TO DESIGN PRODUCT FOR LEARNING

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ABSTRACT
The aim of this paper is to study how knowledge is generated during a product's design. We show how the knowledge generation takes place and how it should be used. That means to use the generated and capitalised knowledge for internal and external learning; learning and training should be considered as a highly added value service which accompanied any physical product. Some potential ways of knowledge usage is explored and some results are provided helping decision-makers to perform their tasks as efficiently as possible. This is a generic learning positioning grid. To design a product for learning is our research field.

PRODUCT: A KNOWLEDGE GENERATOR
Products are often used by firms especially in terms of technology. In this paper, the focus is put on the knowledge and know-how generated by product itself and its lifecycle. The goal of any firm is to prosper. To do so, companies look for products, primarily functional or innovative as determined by Fisher [1]. "A company can outperform rivals only if it can establish a difference that it can preserve", Porter [2].

Therefore, the product design can not be only technology-oriented activity. Firms should take account the knowledge generated by the product during its lifecycle. The concepts developed here would prove that a company should think about an extended product: product and trainings. Technological innovations are hard to accomplish, to industrialise, to be protected efficiently and to become profitable, especially for SMEs. Therefore, if a company looks for differentiation parameter, we claim that it is passed through various services, training and learning processes associated to products.

In this paper, we will discuss this point, by highlighting knowledge to generate for internal and external trainings. In a virtuous loop, the knowledge learned, capitalised and reused internally and externally can also improve the technical solutions to the customer needs, when it is possible and necessary.

THE STATE-OF-ART
The model of Nonaka & Takeuchi [3] is the first and very famous endeavour to illustrating our point of view. Their model proposes to decompose the knowledge creation in three elements:

- The SECI process, knowledge creation through the conversion of tacit and explicit knowledge,
- "ba", the shared context for knowledge creation,

- Knowledge assets, the inputs, outputs and moderators of the knowledge-creating process.

Tollenaere [4] shows that it is necessary to model data and knowledge related to the product from the beginning of the design process. Several methodologies are set up by different school of thought. They study the product knowledge representation possibilities by solving specific problems such as design phase or other phases of the product lifecycle. For example, De Martino [5] treats the multi-facet models (geometric and simulation). Holmqvist studies the product architecture in the case of products with great varieties [6]. The integration between the geometrical definition of the product and the physical behaviour is treated in Concurrent design, applied artificial intelligence by Finger [7].

These interesting works and models do not allow us to keep track of design steps unavoidable in our research. The "Function - Behaviour - State » model by Umeda [8] and the « Function - Evolution - Process » model by Shimomura [9] have similar characteristics by defining the designers' job. Andreasen's proposition [10] is focused on knowledge structuring of any product according to four fields, corresponding to the four sequential activities of design: physical phenomena, functions, organs and parts/items. The multi-model of product, developed by Tichkiewitch [11], Chapa Kasusky [12], and Roucoules [13], proposes the innovative design which looks for: stocking product knowledge coming out from various core businesses and jobs and managing their interactions during the product lifecycle. The multi-model approach generates functional and structural graphs. One or several physical components are associated with a function and vice versa. This leads to the identification of parts, their functions and interactions within the product. The functional surfaces are then built and their intersections could lead to the definition of geometrical, kinematics, constraints and launch the manufacturing of prototypes.

The DEKLARE according to Saucier [14], a European project, purposes a product model based on the integration between three models: physical, functional and geometric. In this routine design, the designer, a mechanical expert, defines the physical model and functional model at the same time. He/She enriches these models then in order to add to them various professional aspects.

WHAT KIND OF MODEL TO CHOSE?

A model is a representation of reality. Casti [15] defines taxonomy of models that include experimental, logical, mathematical/computational, and theoretical. Most Knowledge models are theoretical in the sense that they are an imagined mechanism, or process that has been developed to account for observed phenomena. Theoretical models are based on hypothesized relationships among factors. Within this taxonomy, models are further categorized by their purpose:

Predictive: Enables us to predict what a system's behaviour will be.

Explanatory/descriptive: Provides a framework in which past observations can be understood as part of an overall process. These models are also called descriptive because they are explicit descriptions that capture and organize information.
Prescriptive: Provides a picture of the real world as it will be if certain postulates (prescriptions) or formal axiomatic rules of behaviour are applied.

Our model will be based on predictive, descriptive, and prescriptive together.

PRODUCTS FOR LEARNING/TRAINING

A product must be designed or re-designed in order to improve the positioning of the firm. In this situation the fact that one should design by keeping in mind this final objective is fundamental. Along the lifecycle of an “extended product”, innovative or functional, it is possible to identify learning and training situations Thoben [16]. When talking about learning, we should consider the knowledge and know-how about every phase of the product’s lifecycle. Several kinds of knowledge can be identified by this way. The knowledge generated during several phases: the design, the production, the utilisation and the maintenance (Figure 1). More than this proposition in extended products, we look for the training/learning set of trainees (workers, university students for example). We study these various learning situations, their relationships with the product itself, various interpretation levels, their accumulation and their aggregation, when possible and necessary. By doing so, it will be possible to integrate these huge amount of learning situations in a global strategic potentiality of the firm to determine a differentiation factor.

Figure 1: Knowledge generation during life cycle product.

A product is called learning-oriented product, if it is designed and made in order to transmit some knowledge (a mini-robot for instance). This definition seems to give a clear frontier between a learning-oriented product and other products. We propose that every product can be used as a learning-oriented one with a given Learning-Relevance-Indicator, LRI (Figure 2). This concept is basic in our model.

A GRID TO FORMALISE LEARNING BASED DECISIONS

Hereafter, we will build step by step this grid. (Figure 2)

Culture and Society of trainees:
One of the most important factors in our model is the culture and society. The product will be used and the knowledge and know-how will be understood. Obviously, political, religious and tradition for example influence these elements and generate, more or less, hard constraints over the designers. Readers can refer to the works of De Souza and Dejean [17].

According to this point, we put a “cursor” on a scale going from low-level constraints to high-level constraints (Figure 2). At the right side of this measurement scale, the social and cultural factors are very important to consider during the design of the product and its related learning aspects.

Learning-oriented or usage-oriented products:
The second criterion concerned the main goal of the “customer” of the product: do the customers want just to use the product or do they want to learn with it? In analogy with Fisher’s classification, we fine-tune our first classification (learning-oriented and usage-oriented) into the following: primarily usage and primarily learning. This classification is much more realistic especially by taking account the learning-relevancy indicator.
Obviously, the scale of this criterion is continuous and any product can be put somewhere between absolute usage (a pen) and an absolute learning (a course).

Customers of the product:
Putting the cursor on the left side means that the product is used mainly for learn.

Product lifecycle:
Various phases are shown at the bottom of the grid (Figure 2). Any learning purpose of the firm can be put within the product lifecycle’s phases.

Learning tools:
Whatever the lifecycle’s phase is, the learning tools are:

- Generic tools (word processing software for example) and specific tools (CAD software);
- Generic knowledge (mechanical laws …) and specific knowledge representing the firms’ know-how (laser cutting);
- Human resources.

CONCLUSION

In this paper, we study the learning dimension of a product in every phase of its lifecycle. It is argued that knowledge generation during these various phases does not represent only an important internal innovation source but also, the firm can use the learning and generated knowledge as a tool for positioning firm on the market.
The main tool presented here, the learning grid allows:
- to model the social and cultural environment regarding learning purpose of the firm.
- to underline the purpose of the product, learning/using or something between two.
- to keep track of Knowledge generated in relation with the activity considered.
- to measure the variations between what the firm can do inside and what it should be outsource.

However, in a market with an ever increasing complexity, any efficiency niche should be explored in order to provide a sustainable market position to the firms. We believe that learning as described and modelled here belongs to those tools necessary for such orientation. Further research works are necessary to reach this final goal.

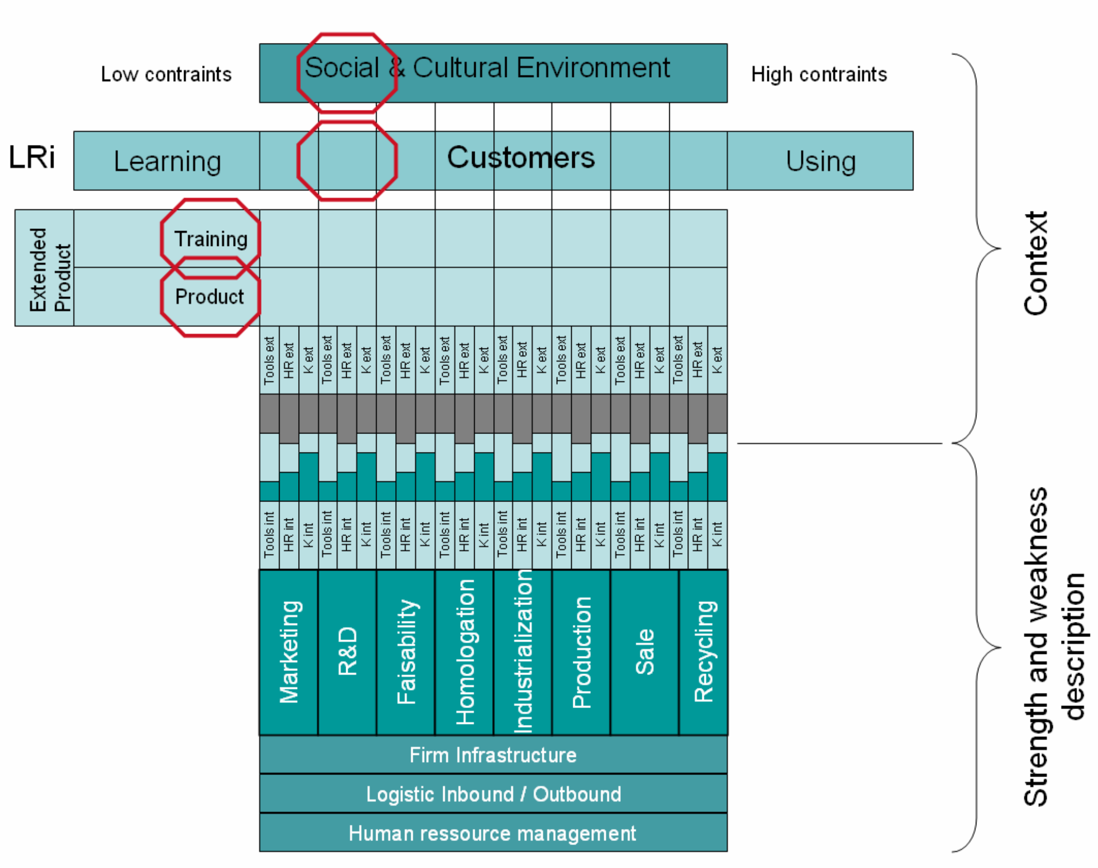

Figure 2: Grid with all characteristics.

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