

## **APPLIED RESEARCH AND INNOVATION FRAMEWORK**

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### **Abstract**

This paper explores industrial (product) design domain and the artifact's contribution to knowledge generation. It discusses the artifact's research situated within the social structure that constitutes *people, activity, context and culture* where an artifact is positioned to be a "mediator" for the generation of new knowledge and its application. Within this concept the generation and application of knowledge were distinguished through the following four research modes: (i) research before the design work is started, (ii) concurrent research conducted during the early stage of the design process, (iii) concurrent research carried out during the design and development stage and (iv) research when an artifact is manufactured and is on the market. The paper demonstrates how new knowledge can be generated by research around the artifacts as "mediators of knowledge", how this new knowledge is represented by them and how it can be applied. It also clearly distinguishes the strategic role of research and design within the different research modes and supports integration between research and application.

*Keywords: research and design, innovation, product design, knowledge, practice*

### **1.0 Introduction**

The understanding of human interaction with an artifact is an essential part of design and the Industrial (product) design's main contribution is to act as an integrator for the range of activities associated with people's interaction with products and services. In this context the artifacts are playing an important role. They are contributing to knowledge or new knowledge building that is generated by research. The artifacts are not to be seen in isolation they exist within their own context. Several theoretical constructs have been explored in developing this concept. They are grounded in Human-computer Interaction (HCI), social sciences, cultural studies and design domains (Popovic 2005).

### **2.0 Applied Research and Human-centred Innovation Framework**

This paper is exploring an applied research and innovation framework that aims to situate design research within the social context (Popovic 2003, 2005) by describing its potentials to generate new knowledge and support innovation. The research is situated within the social structure that constitutes *people, activity, context and culture* where an artifact is positioned to be a mediator for the generation of new knowledge and its application (Figure 1).

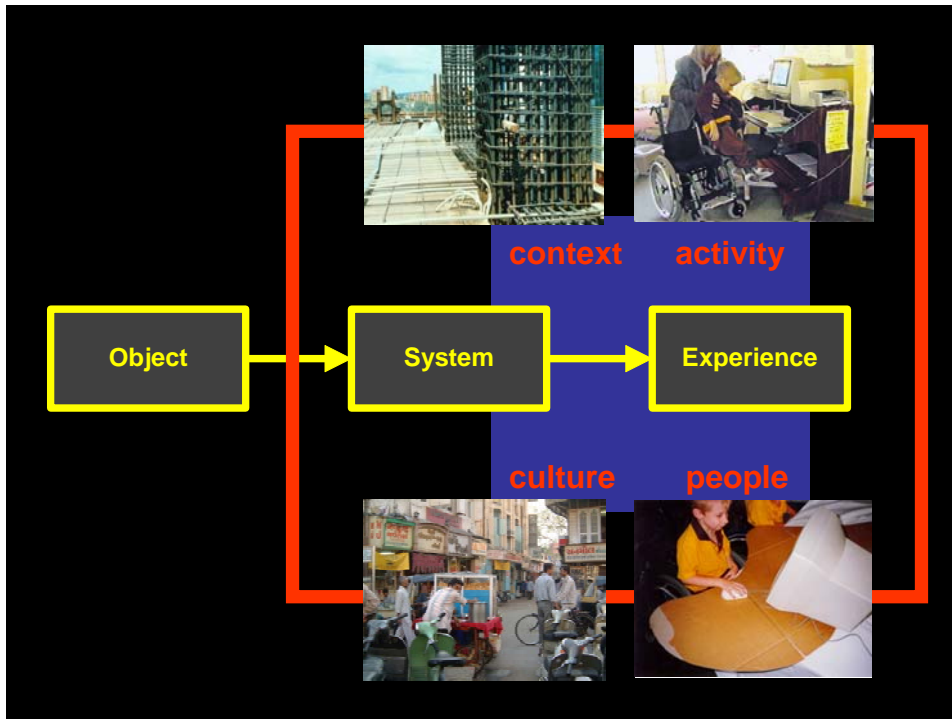


FIGURE 1 Applied Research and Human-centred Innovation Framework

Figure 1 illustrates the artifact design paradigm shift that moves from designing an object to designing for an experience. The design knowledge sources identified are *people*, processes, products (Cross 1999) and experiences within the *activities, culture and context* (Popovic 2000). Within this concept each interaction between people can be seen as unique; one of the ways to explore these relationships is by researching and generating new knowledge and theories from them by focusing on their innovative aspects. It is also understood, that the knowledge derived from the study of people's interaction, within a context and culture, is the main knowledge that contributes to innovation and brings relevant cultural characteristics to be applied to an artifact design (Popovic 2000, 2005). Therefore, within this context applied research refers to the research undertaken within the given framework in order to acquire new knowledge that is directed toward innovative applications.

The theoretical construct of artifacts as mediators of the activity (Kuutti 1991) has been transferred to the artifact concept of being mediators of knowledge generation and utilisation. It is a continuation of the work reported at the "Design plus Research" conference (Popovic 2000) where the generation and application of knowledge were distinguished through the following four modes:

1. research before the design work is started
2. concurrent research conducted during the early stage of the design process
3. concurrent research carried out during the design and development stage
4. research when an artifact is on the market

### 3.0 Research Modes and Human-centred Innovation Framework

The research process presented here consists of four modes which might occur in any order. Within these modes each research example is situated within the social framework (Figure 1) consisting of *people, activity, context and culture*.

#### 3.1 Research before the design work is started

This research mode is based on utilisation of relevant qualitative or quantitative research methods in order to acquire knowledge to be applied to an artifact design. For example: the knowledge might be generated from a context, activity, life style and human interaction. The new knowledge generated can be applied to a scenario in order to predict users' experiences with artifacts and systems. This might convey human's concepts about an activity or artifacts as well as their intentions. This is demonstrated by the research example presented in table 1.

Table 1 Research Example - Research into Context of Use

This research is concerned about the context of use and users experiences within the product design domain. Its research question's main inquiry: "how can the design of product usability be improved in the early stages of the design process?" has been driving the research. One of its objectives has been to identify the aspects of experience and context of use that affect usability of everyday artifacts. It also aims to identify the differences between a user's and a designer's concept of context of use. Research questions and their theoretical foundation grounded the methodological approach of the study. The research plan consisted of three stages: (i) experiment, (ii) analysis and (iii) findings. The participants in the study are artifact users and designers. Artifacts are selected from a diverse context of use. The instruments for data collection are observations, visual representation of concepts, retrospective verbal reports and thematic interviews. Interpretations of data and a coding scheme have been developed within three main groups: (i) experience, (ii) concept and (iii) context of use. Some coding sub-categories are: features with indication of context of use, individual experience within context, episodic data, principled-based concept, descriptive-based concept, intended use and situation. The initial findings provided the knowledge about the user and designer differences related to their concept of context of use. The key difference was that user concepts were based on their experience while the designer concepts were interpretative and descriptive. The expected outcome of this work in progress is to utilise this new knowledge in the development of the model(s) of context of use.

The newly obtained knowledge resulting from the research into context of use (Table 1) will potentially have various applications including the better understanding of user experiences in various contexts that are "mediated by artifacts" or "product scenario" based on context of use. This will assist designers in interpreting the context of use of artifacts they design in the early stage of the design process (research mode two). They will be able to predict user experiences of various concepts of use and build scenarios around them. Ultimately, it has the potential to strategically drive the direction of an artifact/system design that could lead to an innovative outcome. It also has the potentials to generate new market niches by identified new products that are emerging from the research of human's activities.

### *3.2 Concurrent research conducted during the early stage of the design process*

The early stage of the design process is seen as the most significant phase where artifacts are conceptualised by design teams. This stage is crucial to the generation of an innovative design. This is understood to be the most creative phase that encompasses visual searches and analytical tasks. The major component of this early stage of the design process is devoted to the translation and analysis of research findings and the implementation of design constraints (Popovic 1996). This is the stage where user's concepts derived from a scenario should be tested. The testing can be conducted by applying relevant qualitative research methods (eg. interviews, focus groups or protocol analysis). At this stage several design concepts usually emerge. Their representation is done in sketches and annotations with critical reflection and/or evaluation occurring during the design process (Table 2). This enables a designer (design team) to identify, recall and apply the relevant knowledge required (Cross 1999).

### *3.3 Concurrent research carried out during the design and development process*

In this stage additional research may be conducted in the appropriate area that includes (a) detailed concept design, development and user testing, (b) final design development and user testing, (c) user testing and prototype useability, (d) product perception and cultural values. The number of different experts that are contributing to the design and development of a product/system share their relevant knowledge within the design and development team. Nevertheless, this knowledge is integrated by designers and represented in an artifact visual form. (Table 2)

#### Table 2 Research Example: Pipe Measuring System

This following research example illustrates the second and third research mode. The example is from the petroleum industry and focuses on pipe measuring in particular. The artifact was situated within the social framework constituting context: petroleum rigs; activity: pipe measuring; people: petroleum rig personnel; culture: western (sub-culture related to the specific petroleum drilling environment and its personnel). Prior to the design stage the needs for a pipe measuring device and its context of use were identified. The early stage of the design process focused on its form and usability. Different trials were conducted to assess its suitability related to the activity that personnel were required to perform and the resulting knowledge from the context and activity was applied to the design. Concurrently, the laser optic was developed and tested. During the development stage, technology was integrated and device interface developed. User trials of the device were conducted. Knowledge and information search were evident during developing the artifact. Pipe measuring personnel were active participants during the design and development process.

It has been evident that research modes two and three focus on interpretation, translation and implementation of design constraints. The research occurred concurrently during the design process, when appropriate (eg. usability trials or laser technology testing). The relevant knowledge generated (research modes: one, two and three) was applied to the design. This was demonstrated by the artifact's visual form which may convey its values and respond to the context and activity for which it was designed. Integration of knowledge occurred within these two concurrent research modes. Both modes support design innovation by applying the knowledge generated from the research into relevant designs.

### *3.4 Research when the artifact is constructed and is on the market*

In this mode different aspects of artifact/system are researched. They may include: artifact usability, product cultural response related to its visual attributes, intuitive use of products or compatibility between a user and the design concept. The research findings are usually applied to improve the particular product or be utilised to explore new strategic opportunities. The research findings can generate new knowledge to be applied to the design of the next generation of products (eg. aeroplanes, computers).

#### Table 3 Research Example: Driving Experience

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This research project is concentrating on driving and experiences that affect the activity. It investigates drivers' experiences with a vehicle in a real situation. The artifact's social framework consists of - context: urban; activity: driving; people: university staff; culture: western. The research is based on the triangulation approach including interviews, observations and think-aloud protocol. Participants were asked to perform specific tasks while driving and were interviewed before and after driving. During the drive they were video and audio taped. The theoretical framework was based on activity theory and studies of emotions in which an experience is defined within an activity through time and within context. The experience in this case is exploring the relationships between humans, product and overall activity within a context. The aim was to identify aspects that may have affected the driving experience. The findings demonstrate that context plays a significant role in determining the overall driving experience. In particular circumstances, overcoming challenging interactions with the driving interface lead to positive experiences.

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Table 3 research example provided knowledge how different aspects of driving experience affect the emotional conditions of the driver. It identified that context plays a significant role in determining the overall experience of the driver. The knowledge generated has potential applications to an interior of a vehicle (eg. context aware interfaces or interfaces utilising smart materials). It can help to support positive interaction in a variety of contexts and increase the safety of the driving activity. In this case the utilisation of new knowledge leads to a new design and discovery (eg. next generation of vehicle interface designs). It supports the strategic role that research plays in creating new potentials for market niches creations and commercial opportunities.

#### **4.0 Human-centred Innovation Strategic Significance**

The applied design research contribution to innovation and new product design and development is outlined in this paper by pointing out the research significance of each research phase and how the new knowledge might be generated and utilised. This is further summarised in Table 4.

Table 4 Applied Research Contributions to Innovation

Research Modes	Research Contribution	Research Significance
<b>Before design commences</b>	<ul style="list-style-type: none"> <li>• new knowledge building;</li> <li>• identification of new artifacts</li> </ul>	<ul style="list-style-type: none"> <li>• <i>strategic</i></li> <li>• generates innovation</li> <li>• market advantage</li> </ul>
<b>Concurrent research - early design stage</b>	<ul style="list-style-type: none"> <li>• knowledge building and application</li> </ul>	<ul style="list-style-type: none"> <li>• generates innovation</li> <li>• market advantage</li> </ul>
<b>Concurrent research - design and development stage</b>	<ul style="list-style-type: none"> <li>• knowledge building and application</li> </ul>	<ul style="list-style-type: none"> <li>• generates innovation</li> <li>• market advantage</li> </ul>
<b>Finished artifact</b>	<ul style="list-style-type: none"> <li>• new knowledge building for new or next generation of artifacts</li> </ul>	<ul style="list-style-type: none"> <li>• <i>strategic</i></li> <li>• generates innovation</li> <li>• market advantage</li> </ul>

It is well known that the interaction between people and artifacts has existed for centuries. Its complexity has increased in parallel with the development of human civilization. Nevertheless, the impact of cultural factors did not receive appropriate attention in respect to innovation as the real innovation 'always represents a new social value unknown before' (Szántó 2001). Nowadays, societies are trying to demonstrate differences at all levels. This is becoming an indicator for the identity of companies or a country. However, innovation should not be produced for the sake of change but for the sake of achieving an excellence that would contribute to the social and technological development of the society.

Within the globalisation that is taking place innovation has an impact on market competitiveness as well. It has reached the level of industrial scale application all over the world (Quinn, Baruch and Zien 1997). Within the proposed framework (Figure 1) innovation is seen as an introduction of change by implementing 'new benefits' that can be accepted by people. It occurs within a human-centred innovation framework and it is generated by people. Therefore, it is recommended to look for knowledge sources within the innovation framework (Figure 1). In this instance, research should be directed toward new or significant contributions to knowledge, where the knowledge sources are generated from people, context, activity and culture. This is demonstrated by research examples (Tables 1, 2 and 3). The proposed concept is supported by the studies that relate to how artifacts mediate between the users and object and one of these studies states that 'tools [artifacts] mediation is a way of transmitting cultural knowledge' (Kaptelinin 1996). 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'. Nardi (1996) states that 'all human experience is shaped by the tools [artifacts] and sign systems we use'. Tools [artifacts] shape the users' activity and can even influence their goals. Suchman (1987) pointed out that an activity would grow out from the situation while Kuutti (1991) introduces the main idea that artifacts mediate the activity. The latter theoretical construct has been transferred to the notion of artifacts (products) as mediators of knowledge generation and utilisation (Figure 1). Therefore, within this context the innovation characteristics are:

- New knowledge building: This knowledge is generated through research and later applied to an artifact or system design. Requires strategic positioning and planning.
- People oriented: It should be generated from people, their activities, culture and context.
- Rewarding: provides market advantages and creation of new market niches.

## 5.0 Conclusion

This paper explores how research can be situated within the social structure. It showcases the ways in which new knowledge can be generated to their outcome. The examples demonstrate the focus of each research mode. Two research stages (i) *research before the design work is started* and (iv) *research when an artifact is on the market* are identified as strategic for creating new market niches. This is based on the premise that innovation occurs within the activity and it is generated by people. In this context innovation is seen as an introduction of new changes that are beneficial for people and are accepted by them. Therefore, knowledge generated from **activity, culture, context and people** can identify the new strategic direction for design of artifacts, systems and services. This concept also supports the diversification of innovation within international market as it derives from people and their culture. The potentials of this framework are to support new designed products and services to be innovative and human-centred. Therefore, design is seen as contributing factor for knowledge integration while the knowledge is seen to be the resource to support and promote innovation.

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2. James Stuart, Design and Development of Pipe Measuring Device for Petroleum Industry (Masters by Research)
3. Rafael Gomes, Driving Experiences (Masters by Research)