Innovation and design approaches within prospective ergonomics

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Abstract. In this conceptual article the topic of "Prospective Ergonomics" will be discussed within the context of innovation, design thinking and design processes & methods. Design thinking is essentially a human-centred innovation process that emphasises observation, collaboration, interpretation, visualisation of ideas, rapid concept prototyping and concurrent business analysis, which ultimately influences innovation and business strategy. The objective of this project is to develop a roadmap for innovation, involving consumers, designers and business people in an integrative process, which can be applied to product, service and business design. A theoretical structure comprising of Innovation perspectives (1), Worldviews supported by rationalist-historicist and empirical-idealistic dimensions (2) and Models of "design" reasoning (3) precedes the development and classification of existing methods as well as the introduction of new ones.

Keywords: Prospective Ergonomics, Innovation, Human Centred Research and Design, Worldviews, Processes and Methods.

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1. Introduction

As the global environment is becoming more and more dynamic, organizations and businesses are compelled to permanently seek the most efficient models to maximize their innovation management efforts through new methods and paradigms, which efficiently serve existing and new markets with new and/or modified products as well as services [1]. Within the realm of radical innovation, global trends need to be considered in the planning of future products, services and contexts [2]. Hereby, innovation push and pull models are helpful to characterise drivers for innovation. Traditionally, push-innovation referred to knowledge- or technology driven innovation. Although technology push has been considered as a first and important generation of innovation strategy [3], design driven innovation, originating from an internal knowledge-building within companies and among stakeholders and interpreters, has recently been suggested as most relevant in discovering hidden needs [4, 5].

In Market-pull innovation, consumers and users play a central role in the search for new inspiration or knowledge that could trigger innovation. Von Hippel described lead-user innovation [6], a method to qualitatively testing products with advanced or professional users, which has become significantly popular in industry's search for innovation ideas [7]. Market-driven innovation as a source for innovation or inspiration relies very much on the understanding of specific consumer needs, defined market segments, or other information that characterise the existing market.

2. Market-Pull and Technology-Push Innovation

The existence of Market-Pull and Technology-Push innovations has implications for ergonomics in terms of focal areas and integration with other fields of study. For example as predicted by Hendricks [8], "Organisational Design and Management" has gained more prominence as micro-ergonomics failed to reach relevant systems effectiveness goals because of inattention to the macro-ergonomic aspects of the system.

However, with respect to macro-ergonomics, not much has been written with respect to Innovation, Product Planning and Goal Finding, Product Service Systems, etc. The focus of macro-ergonomics is mainly on the interfacing of the organizational design with the technology employed, or to be employed in the system to optimize human-system functioning.

Though with respect to complex human-machine systems as well as socio-technical system concepts, Emery and Trist view organizations as open systems [9], engaged in transforming inputs into desired outputs, and whose permeable boundaries are exposed to the environments in which they exist and upon which they are dependent for their survival. This perspective towards the functioning of organizations provides a linkage for macro-ergonomic thinking in relation to radical innovation, value creation and their processes, where various communities and stakeholders are involved.

In line with macro-ergonomic and product planning processes practices, Robert and Brangier proposed a framework to structure ergonomic activities around corrective, preventive (design) and prospective ergonomics [10, 11, 12], where the latter looks forward in time to defining human needs and activities to create human-centred artefacts that are useful and provide a positive user experience.

Within the context of strategic, service and product design, the commercial element which encompasses designing and marketing, is usually concerned with providing a bridge from technical functionalities to value in a finished product or service [13]. Hereby, Candi (2006) has developed a three-dimensional taxonomy of design consisting of the visceral, the functional and the experiential dimensions [14]:

- Visceral design is concerned with appealing to the human senses [15], and provides a measure of tangibility to services.
- Functional design encompasses usability and performance.
- Experiential design is concerned with message, culture, meaning, and emotional and sociological aspects of a service. In their research on experience design, Pullman and Gross found that one of the key elements for success is creating opportunities for customers to interact with each other, to gain entry into a community [16].

Beyond design, the predictive nature of prospective ergonomics with respect to the development of new products and services justifies the exploration of the following innovation approaches: User-Centred Driven, Design Driven, Market / Consumer Research Driven and Technology Driven.

3. Innovation Perspectives and the Development of New Products and Services

A matrix, comprising of Rationalist-Historicist and Empirical-Idealistic dimensions, is used to position the earlier mentioned innovation approaches, as well as to demonstrate their relationships. Knowledge, which to certain degree can be applied independently of a specific setting, is referred to be rational. Technological developments and market structures are influential in how the product, system or service is being divided into

interconnecting entities. A historicist view on innovation represents a more constructivist conception of the process as a whole, where an iterative cycle of concept development and testing of solutions are characteristic. To illustrate the above, Ansoff's perspective on innovation strategy can be seen as an essential tool for directing market and technological research [17], whereas Mintzberg's strategy model suits a context-based user-or design-driven innovation process better [18].
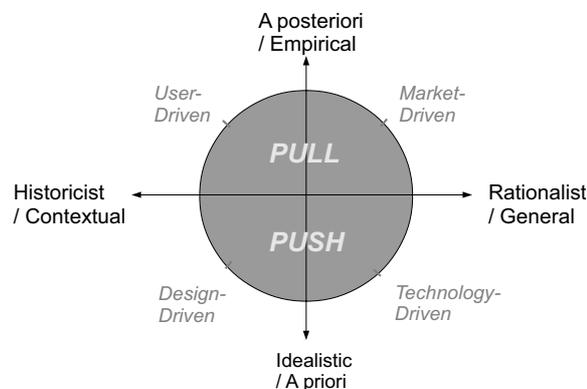

Fig. 1: Classification of innovation perspectives according to Rationalist-Historicist and Empirical-Idealistic dimensions

In terms of research and information gathering, a priori (idealistic) and a posteriori (empirical) data are gathered and synthesized, as well as which actors are involved. These opposites are considered as equivalent to the push and pull models of innovation. The description is polarized in order to contrast the different models of innovation, where the real world would reflect a continuous transition between the extremities described in this paper.

In user-centred innovation, product development activities start from a deep analysis of user needs. In practice, researchers spend time in the field observing customers and their environment to acquire an in-depth understanding of customer's lifestyles and cultures as a basis for better understanding their needs and problems [19]. Latest developments in user involved innovation have challenged user-centred design methods from a participatory design and generative design research perspective through the introduction of co-creation methods [20]. Design-driven innovation, which mimics Technology Driven Innovation, has largely remained unexplored and unlike user-centred

processes, is hardly based on formal roles and methods, such as ethnographic research. Design-driven innovation may be considered as a manifestation of a *"reconstructionist"* [21]. or *"social-constructionist"* [22] view of the market, where the market is not "given" a priori, but is the result of an interaction between consumers and firms. Hereby, actors and stakeholders need to understand the radically new language and message, to find new connections to their socio-cultural context, and to explore new symbolic values and patterns of interaction with the product. In other words, radical innovations of meaning solicit profound changes in socio-cultural regimes in the same way as radical technological innovations, which solicit profound changes in technological regimes [23].

In terms of "Marketing/ Consumer Research Driven Innovation", qualitative and quantitative approaches, supported by statistical methods play an important role in analysing consumer and emerging globalisation trends [2].

4. Worldviews and Models of "Design Reasoning"

With respect to various perspectives on innovation, epistemological worldviews are to be introduced as a foundation for the discussion of various models of "Design" reasoning. In this context, the term "Design" should be interpreted form a broader viewpoint, incorporating *Industrial Design*, *Engineering design* and *Ergonomic Design*. The worldviews to be used and discussed, which are in line with the earlier mentioned Rationalist-Historicist and Empirical-Idealistic dimensions for classifying innovation perspectives, are*: Positivism, Post Positivism, Critical Theory and Constructivism*.

The models of "Design" reasoning are:

- *Problem-solving.* Often is credited to Simon [24], this model represents a systematic and deterministic approach to the design process inspired by engineering, the natural sciences, and the rise of the computer sciences in the mid-1900s. Through a mechanistic world-view, the design process is partitioned into smaller sub-processes or sub-problems, which then can be solved through problem-solving methods [25]. For well-defined problems, this is still the most widely used model for dealing with the design process [26].

- *Hermeneutic.* At the outset of the design process, the potential opportunities and the choices that designers face are practically infinite. The designer must reduce this variety by establishing a directed understanding that reduce the variety and provide some guidance.

- *Reflective Practice.* The constructionist reflection-in-action theory, proposed by Schön [27], is perceived as a reaction to the rational problem-solving philosophy. As design problems are unique and difficult to generalise, it focuses on the designers' or developers' actions and efforts, with respect to reflective and conjectural conversations with the situation to reinterpret and improve the problem as a whole. Methods applied by the designer are to

be based on acquired knowledge, experience and reasoning.

- *Participatory.* Designers act as facilitators to mend the gap between their own perception and understanding of "Design" problems and those of stakeholders. In this cooperative or participatory design activity of interpretation, information gathering and facilitation, users make critical decisions in the design process. This turned out to be an acceptable way of dealing with these "wicked" problems [28]. Sanders and Stappers provided an historical overview of participatory design and co-design, as they underlined a transition from a user-centred approach, towards a user that actively participate in the design process [20].

- *Social.* As design activities are enabled by the social community in which they are situated, a growing conscience of the designers' role in the society marked the beginning of a social model of the design process [29, 30]. Hereby, professional reasoning is not a personal competency but based on the collective wisdom of a community of practitioners, where the scope was more than to promote social and economical sustainability. Buccarelli underlined the impact of design engineers' decisions in peoples everyday life [31], as well as described the nature of the process as a sense of 'social construction', denying the validity of simple linear models of the design process.

- *Normative.* In this prescriptive model, "Design" solutions are fitted to certain standards, values and conventions in accordance to their role and responsibility. The normative framework can be understood as guidelines that should be followed in order to satisfy certain criteria, for example ideals of user/product experience [32], manufacturability or sustainability [33]. This way of thinking is often referred to as Design for X [34]., where the X denotes a certain aspect of the design.
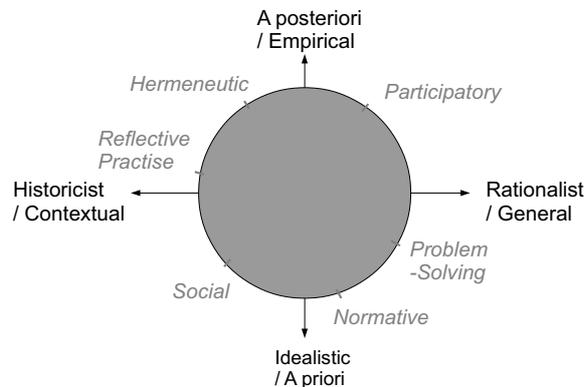
Fig. 2: Mapping of models of design reasoning in relation to Rationalist-Historicist and Empirical-Idealistic dimensions

With respect to figure 2, models of design reasoning will be discussed in relation to Rationalist-Historicist and Empirical-Idealistic dimensions. The following assumptions are made in terms of positioning. In the future, these assumptions need to be verified and elaborated through in depth literature studies, interviews with practicing designers and engineers, as well as through experiments in educational settings. Potentially, theses figures (1&2) provide a framework for prospective ergonomics.

The Problem Solving model, where generic methods are proposed to tackle different types of well-defined problems, is positivist in nature. It is being positioned as a rationalist approach with some "a priori" influence, because of its structured relationship between the problem and the solution as well as its rational decomposition of the design process into smaller sub-problems.

The normative model focuses less on the decomposition into sub-problems, but more on the determined or desired idealistic principles, it is classified as a less generic approach, using more implicit, a priori knowledge. The normative view evaluates whether a solution is good or bad, using a comparison of ideal references.

According to the social design perspective, the social constellation executing the process also defines it. This highly contextual approach of the social design model emphasises in an idealistic manner the responsibility of the designer as a member of the society. Hence, the decisions defining this type of process are taken on an idealistic and contextual basis.

Despite its focus on reflections and experience of the designer, the reflective practice-model is highly dependent on the scope and context of the design project. As constructivist-thinking processes are considered unique, comprising of both "A Priori" and "a posteriori" inputs, the mind of the designer is the principal factor determining the design. Therefore, this model is classified as strictly historicist with regard to the design epistemology.

Reference to a Post-Positivism, Hermeneutics emphasise the importance of how knowledge is interpreted in society or in its area of influence, and must therefore be classified as empirical and historicist. The hermeneutic perspective on design focuses on how the election of methods in the process impacts the end result.

The participatory model can be seen as a response to designers´ lack of ability to manage and solve wicked problems [35]. Solutions to wicked problems derived from a rational decomposition of the design process were obtained through user involvement in the design process. The Information gathered from users is considered external and therefore classified as empirical. The identification of problems, and determination which decisions need to be taken, is considered a rational approach.
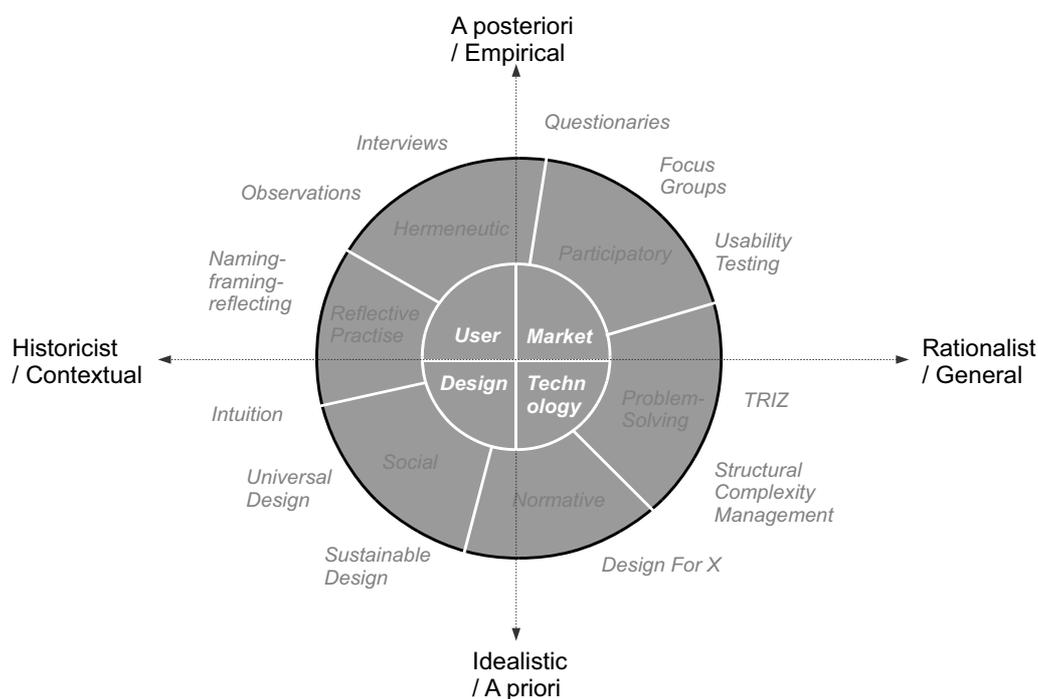
Fig. 3. Epistemological relations between innovation triggers, design models and methods.

5. Relevance and Contribution to the Society and Design Profession

As "Design" is relatively a new field of study and practice, the public sector, industry, civil society and other stakeholders have to be educated about its meaning and value. With respect to (radical) innovation, a key attribute that distinguishes breakthrough products from their closest followers is the significant value they provide for users [36]. Taking it one step further, the more value is created, the higher price people are willing to pay, with the price increasing more rapidly than the costs, resulting in a profit margin, significantly higher for higher valued products. After all, as Drucker has pointed out, *"customers pay only for what is of use to them and gives them value"*. Respective to design and creation [37], Boztepe has categorised user value according to utility, social significance, emotional and spiritual value [38]. Utility value refers to the utilitarian consequences of a product. Social significance value refers to the socially oriented benefits attained through ownership of and experience with a product. Emotional value refers to the affective benefits of a product for people who

interact with it. Similarly, Sanders and Simons identified 3 types of values related to co-creation, which are inextricably linked. These values are monetary, use /experience and societal [39].

Reference to societal value creation, a design driven approach has been suggested by Verganti as most relevant [4], because communities of stakeholders are actively engaged in interactions and interpretation of meanings in relation to the broader context of innovation targeted. However, from a methodology perspective, a design driven approach should not fully rely on "Open Innovation" attitudes. Complementary to working with interpreters and actors in a broader network, prescriptive human / user-centred, engineering and marketing methods should be introduced in the design driven innovation activities involving these interpreters and actors.

From a professional practice perspective, much has been debated on collaboration among engineering and design consultancies, companies and government funded public sector organisations, such as institutes of higher learning. Especially with respect to Industrial and Ergonomic Design, which is a new field of study and practice, many conflicting values and thoughts are present among the different stakeholders, such as consumer organisations, companies, end users, governing

bodies, etc. concerning collaboration, "fair" competition and growth of the "Design" Profession.

The development of a roadmap, as suggested in our point of view, will provide more clarity in the roles, responsibilities, scopes and limitations of the actors in the field of innovation and design.

6. Discussion and Further Research

For developing prospective ergonomics as innovation attitudes, methods and processes are fluid, dynamic and applicable to specific contexts, a roadmap comprising of innovation perspectives, models of design reasoning, and methods is essential to guide companies, consultancies and educational institutions in their innovation approaches and activities.

As shown in figure 3, the range of worldviews and design thinking approaches can be mapped out according to epistemological relations and innovation perspectives. However, the authors' conceptual trains of thought, which have been made explicit in this article, need to be complemented with empirical and case studies. It is expected that the playing field of methods and processes for professional practitiones are to be determined by the relation between research and practice as well as their possibilities and short-comings.

In reality, this addresses the tension field where professional knowledge is being considered as an application of scientific research versus research as a reflection over common frames and techniques emerging from practice.

In the first instance, methods and processes supporting laboratory and protocol studies of design; simulated instances of design or design aspects in an environment where variables and context can be controlled and measured, are to be promoted.

In the second instance, either practitioners' critical self-reflections over common frames and methods, or analysis of general professional discourse is considered the basis for reflective practice.

Finally, in all instances, is probably prospective to be promoted [12]...

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