonomy that is based on the focus of the investigation rather than on the method of research. He focuses on knowledge that resides in people, process, or product: (a) design epistemology: study of designerly ways of knowing (people), (b) design praxiology: study of the practices and processes of design (process), and (c) design phenomenology: study of the form and configuration of artefacts (product).

Cross (1999) argues that designing is a natural human ability that is inherent in everyone, and not just professionals. Hence the immediate subject of design research is the investigation of how people design. Design knowledge also resides in the processes of the activity, tactics, strategies, and tools used for the purpose of designing. Finally, the designed artefact embodies knowledge in its form, material, technology, and context of use.

Fallman (2008) offers a more holistic framework in the field of interaction design research that not only refers to academic research, but includes knowledge gained through practice-based and explorative avenues. The model plots the position of design research activity in between three extremes: (a) design practice, (b) design exploration, and (c) design studies.

The differences are primarily in tradition and perspective, rather than the methods and tools being used (see Figure 1). Design practice denotes activities that are similar to commercial design work, carried out in commercial consultancy but with a difference in that the researcher becomes engaged in a particular design practice with an appropriate research question in mind. The research question is developed and explored either in a reflective manner (through firsthand experience of the tools or processes) or a proactive manner (through an already established research agenda that seeks to change how a specific technique is used). Design exploration is similar to design practice but differs on one key point, in that it aims to explore "what if" questions through the process of designing rather than by answering a particular research question. Design exploration is a way to comment on a phenomenon by developing an artefact that embodies the statement or question that the researcher is attempting to critique or answer. Design studies most closely resemble traditional academic research the goal of which is to contribute to the intellectual tradition and body of knowledge.

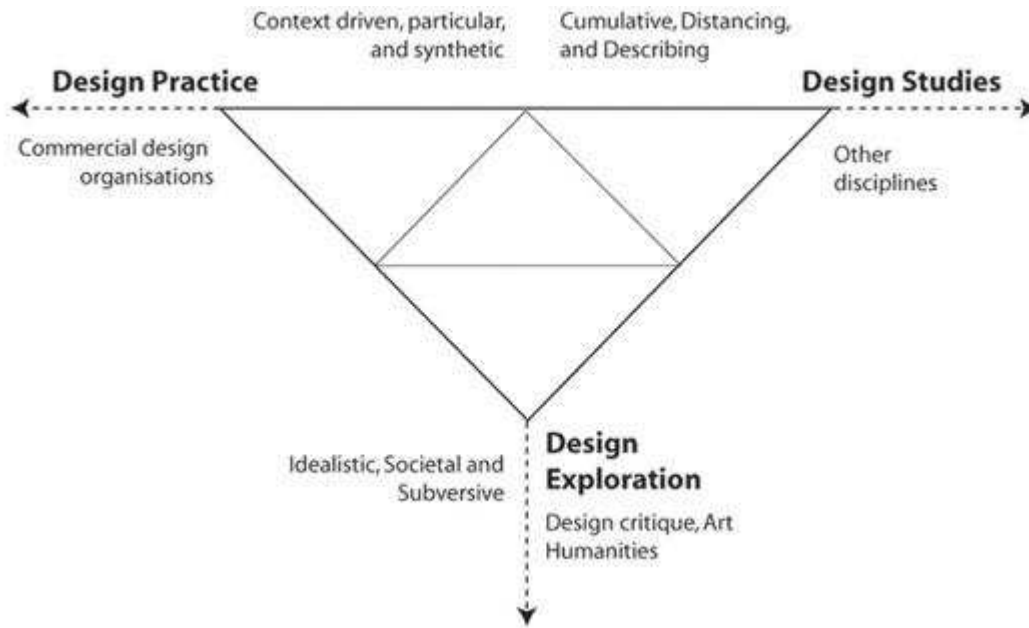


Figure 1. Fallman's (2008, pp. 5) interaction design research model.

Each framework presented here has its own function and value as one does not supersede another but instead provides different facets to the understanding of design PhDs. For the purpose of clarity, this review will frame the chosen examples using Fallman's (2008) framework, but also use Frayling's (1993) and Cross's (1999, pp. 6) frameworks to analyse the purpose and methods of research employed in the selected PhD studies.

3. Characteristics of Design PhDs

Langrish (2000, pp. 302) describes three areas in which a design PhD is distinct from other academic areas: (a) the questions asked, (b) the methods used to answer them, and (c) the type of evidence that is acceptable to a peer group of design academics. First, the questions that design PhDs address are predominately related to the visual manifestation of the artefact, whether that relates to the process of designing (process and people) or the outcome of the design (product and service). Second, a review of design PhDs seems to suggest a mix of methods used, including case study, documentation using photographs, notes, and audio recordings, experiment, exploratory installation, film study, interview, literature study, observation, peer review, reflective practice, visual analysis, and so forth. Third, the evidence produced in response to the research questions can vary from a traditional big-book thesis to a portfolio containing design pieces that are accompanied by a shorter thesis.

Allison (1992) outlines seven types of art and design research: historical, philosophical, experimental, comparative, descriptive, naturalistic, and practical. The first four could be termed as classic research methodologies, having gained acceptance in the research community (Gray & Malins, 1993). In comparison, the last three can be considered to be less scientific and more relevant to a real-world model of practice. Historically, a

majority of design PhDs have been mostly historical, experimental, or descriptive. Based on the [Art and Design Index to Thesis](#) (ADIT), the first recorded design-related PhD was in the area of engineering design: Stevens's study of an electronic control system for a prosthetic limb completed in 1966. Subsequent studies were in the areas of human computer interaction (HCI), for example, Ewing's 1972 study of data structures and computer graphics in computer-aided design, and in ergonomic studies, for example, Cunniffe's 1975 study on the application of ergonomics to wheelchair design.

In recent years, a growing number of PhDs are described as practice-based or practice-led, although actual statistics are hard to find, as PhD abstracts are not sufficiently clear to allow accurate judgements on the role of practice. However, I would posit that Design PhDs are inherently practice-led (i.e., deriving from design practice), either through studying the people, process, or products (Cross, 1999). An increasing number are described as specifically practice-based, using practice as the basis of investigation. Durling, Friedman, and Guntherson (2002, pp. 82) describe practice-based research as "a study where practice is used as an interrogative process" while Rust, Mottram, and Till (2007, pp. 11) emphasise that design practice has to play an instrumental part in an inquiry. It is important to note that practice-based PhDs are evident in other disciplines, for example in the area of health (Candy, 2006), nursing, music, veterinary studies, engineering, and law (UK Council for Graduate Education, 1997).

4. Design PhD: Case Examples

Six examples were chosen to highlight the spread of design research addressing the three areas of concern identified by Fallman, namely design practice, design exploration, and design studies (Fallman, 2008). These examples were also chosen on the basis of their methodological innovation, either in the way the research process has been designed or in the use of a particularly innovative method. The PhDs were sourced from a combination of literature review surrounding design research methodology and searches through thesis databases. The databases referred to were the [Art and Design Index to Thesis](#) (ADIT) and the [Index to Theses](#) Web sites. ADIT claims to be the first comprehensive index of postgraduate research theses in art and design in the UK, while the Index to Theses database is a comprehensive listing of theses with abstracts accepted for higher degrees by universities in Great Britain and Ireland since 1716. An initial list of design PhDs was drafted and their abstracts reviewed in order to identify suitability. A final shortlist of six theses were selected. It has to be stressed that the case examples were not only selected on the basis of their innovative approaches, but also by their impact on the research methodology applied in subsequent PhDs. At the same time, the review has considered other more traditional quantitative and qualitative methods that have been employed with success in design PhDs. Figure 2 illustrates where these PhD projects may be placed within Fallman's (2008) description of design research dimensions.

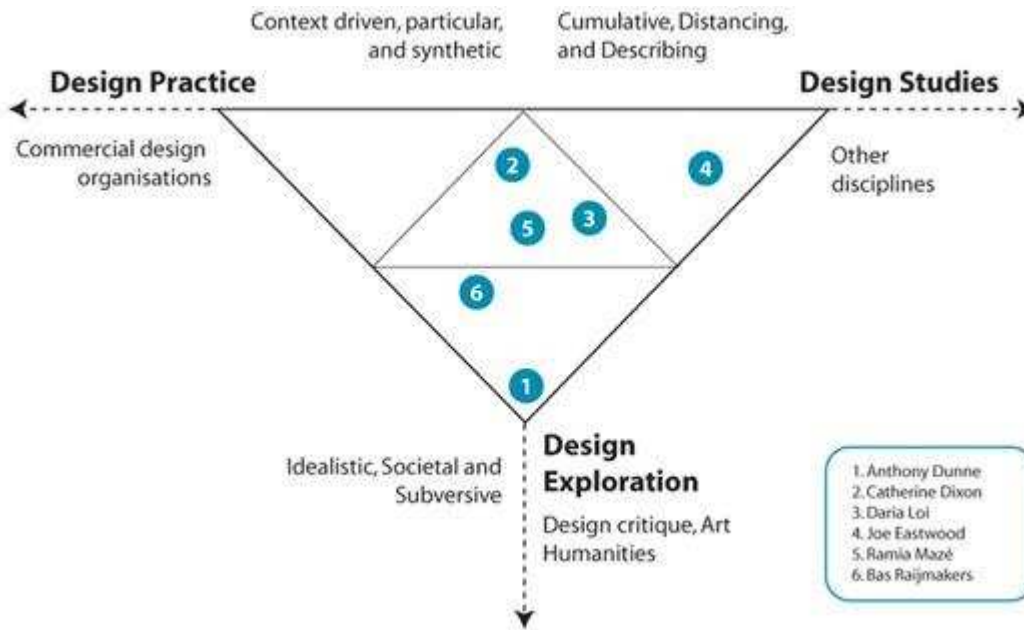


Figure 2. PhD examples placed in Fallman's (2008, pp. 5) interaction design research model.

4.1. Analysis Method

A descriptive case study approach (Yin, 2003) was used for this study. The six PhD theses were considered to be “a set of individual case studies” (Robson, 2002, pp. 181), where common features will be studied and compared. This research treats the PhD theses as case examples rather than case studies as it did not involve an in-depth, longitudinal study of each case to explore causation. It did however use the method to conduct a snapshot study of the examples to find underlying principles of the research methods used.

The selection and justification of the data for this study was influenced by the method of documentary analysis. This method has generally been used to analyse governmental policy documents or curriculum documents to gain insight into an instructional activity or approach. As the main purpose of this study is to examine the methods employed in practice-based design PhDs, the thesis documents and secondary text written about these studies can provide a wealth of easily accessible, relatively unobtrusive, and readily available research data (Forster, 1994, pp. 148; Hakim, 1993, pp. 136). Additionally, it is a non-reactive process of collecting information and enables the application of a different perspective to a topic. The main disadvantages to this method as cited by Appleton and Cowley (1997, pp. 1011) is the limitation of the data, potential bias in description of an activity or situation leading to “hearing only one side of the story,” missing or incomplete data, inaccuracies in original material, and data studied out of context (Bailey, 1982; Hakim, 1993; Stewart, 1984; Treece & Treece, 1982; Webb, Campbell, Schwarz, & Sechrest, 1984; While, 1987). As a method for a preliminary review in preparation for a larger, more in-depth study, it is ideal due to its accessibility and readily available data.

Two main sources of data were used in the analysis. The primary source of information was the actual theses. The theses were a source of text that documented the methods employed and the justification as argued by the researchers themselves. All but one thesis was reviewed in order to identify research methods employed and the reasoning for them. Due to the particular nature of Loi's thesis (which comes in a non-standard format of a suitcase containing artefacts and notes), the study used supporting text by Loi and other authors examining her research methods (see Loi 2004; Rust, Mottram, & Till, 2007, pp. 36; Somerset, 2008, pp. 91-96).

The secondary data used in this study are based on articles written on the PhD studies. Examples of these articles include Mazé and Redström's article (2007) discussing the operational and intellectual basis for critical practice in design and Seago and Dunne's (1999) article discussing new methods in art and design. These articles provided additional insight into the purpose and reasoning behind the methods used. In addition to these two sources, all six researchers of the cited studies reviewed a draft of this article and provided clarifying comments to the interpretation of their research methods. In order to help the study identify the methodological approach taken, phrases or sentences within the text were coded into the following categories:

- (a) Philosophical approach: What are its ontological and epistemological influences?
- (b) Methodology: How did the researcher describe the general methodology applied in their research?
- (c) Methods used: What were the research methods employed in the data collection and analysis?
- (d) Thesis structure: Does the thesis structure provide clues to the way the study was conducted?
- (e) Research purpose: How was the research conducted (using Frayling's [1993] framework)?
- (f) Inquiry domain: Which knowledge area did the inquiry focused on (using Cross's [1999] framework)?

The coded text was then displayed in a conceptually clustered matrix (Robson, 2002, pp. 482), as a method of data display (Miles & Huberman, 1994, pp. 241-242), in order to enable the discovery of patterns, themes, and trends as well as enable comparisons to be made.

4.2. Case Examples

A short description of each study is presented chronologically, where their purpose and methods of inquiry are discussed.

4.2.1. Example #1. Anthony Dunne

Thesis Title: Hertzian Tales: An Investigation Into the Critical and Aesthetic Potential of the Electronic Product as a Post-Optimal Object (Royal College of Art, UK, 1997)

This PhD explored how critical responses to the ideological nature of design can inform the development of aesthetic possibilities for electronic products. The outcome of the project was a “design approach for producing conceptual electronic products that encourage complex and meaningful reflection on the inhabitation of a ubiquitous, dematerialising and intelligent artificial environment” (Dunne, 2005, pp. 147). Dunne’s PhD is considered a methodological pioneer in the development of what would later come to be called a critical design approach (Blauvelt, 2003; Mazé & Redström, 2007). Critical design has since been adopted as an umbrella term for any type of design practice which suggests that design offers possibilities beyond the solving of design problems (Blauvelt, 2003). This thesis can be considered the blueprint of what a critical design approach might look like, and is described by Seago and Dunne (1999) as using investigative design as a “mode of discourse” in order to challenge preconceived ideas surrounding the object. The thesis consists of six essays that discuss existing theoretical perspectives and design approaches for developing the aesthetic possibilities of electronic objects. Five conceptual design proposals were developed as part of the research. Dunne (1997) stressed that these exploratory projects should not be considered as necessarily illustrations of the ideas discussed in the essays, nor are the essays an explanation of these proposals. Instead, they evolved simultaneously and were part of the same design process.

4.2.2. Example #2. Catherine Dixon

Thesis Title: A Descriptive Framework for Typeforms: An Applied Study (Open University, UK, 2001)

This PhD is described by Dixon (2001) as “an applied research study within the field of typeface description. It focuses upon (i) the pragmatic investigation of a problematic situation identified within the field and (ii) exploration of an appropriate methodology located within the studio-practice of the researcher.” The research used “design as research” process, influenced by Schön’s (1992) “designing as reflective conversation with the materials of a design situation.” Dixon also described the process as research initiated for the purposes of enriching or modifying aspects of a particular profession. The research method employed was reflective practice within a studio environment. The research outcome was an alternative typeform description framework that had been tested and applied within the context of an associated design project, resulting in the production of a CD-ROM. The research outcome of this study was explicitly two-part, one part relating to the content of the study and the other to the methodological approach of a practice-based inquiry. This is often the case with design PhDs, where methodological innovation is often a required process due to the uniqueness of each inquiry.

4.2.3. Example #3. Daria Loi

Thesis Title: Lavoretti Per Bimbi: Playful Triggers as Keys to Foster Collaborative Practices and Workspaces Where People Learn, Wonder and Play (RMIT University, Australia, 2005)

This thesis explored ways to foster organisational spaces where collaborative activities can be undertaken using design tools and methods. Loi (2005) argued that in order for co-design activities to emerge, participants and designers have to be linked by meaningful relationships. As a result, she developed a series of tools called “Playful Triggers” and proposed them as effective tools to elicit relationships among users who can learn how to work together before undertaking co-design activities. The way the thesis was constructed and presented has been termed “multisensorial writing” (Loi, 2004), an approach that “mirrors how people experience and filter the world.” The thesis was presented as a suitcase containing participatory devices to enable readers to engage with the thesis in more than one way, including experiencing how the concepts and tools presented in the thesis turn out in the context of use (see Figures 3, 4, and 5). The thesis/suitcase consisted of found and custom-made objects, CD, images and instructional notes. The tools created are based on cultural probes (Gaver, Dunne, & Pacenti, 1999) and offer a “collections of evocative tasks meant to elicit inspirational responses from people” (Gaver, Boucher, Pennington & Walker, 2004, p. 53).

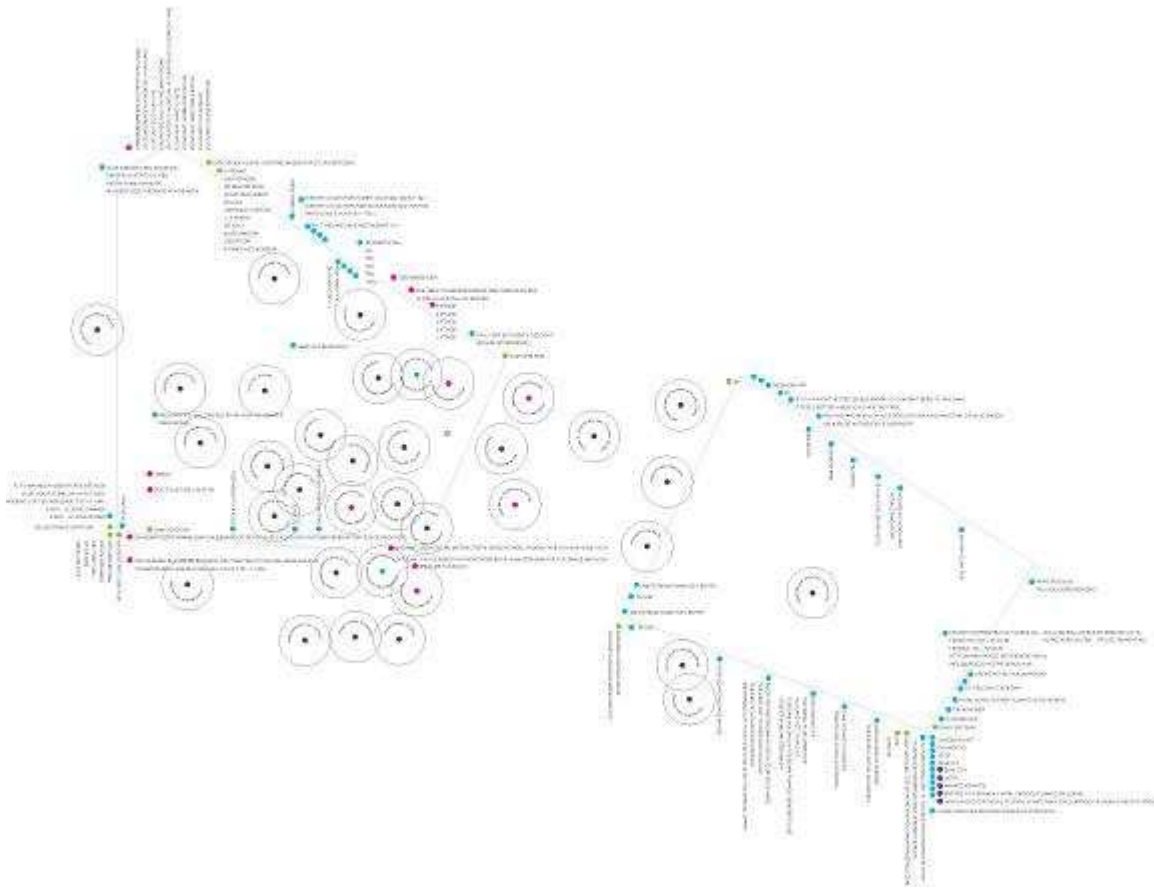


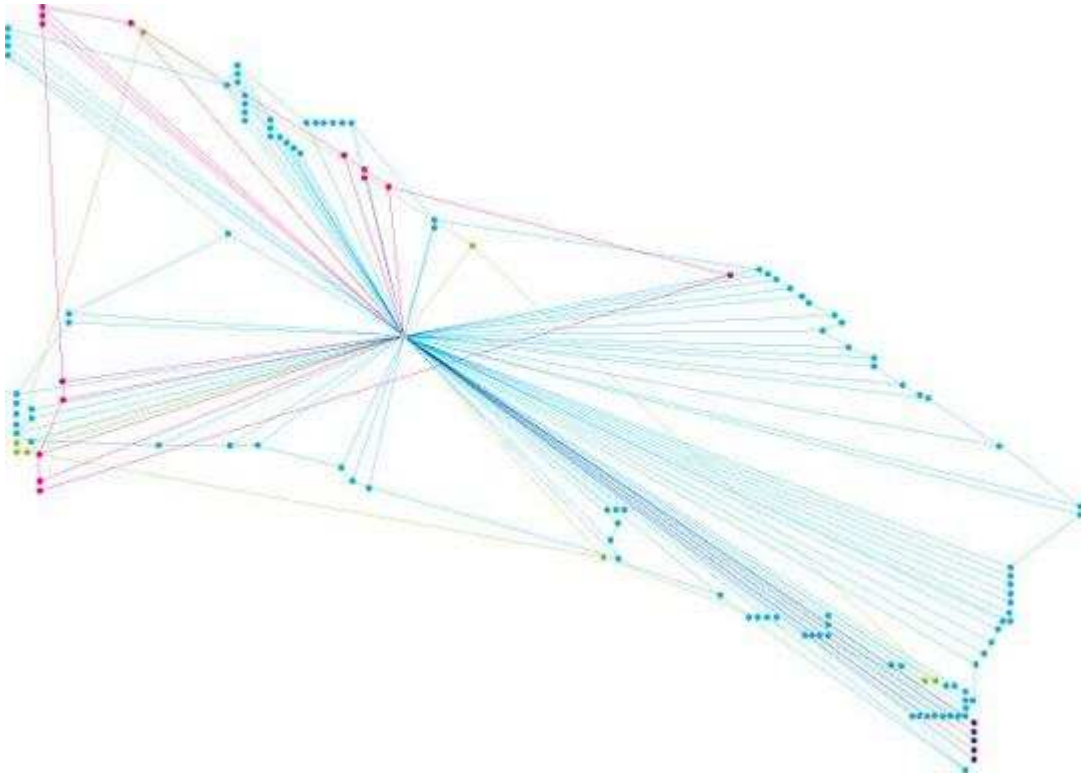
Figures 3, 4, and 5. Loi’s thesis-in-a-suitcase (pictures supplied by Daria Loi).

4.2.4. Example #4. Joe Eastwood

Thesis Title: An Investigation of the Relationship Between Typography and Audio-Based Communication in the Urban Environment, With Particular Regard to Pedestrian Wayfinding (University of the Arts, UK, 2006)

This PhD explored the relationship between text-based messages and audio-based communication within the contemporary urban environment. Issues relating to signage overload and urban movement were identified at an early stage in this study. Pedestrian wayfinding was then selected as a form of communication that allowed for exploration of all the key issues. Eastwood used a phenomenological perspective to reflect the researcher's own perception and understanding of each environment studied. The study was divided into two stages: (a) a contextual review through a series of interviews with designers to identify key questions and (b) two practice-based approaches that utilised analysis and experimentation--using visual analysis methods. The first practice-based approach was fieldwork observation of six public sites where a combination of notes, sketches, photographs, and audio recordings were made of typographic and audio-based communication. These observations were visually analysed and a series of charts and macroscopic drawings were produced to facilitate data collection and analysis (see Figures 6 and 7).





Figures 6 & 7. Examples of visual documentation of Dam Square in Amsterdam extracted from Eastwood's thesis (2007) and project Web site, [Typoaudio](#).

4.2.5. Example #5. Ramia Mazé

Thesis Title: Occupying Time: Design, Technology, and the Form of Interaction (Malmö University, Sweden, 2007)

This PhD is an inquiry into issues of time in interaction design. It argued that a central concern of interaction design must be the “temporal form” of interactive objects and their “form of interaction” as they are used over time. Philosophically, the study drew heavily on critical and “post-critical” architecture theory. Mazé (2007, pp. 20) also referred to Binder and Redström's (2006) “provisional knowledge regime” approach, following which she presented a set of theoretical and experimental strategies and relations as “only one of many approaches, while a common ground is set for constructive and collaborative work” (Mazé, 2007, pp. 20). This study's methodology can be described as a 3 x 3 matrix, exploring the themes within historical, practical, and critical viewpoints, all underpinned by practice-based projects. Figure 8 is my interpretation of Mazé's research design, which she described verbally but not diagrammatically. I have also incorporated my observation of the discussion of themes progressing from theory to practice through the chapters, and how they relate to Frayling's (1993) framework. Mazé's work is unique from the other case examples in that all the practice-based work (the three examples of IT+Textiles, Public Play Spaces, and Static!) were conducted before the start of the PhD study. The form of the thesis reflects this by using the matrix to break up the expected chronological flow, as well as presenting the projects as portfolio-formatted inserts that

breaks the flow of the theoretical and reflective text (Ramia Mazé, personal communication, August 10, 2010).

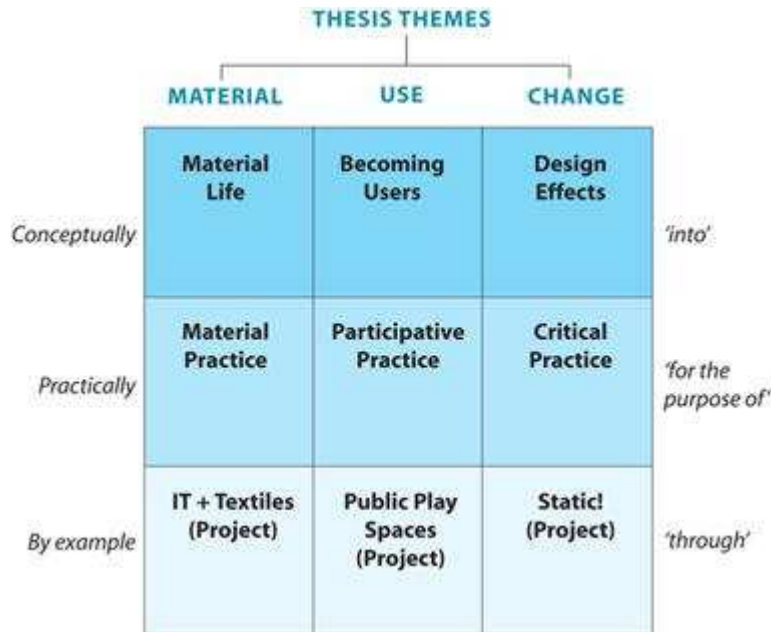


Figure 8. Mazé's research framework represented as a 3x3 matrix, showing the relationship between chapters.

Design projects are presented as self-contained portfolio or documentary pieces. They are "anchored" to the argument through open questions posed as speculations. Mazé uses design projects to initiate an internal dialogue to enable her to apply "criticality from within," with reference to Frayling's (1993) categories of research into, through, and for practice. The study's outcomes are summarised as a series of questions within the three areas of materials, use, and change. These questions are meant to highlight issues that relate to the characteristics of time-based elements, which need to be considered during the design of interactive objects.

4.2.6. Example #6. Bas Raijmakers

Thesis Title: Design Documentaries: Using Documentary Film to Inspire Design (Royal College of Art, UK, 2007)

This is an inquiry into how documentary films can be used in a specific area of design research, known as discovery research. Discovery research is defined by Raijmakers as a way of uncovering hidden knowledge of how people live in order to inspire and inform design practice. The methodology is based on an interpretive viewpoint, derived philosophically from hermeneutics and phenomenology. Documentary films that were created during the research were used to evaluate the applicability of design documentary as a new method for discovery research. The process of making the films became part of the research process. At the same time, the resultant films were considered to be "data,"

used as part of the inquiry. Raijmakers (2007) clarifies the research methods used under three areas:

- (a) Literature studies: Using hermeneutics and critical reflection to interpret text about films and the films themselves.
- (b) Film studies: The researcher conducted interviews with film directors and participated in documentary filmmaking master-classes. These were reviewed through content analysis, semiotics, and an analysis of the film's elements, for example in terms of its direction, lighting, acting, art direction, and cinematography.
- (c) Case studies of documentary films made by the researcher using methods of phenomenology and "thinking-through-making" (Seago & Dunne, 1999), which is described as learning through the activity of making.

4.3. Analysis

The case examples were compiled and analysed based on how each research was conducted, using Frayling's (1993) categories (i.e., research into, through, and for practice). In addition, Cross's (1999) categories (i.e., people, process, and product) were also used in order to reveal the focus of the investigations. The philosophical underpinnings of each study were also identified. A summary of these features is presented in Tables 1 and 2.

4.3.1. How was the Research Conducted?

All but one of the examples demonstrated the use of more than one approach to inquiry in terms of Frayling's categories (i.e., research into, through, and for practice). It seems that while Frayling provides a practical way to describe different types of design research, supervisors will have to be careful not to present the framework as unique and distinctive routes of design research. The examples have shown that inquiries into design-related matters are much more complex and require non-conventional research methods to address them. Examples of Raijmakers and Mazé have shown that it is possible to use all three types of inquiry in design research. The ability to analyse and articulate the type of research undertaken in a study will enable a new doctoral candidate to quickly grasp certain models of design research and begin constructing their own research process.

Table 1. Summary of PhD Examples: Philosophical and Methodological Influence

PhD Examples	Ontological and Epistemological Influences	Methodological Influence	Methods
Anthony Dunne	Material critical theory	Critical design	Exploratory projects Reflective practice (see Note below)
Catherine Dixon	Pragmatic and applied	Design as research	Visual survey Reflective practice Peer reviews
Daria Loi	Postmodern and qualitative Constructivist paradigm Artistic inquiry	Methodological bricolage (dialogic research, storytelling, play, creative action, action learning)	Playful triggers Observation and interviews Reflective practice Exploratory installations Multisensorial writing Experimental techniques
Joe Eastwood	Phenomenological	Design as research	Interviews Fieldwork documentation using photograph, notes and audio recording Visual analysis Exploratory projects
Ramia Mazé	Critical and post-critical architecture	Criticality from within	Exploratory projects Reflective practice
Bas Raijmakers	Hermeneutics and phenomenology	Design as research	Literature studies Film studies Exploratory projects as case studies

Note. Dunne does not explicitly state the research methods that were used in the review of the projects. However, judging from Seago's description of "highly considered artefacts" (Seago & Dunne, 1999), it would seem to suggest that some form of reflective practice process took place.

Table 2. Summary of PhD Examples: Research Approach and Focus

PhD Examples	How was the research conducted? (Frayling, 1993)			What was the focus of the investigation? (Cross, 1999)		
	Into practice	Through practice	For practice	People focus	Process focus	Product focus
Anthony Dunne		X	X		X	X
Catherine Dixon		X	X		X	X
Daria Loi		X	X	X	X	X
Joe Eastwood		X			X	
Ramia Mazé	X	X	X		X	
Bas Raijmakers	X	X	X		X	

4.3.2. What was the Focus of the Investigation?

Three case examples were specifically interested in the study of practices and processes of design (process) while the other three examples looked at studying both the design process and the configuration of artefacts. None of the studies was focused on investigating the manner in which people design. It is not possible to draw any conclusion as to why there is a lack of focus in this last category due to the small sample size. However, it is possible to infer from the analysis that the focus of investigation seemed to be consistent with the research approach (refer to Table 2). Dunne, Dixon, and Loi use two types of inquiry (through and for practice) to focus on processes and products. Mazé and Raijmakers use all three types of inquiry (into, through, and for practice) to investigate process related issues.

4.3.3. Philosophical and Methodological Influences

It is perhaps not surprising to see that an inquiry using the practice of designing as the main source of data generation should gravitate to research models that position the researcher at the centre of the inquiry. The reflective practice method, which involves the researcher thoughtfully considering one's own experiences in applying knowledge to practice, is evident in almost all of the case examples. Additionally, the use of the phenomenological approach was explicitly evident in two of the case examples. Phenomenological research focuses on the subjective experience of the individuals studied, inquiring into their experiences and understanding of a particular phenomenon (Robson, 2002, pp. 195-196). This approach enables the objective study of topics usually regarded as subjective by a researcher through the process of reflexivity. Crotty (1998, pp. 78-86) stresses the importance of reflexivity in order to be aware of the ways in which the researcher as an individual with a particular social identity and background has an impact on the research. The use of critical theory in Dunne's and Mazé's works illustrates the focus of their respective studies in using design as a method to critique, to ask questions

rather than provide answers. Their approach differs from the other examples in terms of their intent for their final designed outcome. Dixon, Eastwood, and Raijmakers employed the design project as a vehicle to explore the research question rather than as a means to reflect upon and question the social, cultural, and ethical implications of design objects and practice.

4.4. Characteristics of the Methods Applied

4.4.1. Format and Structure of the Thesis

The creation of an innovative methodology seems to go hand in hand with adopting an innovative structure for the thesis. This is especially evident in the way Mazé and Loi have translated their research methods into a thesis structure. Mazé's 3x3 matrix (see Figure 7) succinctly illustrates how she explored her themes through a theory to practice model (and vice versa), as well as using Frayling's categories (1993) to frame her chapters and research design. Mazé took Dunne's model of interlinking essays and projects, and provided an additional layer of complexity by linking theoretical concepts with projects through discussions of practice, using existing design case studies. Mazé's thesis structure not only reflects the approach and method of the inquiry but also the institutional circumstances of her PhD study. She became a PhD student when offered 1 year of funding from the Interactive Institute to write up her ongoing research as a doctoral dissertation. As a result, the practice-based projects became the subject of inquiry within the overall structure and are reflected upon in retrospect. Loi has pushed the boundaries of an accepted thesis format by changing the actual thesis structure itself. Although it is fairly common for an artefact to accompany a written thesis in design PhDs, it was unprecedented that an artefact alone should act as the thesis. Indeed, questions surrounding production, accessibility, supervision and examination issues have to be addressed (see Loi, 2004) in order to determine the viability of such alternative thesis format.

4.4.2. Pick and Mix

Research designs employed in all the selected examples can be described as pick and mix--a form of bricolage (Galloway, 2008) or assemblage which often combines methods from the social sciences, humanities, and hard sciences to derive a suitable model of inquiry. The necessity of this approach is not surprising considering the lack of an established research framework for design. However, perhaps this pick and mix has become the established paradigm for design; methodological innovations emerge from the way a researcher combines established research methods with practice-based methods. Kincheloe describes this process well through his description of bricolage as a method that "does not simply tolerate difference but cultivates it as a spark to researcher creativity Sensitive to complexity, bricoleurs use multiple methods to uncover new insights, expand and modify old principles, and re-examine accepted interpretations in unanticipated contexts" (Kincheloe, 2001, pp. 683).

4.4.3. Linking Practice With Theory

Reflective practice (Schön, 1983) seems to be the most popular choice for research that involves a practice-based element, where the process of designing is an integral part of the research. This method is common, even where reflective practice is not the main methodological framework, for example, in Dunne, Mazé, and Raijmakers's works. Dixon's work can probably be considered the most pure in terms of its use of reflective practice as the main methodological framework, even if other methods (peer review and visual analysis) are employed to support this. In contrast, reflective practice was used in Mazé's and Dunne's studies to critically review design projects in order to understand its relationship to the development of theory, which also has been supported by other non-practice-based means. In Loi's case, she explicitly links practice with theory through the actual thesis construction, presenting (and defending) the research outcome through the reader's interaction with the piece.

4.4.4. Visual Analysis

The role of visual analysis was an important part of the data collection and analysis in Eastwood and Dixon's studies. Fieldwork data in Eastwood's study were translated into a range of visual representations, which enabled him to analyse and derive conclusions from the data collected. These data charts and macroscopic drawings also serve to act as data presentation visuals, and have enabled him to communicate his research to his audiences. Dixon's work investigates the actual form of typeface constructions, and part of her research involves a visual survey of recent typeforms. This type of analysis is similar to the comparative research that is often conducted by designers during the early part of a design process.

4.5. Some Considerations on Doctoral Education in Design

4.5.1. Offering an Alternative Research Model

Students should be made aware at the beginning of their research programme that while there are established research models in different disciplines, a pick-and-mix model maybe possible in design research. Design research frameworks such as those of Frayling (1993) and Cross (1999) are useful to establish the purpose and focus of inquiry undertaken by the student in order to help them select appropriate methods. Supervisors could encourage students to evaluate existing practice-based processes and consider how to make them more "systematic, rigorous, critical and reflexive, and communicable" (Newbury, 1996). The models reviewed should also consider the format and structure of the final thesis. The pick-and-mix model requires students to approach research methodology as an active element in their research, rather than a passive, pre-define model that can easily fit into the research project.

4.5.2. Reframing Methods

Instead of discussing research methods by way of their associated discipline (arts, science, humanities) or through the type of analysis employed (quantitative, qualitative), the methods can be discussed in terms of how they might link practice with research and vice-versa. Similarities drawn from practice-based methods and processes are a useful way to aid the novice design researcher link their existing design activity with research activity and emphasise the relationship between these two. Shared processes such as investigative, iterative, and creative processes are evident in both practice and research (Yee, 2007). As such, we should be moving towards a holistic model as expressed by Fallman (2008) in how we discuss and explore knowledge within the design discipline.

4.5.3. A Designerly Way of Researching

The various research methods highlighted from the examples, within this article have drawn from a mixture of established and new ways of collecting and analysing data. I would posit that, creatively combining processes is not dissimilar to how innovative processes are developed in practice (Yee, 2007), and that this should also be encouraged in research. Supervisors are encouraged to be open to methodological innovation and to ensure that the development of these methods is rooted within a research tradition. As long as the student is able to demonstrate that the research conducted is thoroughly argued and referenced (Glanville, 1998) then methodological innovation will often be part of their eventual contribution to knowledge in the field.

5. Reflections

This study is designed to be a selective review of current design PhDs. The selected case examples are chosen on the basis of their innovative use of methods and to illustrate a variety of different research design approaches to design PhDs. Readers should note that the analysis and conclusions drawn are from a limited range of examples and only provide a glimpse into possible research models. In order to fully inform the design research community, doctoral candidates, and supervisors, a more in-depth study enabling deeper critical engagement with a larger sample of case examples has to be conducted.

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