User kansei modelling and eco-design

Bouchard C.
LCPI Laboratory, Arts et Métiers Paristech, Paris, France

Brissaud D.
G-SCOP Laboratory, Grenoble Institute of Technology, Grenoble, France

Aoussat A.
LCPI Laboratory, Arts et Métiers Paristech, Paris, France

Abstract
The use of day-to-day life artifacts is a key phase in the lifecycle of products. Indeed it has a great impact on our environment. User centered methods are not yet taken into account in eco-design approaches. These methods are being developed in two ways, by building new user models encompassing complex dimensions such as Kansei and experience, including values and moods, and by integrating the user himself in the design process. This paper deals with setting-up a new theoretical framework associating user-centered design advanced approaches such as experience design, Kansei studies, or participative design and eco-design methods. The final goal is to support product design by providing some guidelines according to environmental issues linked to the users and their abilities.

Keywords*: User modeling, Eco-design, Use, Kansei, Experience design.*

1 Introduction

In our day-to-day life the use of artefacts is a key phase insofar as it has a great impact on our environment.

Different methods have been generated and practiced in the field of product development in technological areas since several years ago. They have a common goal: to be planned following a repeatable and traceable pattern with the aim of obtaining products better adapted to the users. Many of these methods of product development have generated tools of great potential utility for supporting designers in planning their activities, gathering the users' desires, needs, and activity, looking for information, posing problems or looking for solutions. However, the application of these techniques in the area of industrial design has been centred in the development of products with high technological component and within the framework of big companies. But most of the time the overlapping between user-centred design and eco-design was not well established neither formalised. Even if the phase of use constitutes a key phase in our day to day life, especially because it has a great impact on our environment, this phase is not really taken into account in the traditional eco-design models.

Obviously, at a wider scale, user-centred design should also be turned towards environmental concerns. This adaptation involves an early common work between designers, researchers and users. The development of user-centred products is a complex process that combines knowledge from different fields of engineering, sociology, psychology, engineering, marketing, manufacturing, etc.

This papers aims at proposing a first theoretical framework in order to match user centred design models with those proposed in the field of eco-design. To this end, section 2 will define the main concepts. Section 3 describes a theoretical model that we will experimented in further projects. Section 4 is a discussion about the potential perspective of application of this model.

2 About user-centred design, Kansei design and eco-design, theoretical background

During the last ten years, the notion of user centred design was worldwide developed. Design methods integrate the user at various levels, sometimes as a constraint, but more and more as a stimulator for creativity. The user becomes a co-designer by contributing to decision process according to its appreciation and satisfaction. The context of use and use itself are taken into account. As well as the context, the characteristics of the user in terms of skills and culture are considered.

User-centred design will be apprehended here under the concepts of *experience design* [1], *Kansei design* [2] and *eco-design* [3]. These approaches will be integrated in a single model that will be experimented in the framework of design and development of applications linked to energy, product design and development. This model will mix the various users models and put emphasis on users behavioural characteristics in the environmental performance of products.

2.1 *Experience design*

Products provide a symbolic side behind their materiality. Actually, a product associates material pieces with a complex set of messages and values captured by the user. The combination of both aspects is what determines the user satisfaction as regards the product. The value of a product only exists depending on the user and the particular environment in which both elements interact especially during the phase of use. The product must have a group of properties for possessing the two types of values. Several methods structured around user modelling and participatory design were progressively integrated and applied, that are called today experience design. Experience corresponds to the perceptual and cognitive interaction which occurs along the time between an artefact and the user.

Participatory design [4] was widely spread out thanks to the communities of human factors, cognitive psychology, ergonomics and computing software engineering. Participatory design includes a set of methods which was developed initially in the field of interactive software design. The main characteristic of those are an active involvement of the users during the design process. Users can intervene in the creative phase or during evaluation by using many techniques such as surveys, observations and interviews, scenarios production and application, brainstormings, experience through ecological-economical paper, video or virtual prototypes, and ethnographic approaches.

2.2 Kansei design and engineering

More recently, new themes appeared in design science, which put emphasis on semantics and emotions. As such, Kansei methods, initially developed in Japan, and emotional design according to the European name, are of growing interest in many scientific disciplines such as psychology, design science and artificial intelligence. Behind usability, the understanding of positive and negative emotional reactions in front of an interface or an artefact, or when using it, turns out to be very useful.

2.2.1 Kansei design

The term Kansei is a Japanese term which covers the subjective notions of sensations, values, experience, opinions, intuition, affectivity, or emotions regarding a particular content. This content includes both concrete and abstract information. The information produced and treated in early design is carried out through various media such as conversations, text, images, sketches, physical or digital and gathers every components of Kansei [5].

2.2.2 Kansei engineering

Kansei engineering (KE) technologies were born at the University of Hiroshima in the seventies. They were initially developed by Mitsuo Nagamachi [6] before to be introduced in industry. These technologies are used in order to work out which emotional attributes provoke particular emotional reactions by the users. This allows the designing of products using the attributes which elicit the desired reactions. Evaluation results are integrated in the KE process through a pro-active approach. Although many studies have followed a semantic approach in order to perform KE, authors suggest that new behavioural and physiological measurements should be incorporated. Kansei engineering applies three main steps: data gathering, rules elaboration and their implementation. Few studies attempted to link Kansei studies with eco-design, except some in the field of customisable green materials (CGM) which is set using KE [7]. The linkage between material preferences, desired attributes and attribute importance have been conceptualised into a

framework of optimal design [8]. Another study explored neural network (NN) approach for determining the best design combination of product form elements that match a given product value represented by eco- product value (EPV) attributes [9].

It will be explored here how Kansei technologies could implement the traditional eco-design approaches.

2.3 *Matching user centered approaches to eco-design*

Taking into consideration these methods which lead to a user-centred design, we intend to establish a theoretical model that will integrate environemental issues. This model will focus particularly on the phase of use, in dealing with eco-use and its relation to energy management, and by taking into account both behavioural and axiological dimensions during the earliest steps of design. Here experience design and Kansei design will enable to build realistic scenarios of use, by taking intro account the inter-individual variability between the users regarding their cultural and sociological differences, attitudes and expectations. Also the cultural and geographical context will be considered.

Nowadays the relation between product-process parameters is not taken into account by current Kansei methods. However the success of a product or service is depending not only on matching with the client and the market, but also with industrial processes. Eco-design brings specific approaches to design products and services by taking into account their environmental impacts during the complete lifecycle. It must be regarded in an integrated holistic perspective, where the adequacy of products with industrial processes must consider *procurement*, *manufacturing*, *assembling*, *logistics*, *use*, *recycling* and *reuse*, to bring the product on markets [10]. It is necessary to standardize industrial processes by defining some domain ontologies and formalizing the leading functions of the system by external elements such as Kansei and design. By examining which phase of the life cycle has which particular environmental aspect, all these aspects are evaluated and ranked according to their environmental impact for improvement or potential of change. The phase of use, for which the specificity of the geographical context is very significant, is not so often taken into account. In terms of energy, this phase may have an impact on the consumption of resources, emissions to air, water, and ground, environment and human health, waste and final emissions to the environment, and every consumables, materials and parts used in the life cycle phases with all indirect environmental aspects linked to their production.

The connection between user centred design and sustainable behaviours must be considered through the quality procedures, and through sustainable behaviours stimulated on the base of ergonomics and design considerations.

3 Setting up a theoretical model

In order to establish a theoretical model, the main goals were :

- The characterization in design context of the features linked to the user and product, which have an impact on environment.

- At a wider scale the development of a theoretical user model workable in eco-design, and its translation into an eco-design method using a scenario-based approach for environment integration.

This eco-design method has to mix qualitatives and quantitative evaluation phases and be easily deployed in industry. Sociological, Kansei, cognitive and environmental characteristics must be translated as design features. User modelling will be based on the integration of three main concepts: sociological values and use, user and Kansei modelling and quantization.

3.1 *From values to use and environmental impact*

In order to formalize the link between values, behaviours and their impact on use, we intend to experiment the cognitive chaining method.

The method of cognitive chaining of means-ends [11] enables highlighting the way in which the influence of values is brought to bear on consumer behaviour. This method, at crossing point between psychology and sociology, scrutinizes the value-attribute relationship of the product or service during use or other phases through a serie of hierarchical cognitive sequences ranked into ascending abstraction levels. Product attributes, both tangible (specific evaluative and descriptive features of a product such as material, colour, price, etc.) and intangible (semantic terms such as fresh, light, flowery, etc.), bring about functional and psycho-sociological consequences for the consumer helping the latter to attain their

instrumental and end values. Tangible and intangible attributes are interdependent. Consequences are considered to be functional, as derived from use, from main functions, or psycho-sociological, such as social functions produced by the functional consequences and moulds of socio-cultural standards, e.g.: a sophisticated image, high personal status. Values can be instrumental when they lead to behaviour modes, such as courage, honesty or romantic attitudes, or end values, i. e. aims of life to be attained through instrumental values, such as self-fulfilment or hedonism.

Current applications are associated with the positioning and segmentation of products: the consumer associates the attributes determining their choices with more intangible and personal advantages. Young and Feigin [12] point out that this method is of considerable interest and has a predictive aspect concerning product consumption and brand names. The semantic space can be determined by considering the frequency of appearance of individual items in the various types of chains, then by carrying out a multiple factor analysis dealing with the compatibility between individual items and types of chaining. A chaining is all the more coherent that the total number of links of which it is made up is limited. This method is fundamental for the translation of abstract values into tangible product attributes or vice-versa.

This reinterpretation of the cognitive chain method in design and engineering design turns out to be particularly interesting in order to establish a correspondence between consumer's values and behaviours when using products or services. Indeed it allows linking coherently the conceptual space to the products.

3.2 *User modelling*

With human factors and marketing techniques, the user was taken into account in the design process since a long time. Nowadays he is more and more active in the product and services definition. The techniques used in user modelling go from heuristic formal evaluation, brainstormings, expert reviews in sociology or ergonomics, direct tests on physical or virtual prototypes, acceptability surveys, interviews, observations, participatory design, task analysis, focus group, scenarios production and application, experience through ecological-economical paper, ethnographic approaches.

Other techniques from marketing define and use key user generic profiles (based on a limited number of ethnographic features) named *persona* enable to validate the adequacy between the user and the product during the design process [13].

Nowadays eco-design methods tend to consider the user by introducing notions ergonomics notions. Some of them, visible in the field of NTIC, propose retro-action with interactive products to encourage the user to action [14]. Some others studies have explored how product design can influence users [15], by developing the idea of *scripting* to sustainable product design. They defined scripting as *the design of a product-layout guiding the behaviour of the user, in a more or less forceful way, to comply with values and intentions inscribed into the product by the designer.* Scripting will so make unsustainable behaviour difficult or impossible, while sustainable behaviour is made easy or easier, or even automatic.

3.3 *Quantization of attributes representativeness*

Many techniques are available in order to take into account the user's needs : surveys, observations and interviews, scenarios production and application, brainstormings, experience through ecological-economical paper, video or virtual prototypes, ethnographic approaches. These techniques involve informative, generative and evaluative phases. In the evaluation techniques, quantization can be sometimes macro-evaluations based on cognitive measurements, or in some case micro-measures which call on physiological means. Cognitive measurements by the way of questionnaires based on Likert scales will provide a relevant way of data extraction by the users. Indeed it can adapt to any product attributes, even heterogeneous, and provide a quick feedback with large panels of users. Every attributes will be weighted during users experience at key levels of the activity.

Task analysis is a complementary way to be applied in order to quantify the information through both the cognitive processes and the external tracks that can be gathered during the application of specific scenarios. The analysis includes quantization of frequencies, durations, emotional reactions, environmental conditions, inter-individual differences, and performance factors according to environmental issues. Task analysis enables here to observe real things, assess a specific human behaviour in context of use and so improve this behaviour mainly through product design. It also

allows to examine the rules by which humans adapt and maintain these behaviors.

3.4 Theoretical model

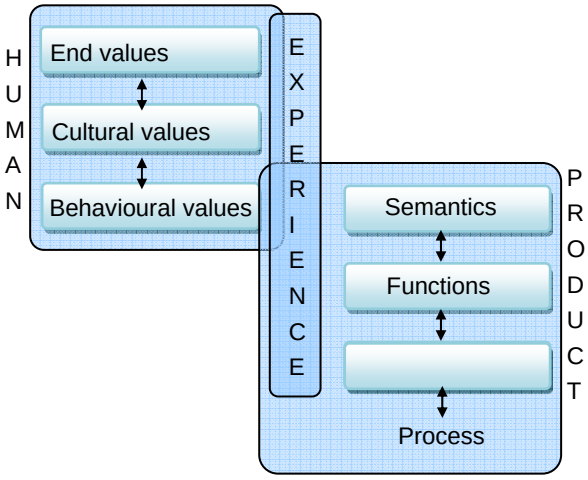

Figure 1: Theoretical model

The theoretical model proposed as both user-centred an eco-design method is focused on the experience of use in a context where users values will fit with product and service features through a number of rules to be applied.

- *End values*: Rokeach [7] has defined a basis of stable values, limited in number. This list will be used in order to quantify the intensity of the aspiration to these values by the targeted users. This quantization can be extracted from bibliographical references or directly by the way of questionnaires to the users.
- *Behavioural values*: end values lead to behavioural modes.
- *Semantics*: products and services can be considered as signs (words, phrases, symbols). These signs are highly linked to the appearance and the symbols used in product design.
- *Functions*: the functions of a product or service are of great importance because they are linked to its utility. The main phase of the lifecycle is often the phase of use.
- *Materials*: the initial matter that will be used to build the product.
- *Process*: manufacturing a material, processus according to which some objects will be transformed into others.

4 Towards a user-centred eco-design method

4.1 *Data gathering*

Data gathering is a main step in user modelling approaches. This action can be led at various levels in order to get some information about human values, about experience and about product features. Data can be extracted both from literature or by gathering directly the information by the designers through methods such as interviews, brainstormings, experience through ecological-economical paper, video or virtual prototypes, ethnographic approaches, or social networks.

4.2 *Scenarii definition*

After gathering data, scenarii will be established in using creative approaches. These scenarii will be moulded to the activity as it was formalised in the previous phase. They will be produced and then applicated in various conditions and contexts. Here the tracks of the users experience will be recorded through automatic media.

4.3 *Data processing*

Tracks recording will enable then to extract some data and apply statistics on them. Results will provide some information to be used for the elaboration of design guidelines.

5 Conclusions

This paper relates a first investigation about how to establish a link between user-centred and eco-design approaches, which remained quite disctinct so far.

User centred design has been taken there as a combination of experience design and Kansei design. Eco-design approaches would gain to integrate the user centred methods. Indeed the phase of use is one of the most critical because it has a huge impact on environment.

According to a literature review, a new user model was proposed, which integrates both point of views, eco-design and user centred design, in order to take benefit from the most recent advances in design methodology.

This theoretical model will be further applied in experimental contexts in order to develop improved design methods, able to satisfy long term users end-values.

Acknowledgments

The authors are grateful to the French National Research Agency for funding this project, and express their gratitude to all partners of the ECO-USE consortium for their collaboration.

References

[1] H. N.J. Schifferstein, P. Hekkert, Product Experience, ISBN: 978-0-08-045089-6 2008 Elsevier Ltd.

[2] C., Bouchard, C., Mougenot, JF. Omhover, A. Aoussat, A Kansei based information retrieval system based on the Conjoint Trends Analysis method, International Association of Societies of Design Research, IASDR 2007, Hon-Kong, Design Research Society, 11-15 November 2007.

[3] F. Mathieux, D. Brissaud, P. Zwolinski, Product ecodesign and materials: current status and future prospects.

[4] K. Noro, A. S. Imada, (1991) Participatory ergonomics. London, Eds. Taylor and Francis.

[5] C., Bouchard, C. Mougenot, F. Mantelet, R. Setchi, Q. Tang, A. Aoussat, Building a domain ontology for designers: towards a kansei based ontology, I*Prom Virtual Conference, July 2007.

[6] M. Nagamachi, Kansei Engineering. 1989, Tokyo: Kaibundo Publishing Co. Ltd.

[7] M. Ushada, M. Haruhiko, 2009. Design of customisable greening material using swarm modelling, *Biosystems Engineering*, 104(2): 169-183.

[8] A. Kaul, V. R. Rao, Research for product positioning and design decisions: An integrative review, Journal of Research in Marketing 12 (1995) 293320.

[9] C.-F. Chen, C.-H. Yeh, Y.-C. Lin, 2010. A neural network approach to eco-product form design, *Proceedings of the 2010 5th IEEE Conference on Industrial Electronics and Applications, ICIEA 2010, Article number 5514832, Pages 1445-1450.*

[10] A. Kaul, P. Zwolinski, D. Brissaud, Remanufacturing strategies to support product design and redesign, Journal of Engineering Design, Vol 19, Issue 4, pp 321 – 335, 2008.

[11] Valette Florence P., 1994, Introduction à l'analyse des chaînages cognitifs, Recherche et Application en marketing, vol9, n°1, pp93-118

[12] Young S., Feigin B., Using the Benefit Chain for Improved Strategy Formulation, Journal of Marketing, Vol. 39, No. 3 (Jul., 1975), pp. 72-74, doi:10.2307/1250907

[13] C. Chapman, E. Love, R. Milham & al., 2008. Quantitative Evaluation of Personas as Information, *Human Factors, September, Pages 1107-1111*.

[14] R. Wever, J. Van Kuijk, C. Boks, (2008). User-centred design for sustainable behaviour, *International Journal of Sustainable Engineering*, pp 9 – 20.

[15] Jelsma, J. & Knot, M. (2002). Designing environmentally efficient services: a *script* approach. The Journal of Sustainable Product Design, Volume 2, Numbers 3-4, 2002 , pp. 119-130(12). Publisher: Springer.