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NEW MODEL OF JOINT CONCEPTION OF AN INNOVATIVE PRODUCT WITH AN ENHANCED INDUSTRIAL DESIGN APPROACH

Philippe Blanchard Ecole Supérieure du Bois philippe.blanchard@ecoledubois.fr

Hervé Christofol Arts & Métiers ParisTech herve.christofol@univ–angers.fr

Simon Richir Arts & Métiers ParisTech simon.richir@ensam.eu

Mark Irle Ecole Supérieure du Bois mark.irle@ecoledubois.fr

ABSTRACT

The purpose of this study was to model an enhanced design methodology applied to the conception of an innovative product in a SME environment. This approach includes C-K theory in a context of disruptive innovation.

In general, the industrial design process consists of four major steps: the ego-design phase where the designer conceptualizes a user need, a techno-design phase where designer and engineer find solutions to materialize the concept, a eco-design phase where social actors involved authorize it and then the ergo-design phase where the user adopt the final product. A methodological reflection leads to the modelling of the innovative enhanced design reasoning (where major actors are replaced by a bunch of various stakeholders).

The specific SME's case was successful. Using the model, the enhanced design project management was efficient. But some more complex application cases would help secure it.

Keywords: industrial design, innovation, methodology, transdisciplinarity, C-K theory

1 INTRODUCTION

This paper is about modelling the process of innovative design in a Small to Medium size Enterprise (SME) context. The main goal is to define and test the model. This model will include the notion of *Enhanced Design* and will use the C-K Theory.

SME are characterized by the limited resources available such as people, finance and technology. In order to succeed in a globalized world where everything is evolving faster, they rely on the innovation process. Garel describes it as an intensive process (more and more products to design), with radical solutions (very disruptive) and which is collaborative (team work and open innovation) [Garel, 2012].

If we look closely at the design process 4 major aspects emerge (Fig. 1).

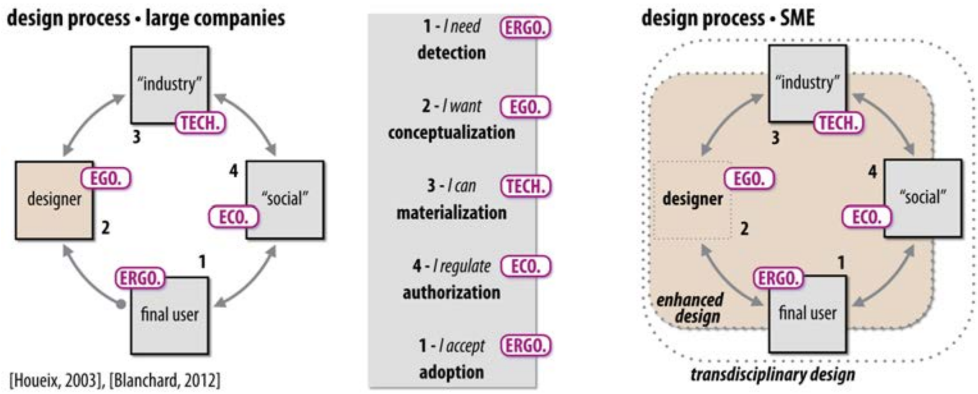

Figure 1 -design interactions with the environment.

If the design process is considered within a large company context, then the starting point is when the final user identifies a specific need that has no existing product to accomplish it (phase 1 in Fig. 1). Consequently, there is a gap between the experience he would like to have and the available artefacts. When he seeks a particular usage, with appropriate ergonomics, then he is preoccupied with an **ergo-design**.

In phase 2, the designer should detect that gap and try to answer it by proposing an appropriate solution. His proposition should be functional and attractive. That solution has to fulfil the ego of the final user. This represents an **ego-design** approach.

Representatives of the industry, who are often the designer's client, would then construct the proposed solutions or products in phase 3. Then, technical and technological criteria become of premium importance. This moment defines the **techno-design** step.

The circle is completed in phase 4 when the object is designed, defined, built and placed in the market. Its economic feasibility is dependent on there being an adequate market and it being socially acceptable. This constitutes the **eco-design** period. Eco should be considered both in terms of "economics" and "ecology".

Returning to phase 1, when the object is available for the final user, the latter could use it, compare it to his initial need and then adopt it or not, thus returning to the **ergo-design** phase.

In a large company context there are identifiable staff for each of the 4 different phases. But in an SME case (see the diagram on the right of Fig. 1), as there are limited resources, specialists for each of the 4 phases are not often present. Then, the designer has to "extend" his working area to those phases that do not have specialist staff.

This brings about the notion of an *enhanced designer*, who has to place himself in the shoes of the main client, the stakeholder and the final user. Thanks to his cross-disciplinary skills, he is able to understand their language and their main values. In order to do that, the enhanced designer should have a "T" shape personality (Fig. 2) [Brown, 2010].

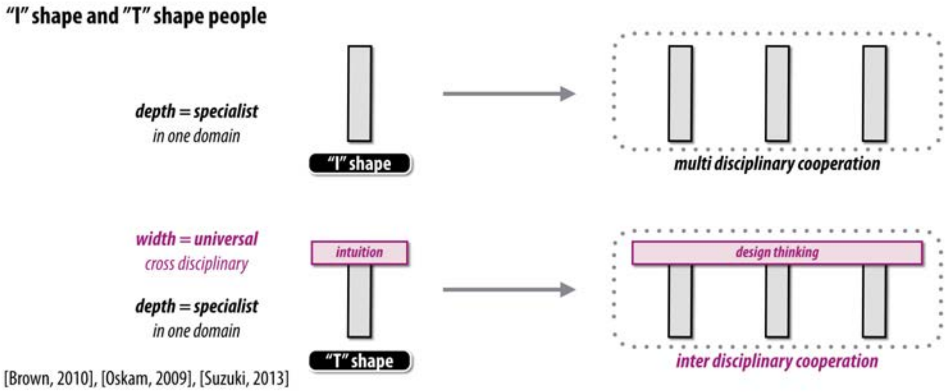

Figure 2 - "I" and "T" shaped people.

He has to act with empathy for all his partners. Thus, he has to gather together and manage a design team (with members from the client's company and members outside of it). He should interact with the artistic, social and technical dimensions of his ecosystem [Findeli, 2005].

In a disruptive innovation process, the proposed product has to be absolutely different from everything known at that time. The *Dominant Design* is archetypal of the generic, mainstream product in that domain. To escape from existing solutions is rather difficult as thought-processes tend to be "fixed" on the *Dominant Design*. In order to imagine something really new, the designer had to completely ignore known artefacts [Agogué, 2013].

2 APPROACH

2.1 BUILDING THE FIRST MODELS

Technical design models. Noticing a gap between the final user's needs and the available products, the *enhanced designer* has to find new ways imaging and defining those desired artefacts. First, he creates an ideal; a sort of mental prototype (Fig. 3).

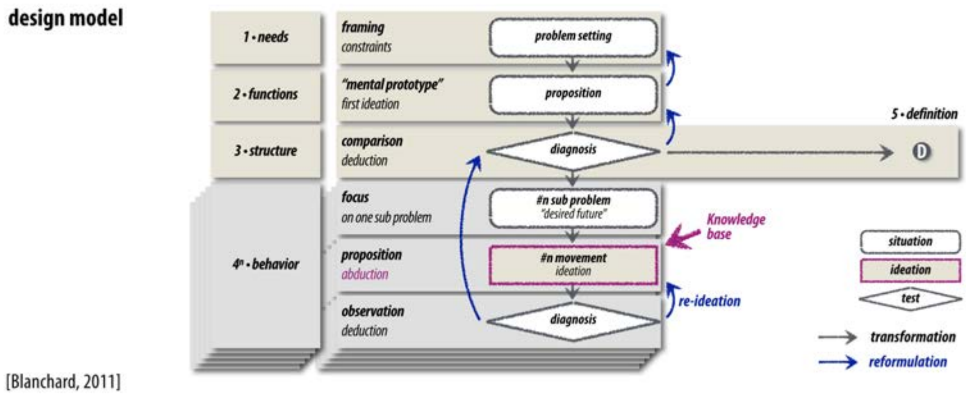

Figure 3 –design model.

He uses his experience, knowledge and skills together with his abductive and analogical capacities, he is able to deduce new solutions. He imagines a kind of cerebral prototype that can be described verbally or through some sketches. Using his analytic skills, he identifies and orders all the dysfunctions of his initial solution. He then examines each dysfunction, one by one, and tries to eliminate the problems. The solutions could have a significant impact on the original cerebral prototype and in turn on the list of dysfunctions [Dorst, 2010]. As Simon explained it, that main process is not linear and can contain main iterations [Simon, 1996]. Also, the designer has to adopt a reflexive attitude so he could do what is necessary and, at the same time, be conscious of his design process [Schön, 1983]. That will enable him to perform his way to do design. When all the dysfunctions in the list are solved, the modified cerebral prototype can be taken to the next step.

'Design thinking' models. As shown on Fig. 4, Beckman and Owen suggest a frame for developing a design thinking process [Owen, 2007], [Beckman, 2007]. The horizontal axis describes the process running from analysis to synthesis. The vertical axis represents the context, mainly beginning by reality, then virtuality and again reality. That graph delimits 4 quadrants which are, globally, showing the design process. Brown and IDEO simplify this representation but with only 3 different phases: immersion, ideation and implementation [Brown, 2009].

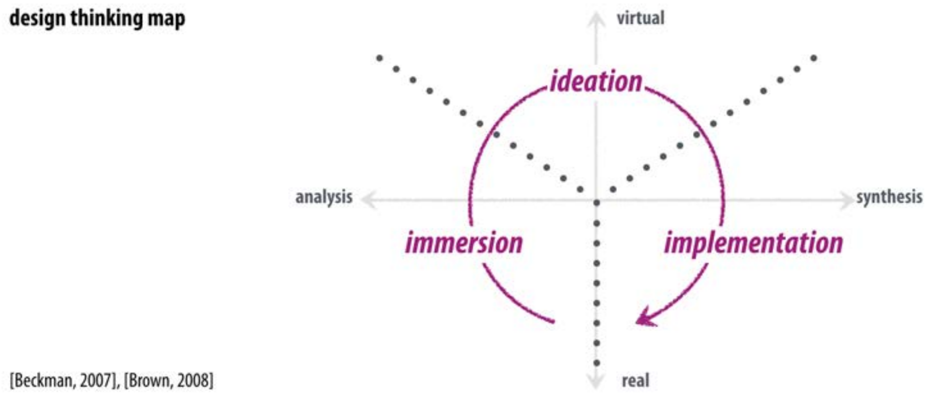

Figure 4 -2 representations of the design thinking attitude.

C-K theory principles. Disruptive innovation processes are very difficult to model [Agogué, 2013]. In order to resolve this, a team at Mines ParisTech developed the C-K theory (Fig. 5).

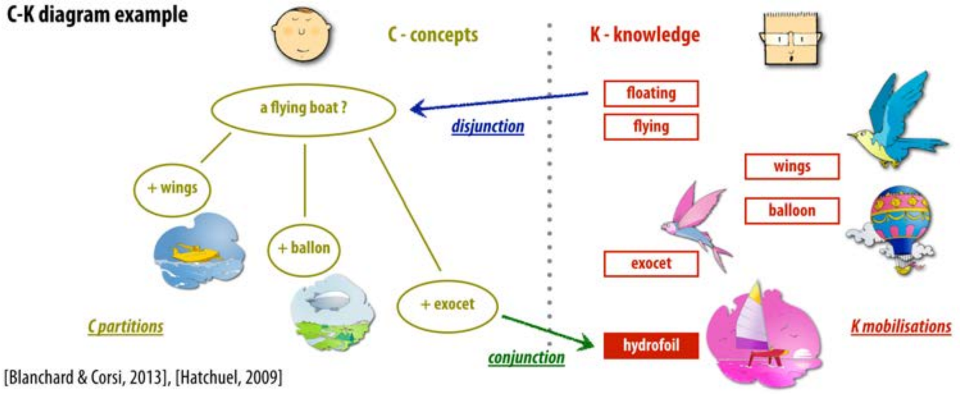

Figure 5 –C-K theory diagram.

The C-K diagram has 2 different spaces. On the right-side, the K space (K for Knowledge) gathers everything that is known and logical, i.e. “true” or “false”. The left space, the C space (C for Concept) represents the place for everything that is “undecidable”; it is impossible to declare each item true or false. During the process, if a given proposition is known, i.e. it is known to be true or false, then the item should be placed in the K space. That C space is composed of potential propositions. Often they are oxymorons, surprising addition of 2 opposite notions that may never have been placed together before (a disjunction). They can be developed further by adding or subtracting different properties to/from them. Each operation could alter the root concept (C_0). The design process consists of C expansions and K mobilisations until the concept is sufficiently described to be given a “true” status and moved to the K space. The main advantage of that theory is that embryonic ideas are not eliminated before their potential is fully explored. Secondly, all solutions are anchored on reality. The third advantage is that the mental process can be retraced and is easy to explain to others.

Synthesis proposition. To sum up, some notions are very important to keep in mind: co-evolution, immersion, mental prototype, sub-problem division and one by one problem solving, multiple interactions –within and outside the design team.

After the constitution of a project team, the generic process consists of a cycle of different steps. At first, the enhanced designer has to immerse himself in the problem –or situation– context. He or she has to interact with all the different domains listed above –industry and technologies, user experience and social issues. This inspiration phase associated with an attitude of empathy will help him or her form a K base. From the entire gathering, some visions are likely to emerge. Many attempts to synthetize or to try some new formulations will help the imagination of a mental prototype. The ideal and desired sketch should orient and drain a flow of ideas to refine and test. The mental prototype could be viewed as the C_0 from the C-K theory. It is a root concept, an undecidable objective but still has a lot of potential and it will attract future propositions –in C space.

The sub-problems division shows the progress of the concept’s expansion. The central model place is where all decisions are made. To answer an identified sub-problem, any candidate proposition is analyzed there. According to the team’s desired criteria, the test is carried out and a decision follows. If it is validated, then the studied sub-problem is solved and the next one is immediately activated. If the expected characteristics are not met, the proposition is rejected and a new one has to be found for the same sub-problem. If no solution is found, then there is a need to go back to the previous sub-problem division and imagine a new one. Those back and forth movements imply the co-evolution of both the problem and the solution.

These notions were incorporated into an enhanced design process model with a specific symbolic representation. In order to build it, it was confronted *a posteriori* with the reasoning process used for some successful design studies. From that experience, four different activities were identified according to four different axes in the model. The first axis corresponds to *ego-design*, the shape, the personality, and the specific contribution of the designer –as a form giver. The second axis called *ergo-design* deals with ergonomics, usage, functionalities; it concerns the designer’s skills –with added marketing and engineering. The third axis takes into account the *eco-design* both economy and ecology. It lists responsive and ethics criteria, with the help of the marketing field. Finally, the fourth axis named *techno-design* refers to engineering, tangible producing and operating aspects, everything relevant to the engineering expertise.

2.2 EXPERIMENTAL CONTEXT

The enhanced design process model had to be tested in a real product development project in order to be confirmed.

SME choice. *TMC Innovation* is a small company of almost twenty people. Its mission is to improve the public area with an appropriate lighting. Faced with cost reduction, some cities turned off the lights in the middle of the night and the sidewalks became unsafe. In that specific case, the company develops a signpost solution instead of the traditional lighting system. A ledstrip fixed to the pole, during the production process, uses only 1 W/h, in comparison with a 100 W/h lamp's consumption. *TMC Innovation*'s clients were so enthusiastic about this device that they asked to implement it on already existing poles. There is a high demand for it and the variety of poles' geometry make that adaptation rather difficult. That specific subject was chosen for the enhanced design process model experimentation.

Building the team and results. The project team was lead by a skilled designer well acquainted with that company and the transdisciplinary domains related to the project. The enhanced designer's role was to meet and coordinate the diverse visions about the innovation. The internal team, a technical and marketing one, was often reinforced by external expertise. In an open-innovation perspective, many specialists were associated to the development. For that technical subject, the team management followed a value analysis methodology [Yannou, 2004]. Four major functions and four limited ones were found. Those 8 functions lead to 30 individual solutions. After the validation and combinations, three concepts were chosen for the next step: 'donut', 'lace' and 'stackable objects'. From that last one a new concept 'cordon' emerged. That last one was fully developed until the final product –Uniklic on Fig. 6.

Figure 6 –The Uniklic ring.

2.3 BENEFITS

For the company. The Uniklic product exists; it is a tangible one, is approved by the clients and meets the cost and deadline targets. Some lighting experts were astonished by its technical audacity. For *TMC Innovation* it represents the first milestone towards an innovative new products strategy.

For the modeling. The enhanced design process model is strengthened by a successful real size experiment. The first hypothesis, the interest to model the design process and apply it to an SME context, is reinforced. Thanks to that model, the project management was efficient, both inside and outside the design team. The major steps of that development are shown in the model –Fig. 7. Initially, the C_0 or mental prototype was ‘how to fix a ledstrip onto a lighting pole’. Secondly, with the value analysis method the problem was *framed* and divided into many sub-problems to be solved one by one with concepts and candidate solutions. Then, the field validation transferred the Uniklic *cordon* from the C space to the K space. Finally, the specific development resulted in the addition of the new product in the company’s catalogue.

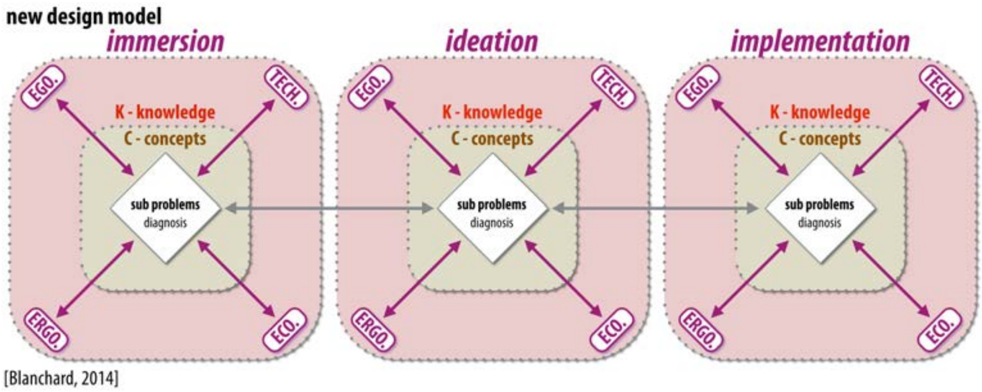

Figure 7 –The enhanced design process in progress.

3 CONCLUSION

Often, due to limited resources available, SMEs cannot afford to recruit multi-specialized teams. So, each team member has to be extremely versatile and take into account various aspects of the design development process. From a transciplinary perspective, the enhanced designer has to interact with the marketing and technical teams in order to expand the initial industrial design territory. Going back and forth according to the principles of open-innovation would complete these three skills. Using this model would be a success factor. Some more complex and less defined application cases –other than the Uniklic one– would need to be explored. This would help secure the model.

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