An Approach to Knowledge Generation by Research and its Utilisation in Practice - Situating Doctoral Research around Artifacts

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Abstract
This paper explores expertise in industrial (product) design and the contribution of knowledge generated by doctoral research. It stands on the premise that product design research should not function as a distraction from practice, but as a development of it. This is documented by doctoral studies and examples that illustrate how new knowledge can be generated by research and later applied in practice. The doctoral research is situated within the social structure that constitutes people, activity, context and culture where an artifact is seen to be a mediator for the generation of new knowledge and its application. This is demonstrated by two examples of doctoral studies. The paper concludes with remarks about the importance of research and practice integration, and points out that situating doctoral research around artifacts, as mediators of knowledge, is transferable to any doctoral study in design.
Introduction
Design has been an area that differs from the well-established notion of research. Research has not been very common among designers because of its nature and the way that professional practice operates. The connections between research and design have not been well defined. Grout and Wang (2002) made two distinctions between "the notion of design as research and that of research about the design process". What is needed, is to build a collaborative research culture between design research and practice, and to build a relevant research knowledge base to be utilised in practice.

This paper situates doctoral research around artifacts in order to facilitate new knowledge generation to be applied in practice. It is a continuation of the work reported at the "Design plus Research" conference (Popovic 2000: 96-101) where the generation and application of knowledge were distinguished through the following four areas: (a) research before the design work is started, (b) research conducted during the early stage of the design process, (c) concurrent research carried out during the design and development stage and (d) research when an artifact is manufactured and is on the market. It also addresses the changes that the profession of industrial (product) design has been facing and proposes the utilisation and application of knowledge that would position artifact research on a strategic level by utilising Doctoral and Masters by Research programs as vehicles.

However, changes have occurred in the profession and industrial (product) design, which are influenced by different factors - social, political or technological. These might influence how the profession is practiced and is redefined. At this stage, it is important to refer to the profession of industrial (product) design briefly in order to understand the relations between practice and research. The profession of industrial (product) design has many descriptions that were adapted and reformulated. However, this paper will briefly compare two descriptions of the profession that have been developed by two major professional associations. The Industrial Designers Society of America (IDSA) (2003) describes the field as

…"the professional service of creating and developing concepts and specifications that optimize the function, value and appearance of products and systems for the mutual benefit of both user and manufacturer. Industrial designers develop these concepts and specifications through collection, analysis and synthesis of data guided by the special requirements of the client or manufacturer. They are trained to prepare clear and concise recommendations through drawings, models and verbal descriptions. […]

[…] The industrial designer's unique contribution places emphasis on those aspects of the product or system that relate most directly to human characteristics, needs and interests. This contribution requires specialized understanding of visual, tactile, safety and convenience criteria, with concern for the user. Education and experience in anticipating psychological, physiological and sociological factors that influence and are perceived by the user are essential industrial design resources".

The International Council of Societies of Industrial Design (ICSID) (2003) describes design as

"Creative activity whose aim is to establish the multi-faceted qualities of objects, processes, services and their systems in whole life-cycles. Therefore, design is the central
factor of innovative humanisation of technologies and the crucial factor of cultural and economic exchange. Design seeks to discover and assess structural, organisational, functional, expressive and economic relationships, with the task of:

- enhancing global sustainability and environmental potential (global ethics)
- giving benefits and freedom to the entire human community, individual and collective
- final users, producers and market protagonist (social ethics)
- supporting cultural diversity despite the globalisation of the world (cultural ethics)
- giving products, services and systems, those forms that are expressive of (semiology) and coherent with (aesthetics) their proper complexity. […]

[…] Therefore, the term designer refers to an individual who practices an intellectual profession, and not simply a trade or a service for enterprises".

Despite these two opposed descriptions of industrial (product) design practice, there are indicators that demonstrate that expertise is needed to practice. It is worth noting that some new categories of expertise that have emerged in practice are design research, scenario design, design leadership, user research, strategy innovation and experience design (Popovic 2001: 150-157). When the latter is compared with the above descriptions of the profession, it can be seen how research might fit into these services or activities. The major difference between the descriptions is that IDSA (2003) describes industrial design as "the professional service..." and the possession of knowledge is "anticipated". ICSID (2003) emphasises that design incorporates "creative activity", "innovation" and the "practice of an intellectual profession". Nevertheless, both indicate that expert knowledge and skills are needed to practice.

Situating Doctoral Research

The emphasis on the importance of design expertise is connected with the design paradigm shift from an object to experience (Figure 1). Within this shift, design expertise plays a significant role and contributes in knowledge application in practice in order to design people's experiences with artefacts and tools. It is understood that design ability should be regarded as a distinct form of intelligence and seen as a discipline in its own right (Cross 1995: 105-120; Cross 1999a: 25-39; Popovic 2000: 96-101). Design is categorised as an adaptive expertise (Popovic 2000: 96-101) as designers adjust to the design tasks by utilising their knowledge which they adapt to the current task and apply during the design process (Suwa, Gero and Purcell 1999: 297-320). It is understood that for a designer to arrive at any solution, knowledge of strategies, as well as domain-specific and general process knowledge is required (Christiaans 1992). The sources to look at for the design knowledge are people, processes, products (Cross 1999: 5-10) and activities, context and culture (Popovic 2000: 96-101). Therefore, in the context of design (product design), expertise can be "understood as the possession of a body of knowledge and the creative and analytical ability to extract, analyse and apply that knowledge" (Popovic 2002: 96-101).

However, the most recent studies of human expertise demonstrated the importance of situation and context. They showed a much broader view toward human expertise and knowledge acquisition and utilisation taking into account the importance of the social condition and the context in which the activity occurred (Feltovich, Ford and Hoffman 1997).
Popovic (2001) presented a paradigm shift in product design and discussed its changing directions and the emergence of the framework that will allow research and study of knowledge by situating artifacts or tools within the following social framework of:

- context
- activity
- culture
- people

It is recommended to look for knowledge sources within the suggested framework - from an object to experience design (Figure 1). In this instance, doctoral research should be directed toward new or significant contributions to knowledge, where the knowledge sources are generated from people, context, activity and culture. The relevant knowledge generated can be applied to design. For example, knowledge generated from activity can be applied in a scenario design or an experience design, or knowledge generated from finished artifacts can be applied in the design of a new generation of products. The artifacts or tools are seen as mediators for knowledge generation and its utilisation.

![Figure 1. Paradigm Shift and Situating Doctoral Research around Artifacts](image)

To assist in knowledge generation, utilisation of different qualitative and quantitative research methods is required. The most common methods applied and tools used are summarised in table 1. They can be selected according to their relevance in assisting in developing new knowledge to be applied when designing artefacts (products). The approach would support expertise building and new knowledge generation in the relevant design field and it is transferable across the domains.
Table 1. Most common research methods, techniques and tools that support knowledge generation

<table>
<thead>
<tr>
<th>Research Methods and Techniques</th>
<th>Analysis Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>checklists</td>
<td>CAD simulation</td>
</tr>
<tr>
<td>focus group</td>
<td>virtual reality (VR)</td>
</tr>
<tr>
<td>ethnographic methods</td>
<td>mock-up</td>
</tr>
<tr>
<td>interviewing users</td>
<td>prototype</td>
</tr>
<tr>
<td>observation</td>
<td>various data analysis softwares (Observer or Atlas.ti)</td>
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<tr>
<td>protocol analysis</td>
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<td>questionnaires</td>
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<td>stories</td>
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<td>scenarios</td>
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<td>life-style explorations</td>
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This brief account of research methods and knowledge generation and their utilisation is demonstrated through two examples of doctoral studies. Both doctoral research examples are situated within the framework illustrated in Figure 1.

1. A new transit system and conceptual models with associated findings to improve urban transport

Activity: travel
Culture: western
Context: suburban and metropolitan
People: users of alternative transit system

Phases: Research before the design work started and research during the early stage of design process.

Contribution to knowledge: Conceptual model that supports planning and design of the urban transit system

Application of knowledge: Design proposal for new urban transit system

Within this study, travel is seen as a social goal, and universal access to transport is seen as a prime objective (Porst 2002). The research methodology was divided in three parts.

7) Research into travelling activities of people and investigation of travel scenarios.
8) Development of theoretical support for design - theoretical model based on findings
9) Design proposal of a new urban transit.

A theoretical model that was relevant for the improvement of alternative urban transport was the outcome of new knowledge generation. The model is pertinent to transport planning, design and development. It contains qualitative and quantitative recommendations for application to the planning of future proposals and prioritises the factors for alternative transport. There are three levels within the model. They are:
• Primary model: Design-centred factors for consideration in the development of alternative transport
• Secondary level model: Traveller needs and fulfilment
• Tertiary level models: Users and useability, convenience, transport quality.

All these models have their sub-categories that indicate which knowledge is relevant to be implemented in the design proposal. The priority of the application of knowledge is identified within each model.

The models are situated in the framework illustrated in Figure 1, which supports an artifact positioning as well; in this case, a new alternative transport system. The system is seen to be a mediator of knowledge utilisation. The new knowledge is contributed to the field of transportation as the proposed design outcome (Figure 2).

Figure 2. Auto-taxi: design proposal of new alternative transport system

2 Intuitive use of products

Activities: operating home theatre.
Culture: western
Context: home
People: home theatres users

Phases: Research when artefacts are on the market
Contribution to knowledge: New knowledge on intuitive interaction with artifacts
Application of knowledge: Design of new artifacts that might better support an intuitive interaction.
This research is a doctoral study in progress. It is based on the premise that intuition is a type of cognitive unconscious processing. It utilises stored experiential knowledge. Intuitive use of products involves utilisation of knowledge gained through experience(s). Therefore, "products that people use intuitively should be those with features they have encountered before" and rely on experiential knowledge (Blackler, Popovic and Mahar 2002: 120-135).

The artifact that was selected as a mediator for knowledge generation was "Marantz RC500i" touch screen remote control (Figure 3). The operations were designed to investigate most of the features of the product (some are common to many digital devices and others are found on most audiovisual equipment). The experimental methods involved observations and concurrent protocol and structured retrospective interviews. The coding and analysis of data were done by using Observer Video Pro software. The correlations reported in the experiment (Blackler, Popovic and Mahar 2003), between time, Technology Familiarity (TF) score and intuitive uses of the features support the results found in the previous work (Blackler et al 2002: 120-135). People seem to use their previous experience with similar features in order to use new features intuitively. These results also suggest that the decision to use the TF score as the Independent Variable to group participants rather than the level of expertise was the right one.

Figure 3. "Marantz RC500i" Remote Control Used as Knowledge Generation Mediator

The main experiment results concur with those from the first experiment - the more familiar a feature is, the more quickly and intuitively people are able to use it by transferring knowledge of known products to the new one. The data on intuitive first uses are particularly important as they confirm that people are able to use a feature intuitively the first time they encounter it if they are already familiar with a similar feature.
The next step of this study is to re-design the remote control and utilise the knowledge generated by this research to increase an intuitive interaction. The new design is going to be tested and compared with the experiment results to determine whether or not the new design has made the artifact more intuitive.

This research has the potential to assist designers with new knowledge in designing artifacts for intuitive interaction by utilising the knowledge generated by this research and applying it to products (artefacts) they design.

Discussion

Many studies relate how tools mediate between the user and object and state “tools mediation is a way of transmitting cultural knowledge” (Kaptelinin 1996: 45-68). This is an example of implicit learning using objects. Indeed, “…some cultural anthropologists have long seen the artefacts we create as the medium through which cultural identities are preserved and communicated to subsequent generations”. Others have gone so far as to “equate culture with the artefacts a society uses.” (Krippendorff 1990). Nardi (1996) believes that “all human experience is shaped by the tools and sign systems we use”. Tools shape users’ activity and can even influence their goals. Suchman (1987) pointed out that an activity would grow out from the situation. The main idea that artifacts mediate the activity is introduced by Kuutti (1991) and its theoretical construct has been transferred to the artifact concept of being mediators of knowledge generation and utilisation.

The two doctoral examples demonstrated how artifacts can be used to generate new knowledge that could be applied to the design of new artefacts. They also illustrated how important it is for research to be situated within the social structure (Figure 1). Therefore, it is possible to situate doctoral studies within the social framework (Figure 1) that will support the generation of new knowledge to be applied by practice.

This paper referred to four research phases, two of which are identified to be significant for new knowledge generation and to have strategic importance for artefact (product) innovation. They are: (a) research before the design work started and (d) research when the product is on the market. These stages are compatible with the practice operations.

Research before the design work is started is an initial research stage in which different qualitative or quantitative research methods can be utilised in order to acquire domain-specific knowledge to be applied to the design of particular experiences or artifacts. The emphasis might be on generating knowledge from a context, activity, life style and human interaction and on an understanding of knowledge shared between the activity players. For example, the new knowledge generated by studying travel activities can be later applied to the design. The designed artifact (product) is seen as a "mediator of human thoughts and behaviour" (Nardi 1996: 7-16).

Research when the product is on the market demonstrated that research results are usually applied to improve a particular product or be utilised as research data. They can generate new domain-specific knowledge to be applied to design new products. For example, the knowledge generated from the remote control is going to be utilised in its re-designing or transferred to similar products. This supports the evolution of artifacts (products)/systems which is reflected in the design of the next generation of products (eg. aeroplanes, computers). In this case, the design is an agent of
change where the utilisation of new domain-specific knowledge, generated by research, leads to a
new design and discovery and new activities.

This approach imposes challenges for doctoral studies as it opens an opportunity to focus on design
research by situating doctoral studies in the social structure (Figure 1). The approach is compatible
with the practice operations and related to both descriptions of the industrial (product) design
profession as there is a discrete indication there about the importance of knowledge within the
profession as “a social construction that can be defined and redefined” (Popov 2002: 1-16).

Conclusion
This paper explored how doctoral research can be situated within the social structure. It
demonstrated the ways in which new knowledge can be generated, as the outcomes of doctoral
studies. The approach of situating doctoral research around artifacts as mediators of knowledge is
transferable to any doctoral study in design.

This approach has potential to generate the new knowledge needed, and supports its application to
designing innovative artifacts in practice. In this case, the research becomes an integral part of
practice not a distraction from it, and it contributes to its development. It supports collaborative
culture building between research and practice.

Acknowledgements
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University of Technology, School of Design and Built Environment, Brisbane, Australia.
Example 1: A new transit system and conceptual models with associated findings to improve urban
transport, author: Roland Porst (completed 2003).
Example 2: Intuitive use of products, Alethea Blackler, PhD Candidate

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