

Introduction

As a first approximation, *design research* may be interpreted as scholarly investigations into phenomena in the various fields of design, including architecture, graphic design and industrial design—an underlying objective being the development of significant new knowledge and original understandings of specific areas in these fields (Jones, 1970a & 1992b; Margolin, 1989; Margolin & Buchanan, 1995; Buchanan, 2001; Cross, 2006a & 2011b; Crouch & Pearce, 2012). This paper begins with a concise literature review related to current thinking about design, design processes and design research. This is followed by an outline of the characteristic phases of the *design process* as commonly applied in *designing* products and artefacts of simple configuration (Lewis & Bonollo, 2002; Cuffaro, Paige & Blackman, 2006; Montana Hoyos, 2010). A comparable approach is taken to describe the main phases of the *design research process* with respect to a simple, interactive model, which may be used to describe the tasks that researchers often follow, especially in fields similar to industrial design. As will be discussed, there are strong similarities in the respective phases of each process that are worth further study.

Literature Review

Design is evolving from merely the conception of *things or products for manufacture* (be it a printed book, a chair, a vehicle or a house), to broader problem-solving, management and strategic approaches fundamental to achieving predetermined goals. Some of these recent approaches include systems design, service design and design thinking, with emerging new specialties such as user-experience design (UX), interaction design, digital design, and interface design among others (Siegel, 2008).

In addition, current design practice increasingly merges with design research, sometimes blurring the boundaries between both. In the previous century, arts and design mainly adapted data and research methods from the sciences and humanities, supported by literature on research design and research project management in general (Glaser & Strauss, 1967; Bell, 1999; Punch, 2000; Williman, 2005; Booth, Colomb & Williams, 2008; Creswell, 2009). However, the last two decades have seen further advances in *design research* and *design research methods*, but yet there is no apparent universal agreement on what these are.

There is no apparent single definition of *design research*. Interestingly, two books, *Design Research: methods and perspectives* (Laurel, 2003) and *Design Research* (Downton, 2004), as well as many academic research papers on art and design, use the categories established by Frayling in 1993, namely:

- Research **into** art and design
- Research **through** art and design
- Research **for** art and design (Frayling, 1993)

Although research *through* design is today widely accepted, more recently *constructive design research* has been defined as: ‘design research in which construction- be it product, system, space or media- takes center place and becomes the key means in constructing knowledge’ (Koskinen *et al.*, 2011).

The relationship of *design practice* within research is also widely discussed nowadays and can be controversial, in the context of Art and Design postgraduate education, in terms of validity and academic rigour. As defined by Candy (2006), ‘research in which practice is a central focus can be divided into two main types: practice-based and practice-led.’ It is proposed that if the research *leads* primarily to new understandings about the nature of practice, it is *practice-led*. Alternatively, if the research includes a creative artefact as the *basis* of the contribution to knowledge, the research is regarded as *practice-based*.

This practice-based research is also understood as ‘investigative designing, 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 or the application of design within a wider research context’ (Durling & Niedderer, 2007). This conception poses interesting questions about the relationships between the process of ‘systematic designing’ and a ‘research process’, as discussed later.

Finally, doctoral education in design has been widely discussed (Durling & Friedman, 2000), and doctorates in general can be divided into PhDs and professional doctorates (for example DDes or Darts in the case of the latter). As cited by Durling & Niedderer, ‘both degrees have a research agenda, though the difference between a 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 & Powel, 2005)

This paper does not discuss *design research* in depth, nor tries to critique practice-related research approaches in art and design, but rather offers an intuitive comparison of the design and research processes in the context of PhD research, especially in industrial design and product design engineering.

Modelling the Design Process

Design process models can vary in configuration depending on design discipline and academic or professional focus (Cuffaro, Paige & Blackman, 2006), but there are many similarities. Based on an extensive research, the *design process* can be modelled on the basis of five interdependent and iterative phases as shown in Figure 1, below (Lewis & Bonollo, 2002; Bonollo, 2010). In turn, each of these phases (or subprocesses) has a number of constituent elements that describe related tasks and information at a macro level of detail.

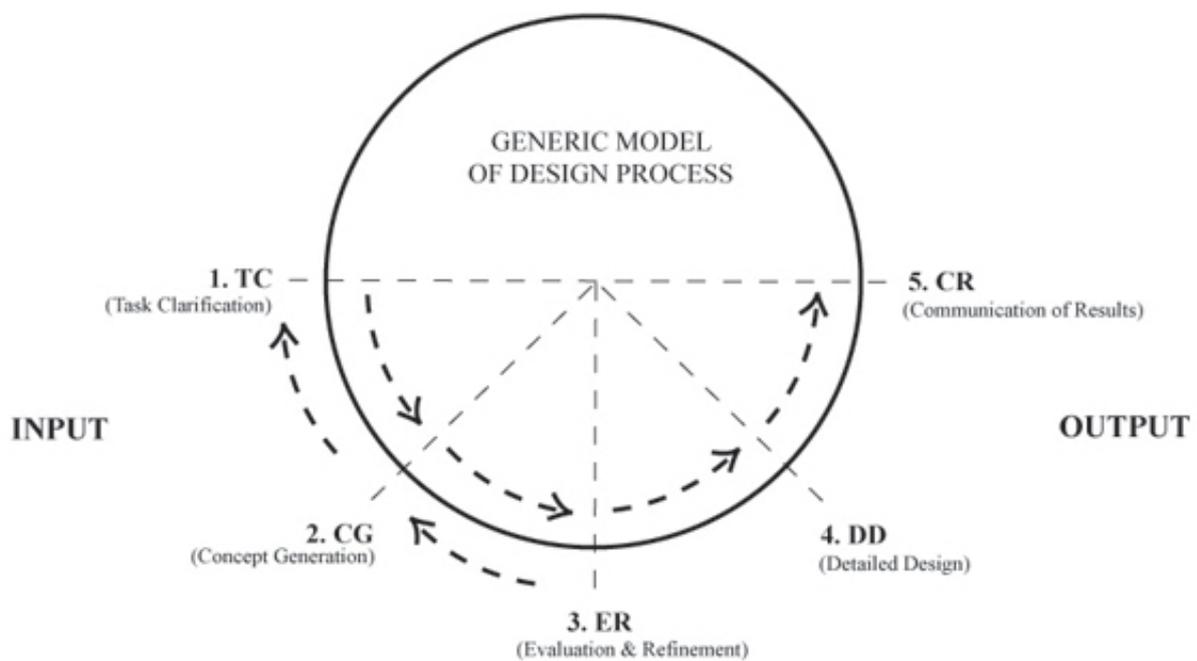


Figure 1: Typical (generic) model of the design process. TC (task clarification), CG (concept generation), ER (evaluation and refinement), DD (detailed design) and CR (communication of results).

Moving anticlockwise around the periphery of the semicircle, TC (1) represents the *task clarification phase* where information search is undertaken, the design problem is formulated and the design brief and product specifications are developed. CG (2) is *the concept generation phase* where several potential solutions to the design brief are proposed. This is

usually followed by ER (3), an *evaluation and refinement phase* where a preferred solution is selected for further development and proof of principle. Phase 4 (DD) denotes the *detailed design phase* where the preferred concept is fully detailed through appropriate drawings, models and, if required, a three-dimensional model or functional prototype. Finally, CR (5) is the *communication of results* phase where the finalized design solution is explained by means of renderings, technical drawings and other media. Again, note that this interactive model, which can be configured in other ways (compared to the one shown in Figure 1), is only concerned with the macro level of the process and does not restrict nor direct how individual designers go about finding solutions to design problems in their own unique ways.

Referring to Figure 1, a well-understood objective in achieving an acceptable design outcome to a particular brief is to be able to move anticlockwise around the periphery of the semicircle in a continuum from point 1 (task clarification phase) to point 5 (communication of results phase) in the shortest possible time, and with as few iterations as possible (Green & Bonollo, 2002). The underlying procedural idea in this case is that the design problem is clarified progressively as the solution is generated. A steady, iterative progression from point 1 (TC) to point 3 (ER) is clearly required in order to arrive at a preferred solution concept and, understandably, designers may employ a combination of problem-solving approaches to reach this point as the need arises. For the sake of comparison with the research process described below, this model configuration has been rotated 90 degrees clockwise as depicted in Figure 2.

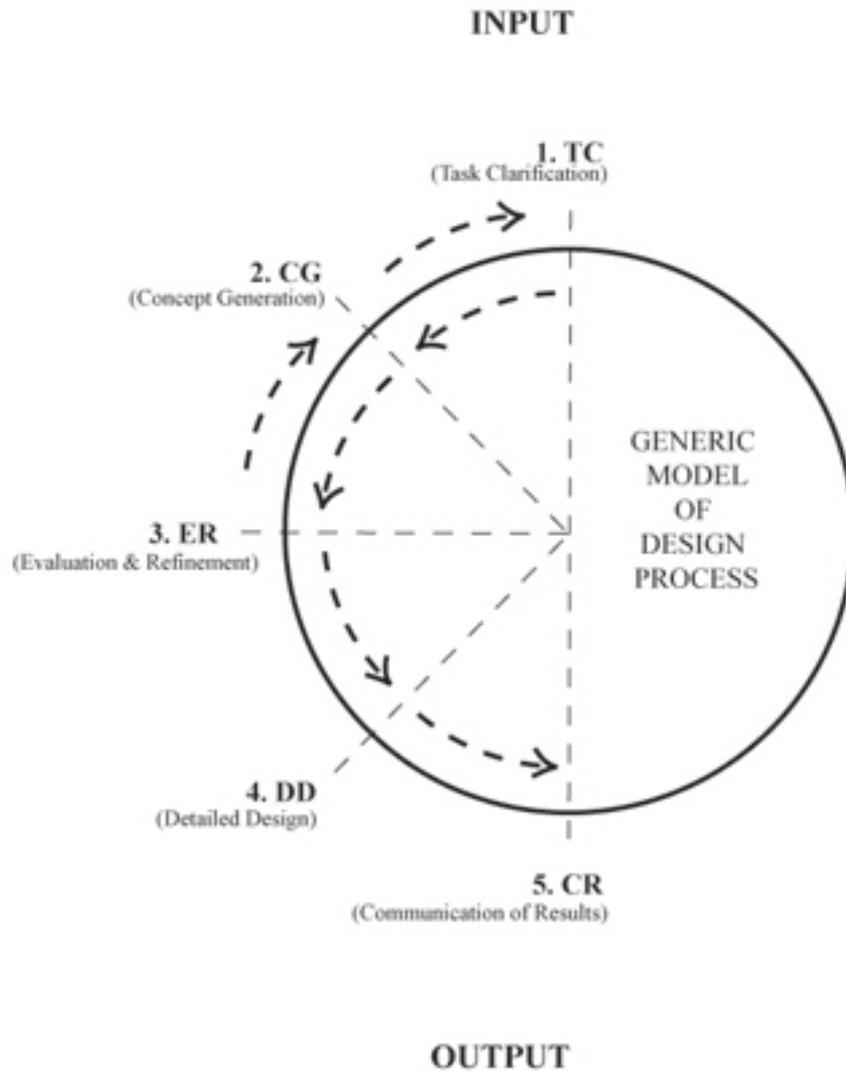


Figure 2: Typical (generic) model of the design process, rotated for the purpose of comparison with model of the research process, as explained later.

Modelling the Research Process

A model of a typical *research process* in higher education (design disciplines)¹ is shown in Figure 3, with the interdependent and iterative phases numbered 1 through 5, and configured in a similar manner to the design process above. In the authors' academic domain, this is consistent with the *research track* followed in many PhD and Professional Doctorate programs in design (Durling & Friedman, 2000; Green & Powel, 2005; Durling & Niedderer, 2007), at a macro level of activity and task description.

¹ This process syntax or schema is used widely by Industrial Design PhD students in the Faculty of Arts and Design at the University of Canberra.

However, it is realised that there are many ways of carrying out a research program and writing up a thesis, dissertation or exegesis. Consequently the number of these phases may be modified according to the substance of the research project undertaken. In addition, research is not a strictly lineal or sequential process since—whilst necessarily moving forward along the research time track to achieve an outcome—iterations can and often do occur between any of the phases shown. Moreover, the task content (information) of each component part of each phase can move from one phase to another, as is often influenced by the nature of the research project and the *investigative designing* (Durling & Niedderer, 2007) style of the researcher. Consequently, the boundaries between each phase can be quite *fuzzy*, and the final configuration of these phases and their content often flexible, bearing in mind that the respective time allocation is not reflected in this model. Nevertheless, by the end of Phase 3, the research process should be well defined with a clear *research design* (including *research methods*) and *experimental program plan* in place; otherwise it may be necessary to return to Phase 1 and start over with the resulting disappointment and loss of time.

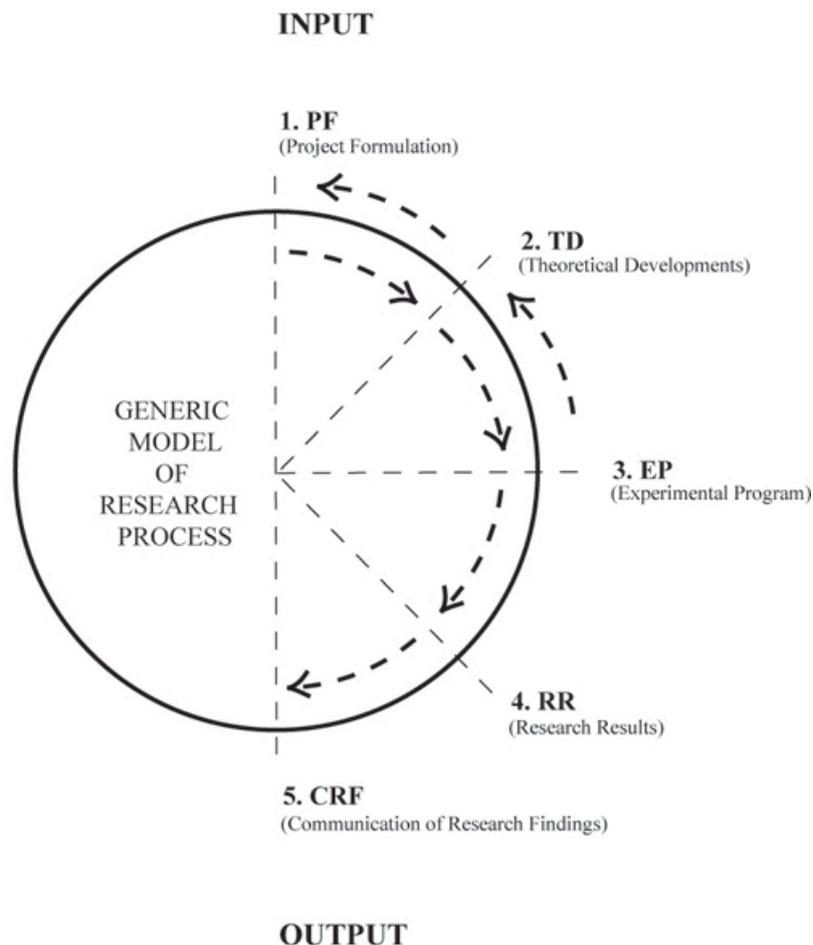


Figure 3: Typical (generic) model of the Research Process

In brief, and moving clockwise around the periphery in Figure 3, phase 1 (PF, project formulation) is primarily about formulating the research problem, which typically includes a research proposal with aims and research questions, hypotheses or propositions, an overall plan of the research, a literature review of the *state of the art* (including a summary of findings) and summary of possible gaps in knowledge that support the justification for the research. The *research proposal* is usually refined and formally accepted as part of this phase, with the research tasks clarified in reasonable detail (Punch, 2000).

Phase 2 (TD, theoretical developments) is concerned with conceptualising/theory building and modelling, i.e., *synthesis* based initially on the findings of the literature review, along with planning the empirical program to test or evaluate the theory. This may include constructing graphic or system models of the existing situation or phenomena identified in the findings and, hence, determining what research design/methods to use in developing new knowledge to add to these initial interpretations—for example, quantitative, qualitative and mixed methods (Booth, Colomb, & Williams, 2008; Creswell, 2009). This also includes formulating a plan to conduct the experimental program/field work using appropriate tools such as surveys, questionnaires, laboratory work and what product or system designing may be needed to reinforce the experimental program.

Phase 3 (EP, experimental program) is where the experiment/field work is conducted using the research design/plan developed in Phase 2. Empirical data are collected, coded, and processed with appropriate software packages, such as NVivo software for coding and analysing qualitative data, or statistical packages for analysing quantitative data, or both if mixed-methods of analysis are used.

Phase 4 (RR, research results) is about final theory building, modelling and validation based on the new data found in phase 3, summarising these findings including a discussion about the significance of the new knowledge proposed, explaining how these results may be deployed, and providing a summary of conclusions along with suggestions for further research. New models and original interpretations of the research investigation may be proposed, along with a review of the original research aims, in preparation for thesis writing in phase 5.

Finally, phase 5 (CRF, communication of research findings) is concerned with communicating the findings and conclusions of the research, which includes documenting

the contribution to new knowledge—typically through a thesis, dissertation or exegesis—along with suggesting areas for further research. The structure of the thesis or dissertation may follow the structure of the research process phases, but may be expanded into additional *chapters* depending upon the volume and rational organisation of the information to be documented. Although not specifically included in the diagram, a doctoral program would include the examination phase and communication of results through publications, etc.

Research and Design Process Relationships

When compared one-on-one in Figure 4, below, the noted progression through the various phases of the *design process* is clearly very similar to what happens in the *research process*. Of course, both the design and research processes are part of respective *projects*. In both these projects, creativity and proposing new and socially worthwhile knowledge are fundamentally important objectives. Thus, due to the exploratory nature of both, the results might be unsuspected, and the nature of the processes iterative and cyclical in search of this novel and creative result (Amabile, 1996).

Some relationships of designing *in* research have been classified, for instance, *designing to test*, *designing quick and dirty*, *designing as demonstration*, *designing as ideal*, and *designing as creative exploration* (Durling & Niedderer, 2007). However, in keeping with the aims of this paper, further exploration of the relationships between the design process *and* the research process is now timely.

Interestingly, and mindful of the earlier explanations, it is realised from Figure 4 that the tasks described at the corresponding numerical phases of the design and research processes are similar and/or analogous with respect to their respective objectives and information content. That is, the tasks in PF (1) for *research* are similar in nature to those for *design* in TC (1)—both are concerned with searching for relevant *information* to clarify the research or design problems. Likewise, the tasks in TD (2) are similar or analogous to those in CG (2)—both of these phases (or subprocesses) are preoccupied with conceptualising and developing theory and propositions.

At phase 3, the respective phases (EP and ER) are focused towards planning the experimental and practical side of the related processes.

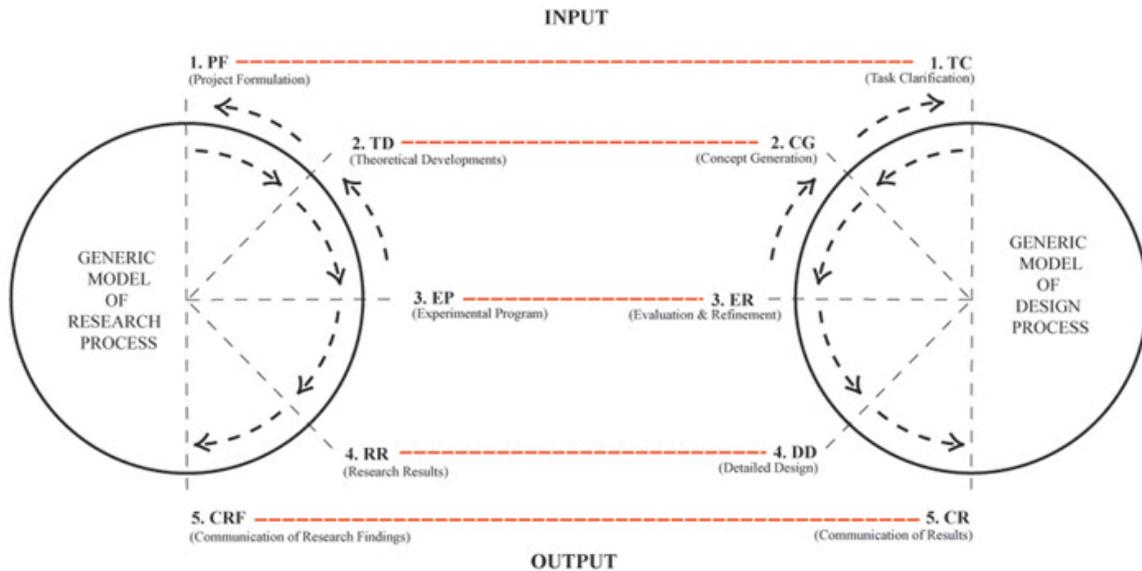


Figure 4: Graphic comparison of the *research* and *design* processes, respectively.

Similarly, phases 4 (RR and DD) are concerned with realising the outcomes of the respective projects, while the final phases in each process (CRF and CR) are all about communicating the results of each project. There are clearly parallel similarities and correspondences in each pair of design and research phases. With all of this *information processing* phenomena, however, there is still the question of deciding if the process is predominantly a research process *or* a design process *or* other possibility?

From a theoretical point of view, it is reasonable to assume that the research and design processes are not necessarily the same—this follows since the overall respective aims and evaluation criteria are often different and, moreover, the context can vary widely. Four of these possible variations in relationships are considered in the following Venn diagrams, labelled Figures 5 through 8, respectively. The related interpretations given below are hypothetical (i.e., without supporting empirical data) and for discussion purposes only, and are not meant to be definitive in any way.

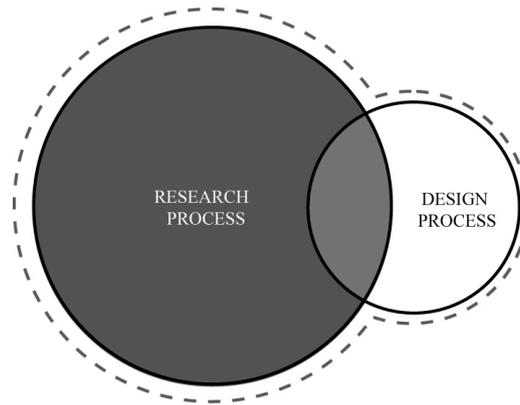


Figure 5: Case 1, Research Process is Project Predominant

In this first case (Figure 5), the dotted line around the periphery of the diagram represents the *union* of the two sets of information—noting that *tasks* may also be described simply as *information*—meaning the sum total of information in the research project. The area circumscribed by each process denotes the approximate quantum of information. As denoted by the respective areas, research information is clearly predominant and design is the subordinate, but necessary, process.

The *intersection* of the two sets, shown by the lighter shaded area, represents information common to both processes, or information that applies equally and may be classified as either research or design information. The relative size of these areas signifies the quantum of information contained in the respective processes. However, information excluded from the noted *intersection* (but included in the union) may be classified as *research* or *design* information but not both. This case may represent research projects where design is being used as a *vehicle*, or as a significant part of the project to test some theory. An example of this is designing a product such as a creative furniture object, or a tool (which in itself stands alone as a design project), with the aim of using this product to test the perceptions of users from different cultures, in the context of a bigger research project. In terms of Frayling's categories, this could be an example of *design for research*.

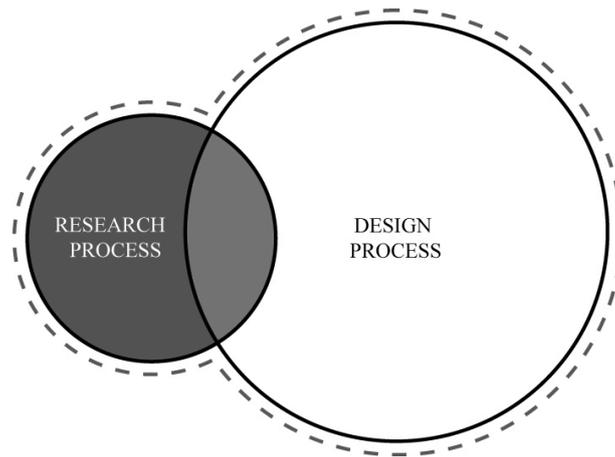


Figure 6: Case 2, Design Process is Project Predominant

Figure 6, above, illustrates the converse situation to case 1: the *union* and *intersection* of each set have a similar meaning, in terms of information content, as for the previous case. However, design information and, hence, the design process is the predominant partner in this case. As before, information excluded from the *intersection* shown is peculiar only to the respective processes. Case 2 is comparable to practice in professional design where substantial research is necessary in order to achieve the high level of creativity, quality and social worthwhileness desired. This situation is also related to new product designs and innovation, especially when linked to a new technology. The new technology may have evolved from an independent research process in itself, and informs the design process in order to create a novel product. In relation to Frayling's categories, this could be an example of *research for design*.

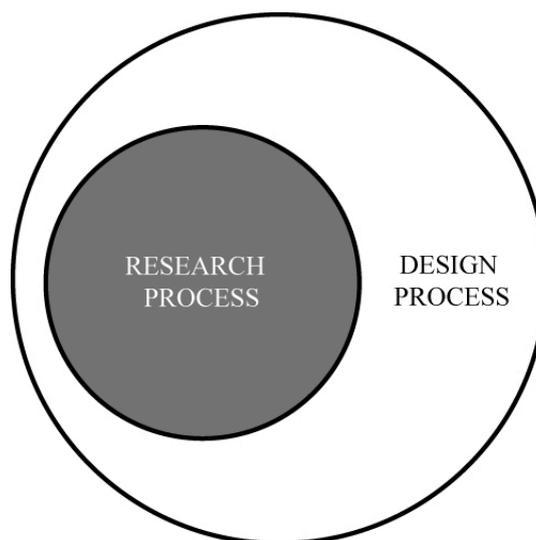


Figure 7: Case 3, Research Process as an inclusive part of the Predominant Design Process

In this third case, the design process is the predominant partner. The *union* of the two sets is inclusive since the research process information is subsumed or embedded in the design process set. Information in the shaded area (the research process set) is not unique to this process but may be classified as applying equally to both processes. Here research information can clearly vary in quantum so that the situation is more in line with common professional practice in design.

An example of this could be the re-design of a product, informed by market research. The market research does not operate by itself, but in its totality as part of the product development process, where various iterations of the same product are validated through specific market research and tests with potential users. In relation to Frayling's categories, this could be an example of *research within design*.

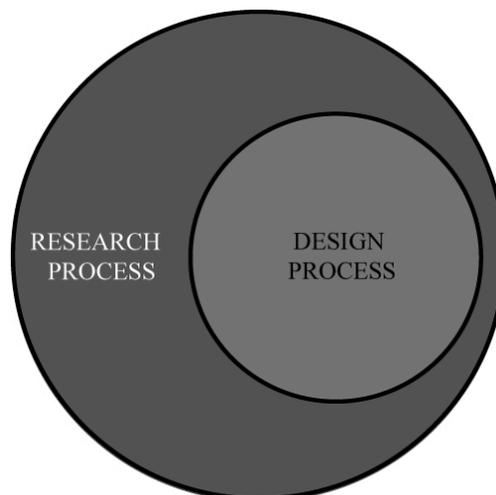


Figure 8: Case 4, Design Process as an inclusive part of the predominant research process

Finally, this fourth case represents the converse of case 3: research information is shown as predominant with design information as an inclusive part of the research process. As above, the information in the design process set is not unique to this process as it applies to both processes. In this case the design process may or may not be a significant part of the research process depending on the respective quantum of related information and the purpose of each process. An example of this could be a piece of equipment specifically designed and built for a research project. The piece of equipment is not a standalone design project, but is embedded within the research project. In relation to Frayling's categories, this could be an example of *design within research*.

Concluding Remarks

The authors have explored important philosophical and practical relationships between the 'design process' and the 'research process' in the context of research in postgraduate Art & Design education. It has been proposed that the 'research process' and the 'design process' are not necessarily the same, although there are valuable similarities that enhance design and research outcomes. Moreover, it is useful to explore these relationships in contexts such as posited by Frayling, as well as in the context of *information processing* to better understand the predominant design or research processes and their practical meaning.

A widely published, five- step generic model of the design process has been used to develop a comparable model of the research process, and to demonstrate the parallel similarities in these processes. In this framework, two models of *design within research*, and two models of *research within design* have also been presented, discussed and illustrated by concrete examples of possible design and research projects. Clearly, other relationship cases are possible and may be linked to actual case studies of research and design projects – there are no apparent hard and fast rules for interpreting the relationships between the research and design processes, and further research should prove useful.

The aim of the proposed models and related discourse is to contribute to a better understanding of design and research—hopefully, these will stimulate discussion and serve as useful tools for supervisors and students in planning design-related doctoral research projects.

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