Products to learn or products to be used?

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Abstract

The aim of this paper is to study how a product generates knowledge throughout its lifecycle. We show how the knowledge is generated and how it should be employed on various levels of decision making within the firm. Outside the form, learnings and trainings induced by the product throughout its lifecycle participate to the generation of an additional service which can be provided to customers and final users. Some of these ideas have been already tested through an industrial case but other prospective results are also proposed. These ideas may help the definition of a more efficient business strategy. A generic tool, a strategic training positioning, is suggested in order to allow a clear definition of the firm's needs in terms of learning and training.

Keywords: *Generation of knowledge, extended product, ingenition, strategic decision.*

1. Introduction

Innovation is often considered as a main factor of differentiation by society. This differentiation is generally based on new technologies. Nevertheless, the differentiation cannot be guaranteed only technological innovations. This paper will show how the product can generate knowledge by itself or can foster knowledge generation throughout its lifecycle. Authors believe that this represents a long-term differentiation parameter. Products are either functional or innovating (see Fisher [1]), and firms will achieve the differentiation goal if their managers set up and follow a coherent strategy, not only in terms of technological innovations but also in terms of knowledge management. "A company can override its rivals if and only if it can establish a difference which it can preserve" Porter [2]. Consequently, the design of products cannot be an activity primarily directed towards technology.

We focus our research on a specific kind of products used mainly to learn and teach something to some trainees. We call this class of products "Used for

learning". It is this specific design which is further detailed and which we call « Ingenition ».
These "Used for learning" products are *extended products*. An extended product is a product delivered with all associated services to customers (see for example the work of Thoben [3]). In our case, the additional service consists on training. This additional service could consolidate the strategic differential positioning, if it is designed in harmony with the physical product along the product development phases. Porter shows that the technological innovations are extremely difficult to implement by giving the following reasons:

- Difficult to conclude
- Difficult to industrialize
- Difficult to protect effectively from competition
- Difficult to become profitable and release some profits

Similar products, often imitated, will come on the market quickly. The technological innovation is a hard challenge to carry out. Therefore, companies should seek for their differentiation parameters in other fields than in technological innovations too. A company can empower its relative business position on the market by providing various business services. These services are offered to the customers and final users. The trainings correspond to one of these services.
This is not a new idea. What is new, is that *this service has to be designed and realized by setting up a cross-functional training strategy, focused on customers' training and learning needs, along the whole physical product lifecycle.*
The training associated with each phase of product lifecycle (from design to industrialization followed by use and recycling) should use and capitalize the required knowledge for the firm's differentiation.
The knowledge that can be backed up easily is the knowledge generated and managed by the Internal Knowledge Generation (IntKG) process within the firm's services. This knowledge can be used by all employees. They will be able to adapt it according to their specific needs. We propose to study the knowledge generation processes. We can observe, extract, store and study how the knowledge grow up. The knowledge generated throughout the product life cycle forms the main differentiation factor for the strategic decisions. In a virtuous loop, the generated and managed knowledge contributes to the training and can be re-used internally and pushes also towards new technical solutions.
The next paragraph reconsiders the research works related to knowledge. We will define some concepts which clarify our future use of the initial paradigm. We will propose finally a grid of analysis, design and study. The results are exploratory and at the end of the article they will be discussed determining on-going research works.

2. State of the art

Many works do exist in the field of knowledge management and obviously this brief state of the art cannot be representative of all of them. Nevertheless, it contains the most important ideas related to our works.

The model proposed by Nonaka in [4] distinguishes a knowledge creation framework by three different elements:

- SECI Process, is the creation of knowledge by the conversion of tacit and explicit knowledge, in knowledge reusable and transposable.
- "Ba", is the context of social sharing, cultural, environmental for the creation of knowledge. This concept is not translated because it is firmly attached to the crop and Japanese perception.
- The capitalization of knowledge, input, output and regulators of the process of knowledge creation.

Tollenaere [5] proved that it is necessary to model the data and the knowledge related to the product at the beginning of design process.
Several methodologies are used by the Anglo-American and Scandinavian researchers. They study the product knowledge representation by solving specific problems such as the phase of design or other phases of the product life cycle. For example, De Martino [6] speaks about models under several aspects (geometrical and simulation). Holmqvist [7] studies the architecture of the products in the case of the products of large varieties.
Moreover, integration between the geometrical definition of the product and the physical behavior, are discussed by Finger [8]. Approach of Grabowsky [9] sets the problem in the product life cycle. Four levels of modelling appear:

- Level 1 - Modeling of the conditions
- Level 2 - Modeling of the functions
- Level 3 - Modeling of the physical principles
- Level 4 - Modeling of the form

"Function - behavior - state", modelled by Umeda [10] and "function - development - model process" by Shimomura [11] have similar characteristics. The proposal of Andreasen [12] is concentrated on the knowledge structure of any product according to these four fields. This knowledge structure corresponds to the four sequential activities of the design: physical phenomena, functions, organs and items. The multi-model of product, developed by Tichkiewitch [13], and Chapa Kasusky [14], and Roucoules [15], consider the design innovating by seeking the knowledge of a commodity coming from various foreign companies. This way of thinking makes it possible to preserve the last experiments and shares. This work is in agreement with Ouazzani [16] who shows how the designers come to discover specific solutions. But, in this work, the operational aspect is not studied and the links between this model and the other activities of the process or with the product itself are not mentioned. We think that this point of view of creation, re-use and capitalization of knowledge is very important. We find also the structure matrix, « Design Structure Matrix" (DSM) showed by Browning [17]. This matrix keeps tracks of to possible paths of design. DSM is often employed in work of the Anglo-Americans scientists and Scandinavian. Fagerstrom [18] employs it and structure the links between the designers and the subcontractors in a process of design. Lockledge [19] conceives an information system to facilitate the communication between the actors. European project "DEKLARE" studied by Saucier [20], shows a model of product based on the integration of three models: physical, functional

and geometrical. Finally, the approach of Pourcel (see [21]) is close to our research interests even if it remains concentrated on the knowledge management and not on the generation of knowledge.
This short state of the art proves that our work is clearly related to all of them and suggests new possibilities and new fields for further research in this area.

3. Products to learn

A product must be designed or reorganised in order to improve strategic positioning of society. The design activity, by considering that as a fundamental objective, is an operational potentiality allowing a clear competitive differentiation of the firm. While designing products, the various sectors of the firm will generate knowledge. It's possible to learn and thus to better know and manage all parts in designing process. Throughout the product life cycle, innovating or not, it is possible to identify situations of study and training. When speaking about study, we include the knowledge and the know-how generated internally in each phase of the product life cycle. Several types of knowledge can be identified: 1) knowledge produced during the phase of design, 2) knowledge produced during the phase of production or manufacturing, 3) knowledge produced during its use by customers and final users, 4) knowledge produced during its maintenance and finally, 5) knowledge produced by the product itself during training phase.

3-1- Extended Product.

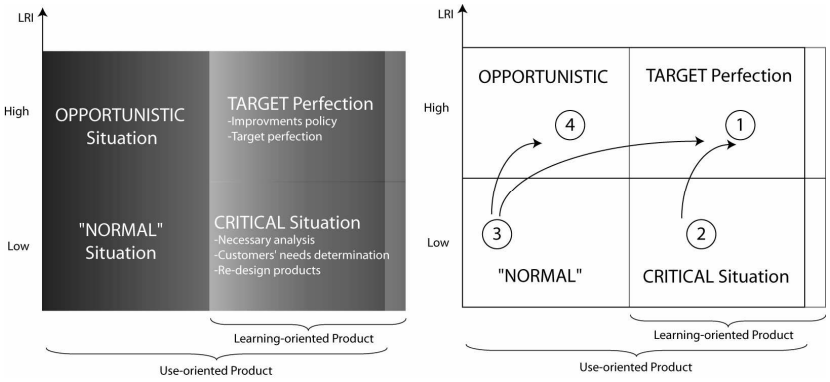
Based on Thoben [3], we define extended products as combination of physical product and additional services. The main service that we study in the extended products is the training-learning. This service is provided for operators (within the firms, who have to work either on the physical product or the data related to it), students of university, schools or high-school pupils for example.

3-2- Extended product oriented training

We call a "didactic oriented product" if it is designed and carried out in order to forward knowledge (a constructible minirobot by students for example).
This definition seems to draw a clear border between a "didactic oriented product" and other products. However, we think that any product can be employed as a didactic oriented product characterizing by an indicator called "LRI - Learning Relevancy Indicator". This concept is, in our opinion, fundamental. We will develop it during the next paragraphs. The LRI should measure the product potentiality implemented in the following way:

- if a « didactic oriented product » has a low coefficient LRI, it is not adequate for the provided knowledge transmission. This product will not be a good support for the knowledge transmission.
- if an industrial product, therefore usage-oriented, has a high LRI, then it can be used a support of knowledge transmission.

This indicator of relevance for training (LRI) is a powerful element of decision making for the top management of a firm. The main trends and ideas regarding the use of the LRI are resumed in the following figure. Four main market positions are identified: Critical, Target perfection, Normal and Opportunistic. The critical situation concerns that product which does fit to the learning purposes of the product (a micro-processor used for learning the bipolar transistor principles). The Target perfection situation is that situation where the product fits quite well to the requirements. The only axiom in this situation is to improve continuously. The other two situations correspond to the usage-oriented products (a TV or a car). At the beginning, such products could be designed and realized without any learning purpose ideas. Nevertheless, if a usage-oriented product is a useful support for knowledge transmission, this could give a new differentiation factor for his market conquest. The basic improvements strategies are numbered at the self-explanatory right side of the figure. The works done in our research looks for the determination of the strategy which helps firms to go from the critical situation towards target perfection situation.



But let us look deeply at the knowledge generation process. In the figure below, we show the various sources of the knowledge generation related to a product:

- The internal knowledge generation, Int-KG.
- The knowledge generation during product usage, KG-Using.
- The knowledge produced during the maintenance of the product, KG-Maintenance
- The generation of knowledge for the knowledge transmission, KG-DOP (learnability dimension).

4. Various situations in the generation of knowledge

4.1 Internal Generation of Knowledge.

The product generates knowledge throughout the various phases of its lifecycle:

design, manufacture, marketing, etc…. They represent somehow the power and capability of a firm. Various methods are available such as MASK, REX, MSKM, etc… to model the knowledge generated within these phases

Figure 1: Generation of knowledge with an "Extended Product".

4.2 Generation of Knowledge by using

Often, final users understand what a product can do exactly by using it. Consequently, the firms provide instruction manuals to help them identifying the variety of the services which the product can offer. In this case, the product is an *operational vector* of transmission of knowledge. This corresponds to a specific whole of strategies of study which we call "Learning by using". The experiences of users, if correctly collected, analysed and capitalised, form a significant source of knowledge for all of the services of the firm espcially for designers. It is what we could call the generation of knowledge by experimental know-how of the users.

4.3 Generation of Knowledge by maintaining

Often, the manufacturers think of maintenance of the product from the beginning of design. Two kind of maintenance are often distinguished: preventive and curative maintenance. In both cases, the knowledge is different. We know that the knowledge generated by the users in these situations is not identical to that generated by the experts. This is "Learning by maintaining".

4.4 Generation of Knowledge by training

The firm puts on the market a product which will be used to support knowledge generation for the final users such as learners, students, etc. To discuss this last concept, we refer to our practises of teacher (in university or in school). Sometimes a product used to support our teaching does not help us at all or sometimes the results are completely different from those awaited ones! In these scenarios the most pessimistic trainees do not understand anything. Often the adequacy between the product support and teaching is seriously questioned! This is related to indicator LRI (i.e. the critical situation). Therefore, a strategy should be set up in order to go towards Target Perfection situation. To help decision makers in this crucial task, we are working on a global framework composed of a reference design model, tools and methods. This framework allows differentiating clearly usage-oriented and learning-oriented products with their specific set of constraints.

We study various learning situations, their relationship with the product itself, the various levels of interpretation, their accumulation and their aggregation.

5. The analysis grid

The idea of this section is to establish a grid of analysis which helps decision makers to formalise their strategy and to support their decisions in this field. Like Merlo [22], we seek how the knowledge, know-how and human factors grow up in order to identify methods for capitalization of knowledge and know-how in the design process. In fact, decisions should be taken based on data, models and knowledge which one will employ in the design process. Consequently, the grid must allow the expression of various levels of decision of design through a different granularity. On strategic level, one of the firm finalities should be to have a comprehensive view of learning-training objectives. The decision makers have to distinguish how various (internal and external) factors can influence the design process, the production and the organisation. To do so, the analysis grid is built. Its main role is to help formulation of decisions regarding learning-training within the firm or for final users. In this section, we will build this grid step by step.

5.1- The social context and environmental interest

In this item, one of the most important factors is the manner by which the social environment and society influence the design, the manufacture and the use of the product. In the same way, it is interesting to observe how a product can influence the social environment and society (phone cellular). This means that the transmission of knowledge relating to the product will be influenced by the social environment and "the society of the customers" (the *haute couture* for example) [23]. It is also important to consider the aspects of the relative studies to the sociology for which the future product is intended. Using this point of view, we can use a cursor which measures the social constraints on a continuous scale of going from the soft constraints to the hard ones (to see Figure 2). Soft constraints mean that there is no specific constraint on the product (a pen for instance). A product hardly constrained means that designers and all of the internal operators and managers should take care of them in order to offer a product respecting social and cultural constraints of final users (clothes industry). By enumerating all these constraints, the creation of the product can seem as a serious strategic error. The tools for cursor positioning are based on experts audit and are under development.

5.2- The products and their customers

The second criterion relates to the final relation between the customer and the product: do the customers want just to use the product and/or want to learn/teach with it? By analogy with the classification of Fisher [1], we propose a first "classification". It is easy to understand that this criterion offers to the users a continue scale of which the two ends are respectively made up of the usage-oriented products (a calculator) and learning-oriented products (a rule).

Nevertheless, we put a postulate saying that "a product is always useable for both use and learning-training purpose. It means that even a pure usage-oriented product can support a given knowledge transmission process. For example, a computer can be used not only for precise purposes (use) but also it can be used to understand the way that a human uses it. It is understood naturally that the educational levels and of observation permitted by the product are not the same ones in these various cases (e.g. a pneumatic cylinder for industrial use and this same pneumatic cylinder made translucent for the study of the internal components). We would like to explain that a usage-oriented product can be employed for the study and knowledge transmission but obviously the results will not be identical compared to the oriented products training. This simple observation shows, sometimes, why the instructors cannot transmit their knowledge to their students. The product is badly adapted (low LRI and critical situation).

5.3- Knowledge Generation in product life cycle

Now, we will integrate into our model the product life cycle. Various phases are shown on this new grid (see Figure 2).

5.4- The resources are integrated

On the level of the product life cycle, the three classes of resources included in the model are: 1) Generic tools (data-processing software for example) and specific tools (a software of CAD), 2) generic knowledge (mechanical laws...) and specific knowledge representing the know-how of the firms (laser cutting...), etc. 3) human resources. The managers must find these resources in-house or externally. Thus, the grid will include three indicators, tools, human resources, knowledge.

6. How to use this grid?

This grid contains two distinct parts: 1) context allowing the description of the constraints of the environment, those related on the users and the product. 2) the operational one describing the forces and weaknesses of the firm throughout the product life cycle in comparison with the human resources and knowledge of the actors. Initially this grid makes it possible to describe the actual position (AS IS) for the firm within the framework of the launching of a new project of product. This analysis makes it possible to the decision makers to identify the requirements for tools acquisition. It allows set up a strategy of acquisition of knowledge. We propose the formulation of this strategy in three points: - formulation of the needs, - highlighting of the interdependences between these various acquisitions, - planning in the time of the trainings necessary. The execution of this strategy should allow the realisation of the objective initially identified (TO BE).

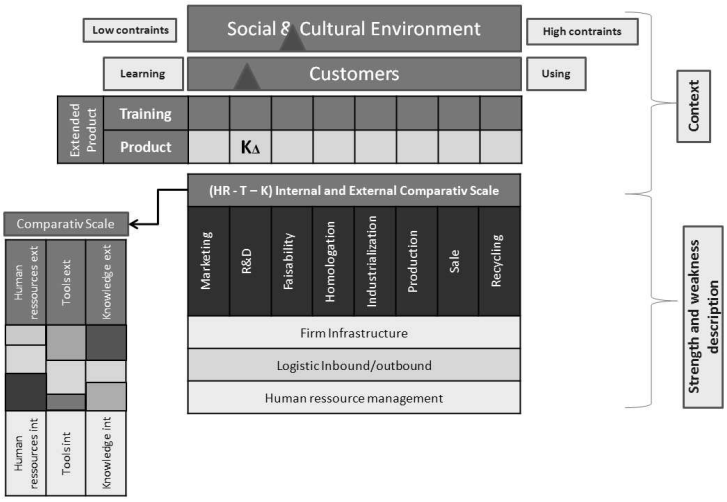


Figure 2 : Final grid.

7. Conclusion

In this paper, we study the dimension of a product dedicated to the training in each phase of its life cycle. The main idea is that the generation of knowledge during these various phases represents an important internal source of innovation. The firm can use the knowledge produced as a tool for its competitive positioning on the market. The main tool presented here, the analysis grid of study and positioning makes it possible to model social environment and cultural. It allows, to stress the aim of the product, with vocation training or vocation use or something between, to preserve the knowledge produced in relation to the activity considered, to measure the variations between what society can do itself and what it would externalise; In a market of an always increasing complexity, any solution improving the effectiveness should be explored in order to provide to society the means of keeping an interesting position on world market. We believe that the study described and model here can be tools useful. However, other research tasks are necessary to refine and reach the final objective that we fixed ourselves.

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