Product: something between learning and using

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Abstract: The aim of this paper is to study the way by which knowledge and know-how are generated during a product's lifecycle. We show how the knowledge generation takes place and how it should be used at various decision-making levels as useful business option. This is 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. A set of interesting research fields is determined finally.

Key words: Knowledge generation, extended product, ingenition, learning and training strategy

1- Product: a knowledge generator

Products are often used as the main differentiation factor 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 over time in a sustainable manner. To do so, companies look for products, primarily functional or primarily innovative as determined by Fisher in [F1]. However, a company can reach this ultimo goal if its managers are able to pursue a sustainable strategy, not only in terms of technological innovations but also in terms of knowledge management. "A company can outperform rivals only if it can establish a difference that it can preserve", Porter in [P1].

Therefore, the product design, from our point of view, can not be only technology-oriented activity. Firms should take account of knowledge generated by the product during its lifecycle.
The knowledge management is not a buzzword neither for academics nor practitioners and we focus our research on a specific kind of knowledge "that one used for learning".

The concepts developed here would prove that a company should think of an extended product: product and trainings if they want to act differently as their competitors as suggested by Porter.
Technological innovations are hard

- to accomplish,
- to industrialise,
- to be protected efficiently and
- to become profitable,

especially for SMEs. Similar and imitated products will come on the market rapidly. This means that the innovation is hard challenge and managers are aware of it.
Therefore, if a company looks for differentiation parameter, we claim that it is passed through various services and especially training and learning processes associated to products. Training could be offered to users based on their needs and according to the strategy of the firm.

Here, we will discuss this point, by highlighting knowledge to generate for internal and external trainings. The lifecycle knowledge generated is a differentiation factor that the company can use in its strategic decisions.
In a virtuous loop, the knowledge learned, capitalised and reused internally and externally can improve the technical solutions to the customers needs too, when possible and necessary.

The rest of the article is structured as follows. Next section discusses previous works related to knowledge and learning paradigm inside firms. In section three, we define some concepts which underline our basic understanding of the paradigm. An analysis and design grid is then proposed. Finally some discussions and conclusions finish the paper.

2- State-of-the-art

Works done in the field of knowledge management and obviously this brief state-of-the-art cannot be representative of all the works done.
Tollenaere [T3] 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 the Anglo-American and Scandinavian 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 in [DeM1] treats the multi-facet models (geometric and simulation). Holmqvist studies the product architecture in the case of products with great varieties [H1].
Finally, the integration between the geometrical definition of the product and the physical behaviour is treated in Concurrent design, applied artificial intelligence by Finger [F2].

These interesting works and models they offer do not allow us to keep track of design steps unavoidable in our research.
To cope with this lack, Grabowsky's approach [GT1] positions the problem in the product lifecycle. Four modelling levels, called layers, are then necessary: modelling the requirements layer, functional layer, physical principles modelling layer and forms modelling layer.
In this school of thought, the "Function - Behaviour - State » model in Umeda [U1] and the « Function - Evolution - Process » model in Shimomura in [S1] have similar characteristics by defining the designers' job according to three sequential steps.

Andreasen's proposition in [A2] is focused on knowledge structuring of any product according to 4 fields, corresponding to the four sequential activities of design: physical phenomena, functions, organs and parts/items.

The multi-model of product, developed by Tichkiewitch in [T1], and Chapa Kasusky in [CK1], and Roucoules in [R1], envisages 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 conducts to 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 prototype allows the use of those professions and jobs which participate to the definition of the primary phase of the approach. In short, the designed prototype (and the product) has a unique architecture with several facets related to professions (assembly or turning for instance).

This structure permits to conserve the track of past objectives and actions according Ouazzani in [O1] which pushes designers towards specific solutions. But, in this work, the operational aspect is not studied and the links between this model and the others activities of a process or with the product itself are not mentioned. This, from our point of view limits largely the study of possibilities of knowledge generation, reusage and capitalisation.

At the heart of these models, one can find the Design Structure Matrix, DSM in short, associated with a product description module. DSM structures the product development phase by splitting it into several problems to solve. This matrix allows keeping track of past paths of design too. DSM is often used in the works of the Anglo-American and Scandinavian scientists. Fagerstrom [FJ1] uses it and structure the links between designers and sub-contractors in a design process. Lockledge [LS1] designs an Information System to ease communication between actors. Clarkson [CM1] in Cambridge explain the Visualization techniques to assist design process planning. It's extremely important for us to have a pattern to show our project and the applications.
The DEKLARE according to Saucier in [S1], an European project, purposes a product model based on the integration between three models: physical, functional and geometric. This is a 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. This allows achieving to a validated physical model. A new set of parameters are then deduced and transferred to the CAD/CAM software tools.

The process model proposed by Vargas [V1] is based on task (problem to solve) and method (means to solve) in order to ensure the design evolution. A task represents a problem and indicates the links with physical model components and functional model defined in precedent project. These works are developed in the KOMOD environment by Yvars [Y1].

Research of Mamqvist in [M1] studies the constraints and the past steps of the design. Decisions history is based on the solutions (functions) associated to problems (needs or requirements) and the models of product and process. This work is deduced from the theory of Andreasen [A1].

We found that the works done by Pourcel in [PC1] are closer to our field even if he is focused on knowledge management and not on knowledge generation.

This brief state-of-the-art shows that even if our work is clearly related to all of them, more specified results have to be provided to the global scientific corpus.

3- Products for learning/training

A product must be designed or re-designed in order to improve the strategic positioning of the firm. In this situation the fact that one should design by keeping in mind this final objective is fundamental.
This refers to as the operational potentiality of a firm in designing products and generating training/learning knowledge.
Along the lifecycle of a product, innovative or functional, it is possible to identify learning and training situations. Talking about learning, we include inside knowledge and know-how about every phase of the product's lifecycle.

Several kinds of knowledge can be identified by this way: those knowledge pieces generated during the design phase, during make phase, during its usage, of its maintenance and finally its potentiality in transmission of knowledge.

3-1- Extended product

Let us have a deeper look at products. We study extended products defined as a combination of a physical product and some additional services provided with it. Thoben in [T2], first, works on extended products. This concept allows taking into account various material or immaterial products, from cars to software packages and bank credits. The only service we look for in extended products is the *training/learning* related to a given set of trainees (workers, university students or high-school ones for example).

3-2- Learning (didactic)-oriented 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. However, this is untrue, because it is claimed here that every product can be used as a learning-oriented one with a given Learning-Relevance-Indicator, *LRI*.

This concept is fundamental in our opinion for the reasons we develop hereafter. But before, let us imagine that we have in our hands (not yet unfortunately) a measurement protocol of learning-relevancy of any product.

- If a learning-oriented product which is used for learning purposes has a very low level LRI, it is misused patently.
- If an industrial product or usage-oriented product has a high LRI, then it must be used for learning purposes too.

Therefore, the learning-relevancy indicator, once evaluated, is a powerful element for decision-makers.

Figure.1 shows various knowledge generation possibilities by products:

- Internal knowledge generation, *KG-Int*.
- Knowledge generation during the usage of the product, *KG-Using*.
- Knowledge generated during the maintenance of the product, *KG-Maintenance*, and finally
- Knowledge generation for transmission, *KG-DOP*.

These possibilities are defined in the following section.

Figure 1: Knowledge generation during life cycle product.

4- Knowledge generation situations

- **KG-Int.** It refers to the fact that the product acts as a knowledge generator during its « life » inside the firm, from the marketing and specification phase through design activities, its manufacturing and delivery. It is "Learning by Doing". Various methods are available for modelling of this kind of knowledge, MASK, REX, MSKM, etc.

- **KG-Using**. Often, users do understand what a product can perform by using it. Therefore, the firms prepare enough information for users in order to help them to identify the variety of services the product can offer. We can think about manual of a DVD-Writer, or a car. In this case, the product is an operational knowledge transmission vector. This kind of learning corresponds to a specific set of learning strategies: learning by doing. Obviously, users' experiences form an important source of learning for the firms. These are the experimental know-how of users.

- **KG-Maintenance**. When a product is used, often the makers should think about its maintenance letting the product to offer its services continuously. Two sets of maintenance are therefore possible: preventive maintenance and reparation. In this case, the knowledge to generate is different. One, the users or the firms' after sale services should be able to make the product runs. Intuitively, we can imagine that the knowledge used for users in these situations is not the same that those ones necessary for the after-sales service experts. It is clear that the way that the necessary knowledge is offered to the final users can improve their loyalty or on the contrary push them far away from the company and its products. Even if this subject is quite interesting, we do not develop it further in this paper.

- **KG-DOP**. The last knowledge generation situations correspond to the goal of a firm to put on the market able to transmit a given set of knowledge to a given set of trainees. In fact, we claim that any product can be used by this way (refer to the last section). However, as the practitioners of teaching in the university and schools, all of us have already use products that do not allow us to learn students something and sometimes the results are completely different. The trainees miss-learn! This is again related to learning-relevancy indicator.

Therefore, form our point of view there should be a set of tools and methods to help firm managers to put on the market products going from the "absolute" learning-oriented products to "absolute" usage-oriented products. And if they do not want to use their product as a knowledge transmission vector, they should have enough tools to understand till which level the product is just an usage item.
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. Moreover, we believe that it will generate new understanding of the design process in general, especially for innovative products.

5- Learning-oriented products analysis

The idea of this section is to explore the learning fundamental elements in order to set up an analysis grid which helps decision makers to formalise their learning strategy first and to support their strategic decisions in this field.

Merlo in [M1] looks for taking account of knowledge, know-how and human factors in order to identify methods for knowledge and know-how capitalisation within the product design process. In fact, efficient decisions should be made based on data, models and knowledge that one should use in design process.
Therefore, the grid has to allow the expression of various *granularity* design decision levels, related to learning purposes, and putting them together to ease the decision making process.

6- A grid to formalise learning purpose decisions of a firm

At the strategic level, one defines the global view of the firm and especially in terms of design and learning objectives.
This level has in charge to determine how various global factors (internal and external) might influence the design process, the product and the organisation.

Hereafter, we will build step by step this grid.

6.1- Culture and Society of trainees

At this level, one of the most important factor to model and to take into account is the way by which the *culture* and *society* in which the product will be used and the knowledge and know-how will be taught. It means that the firm's top management should define whether the product and its related knowledge transmission are influenced by the clients' culture and society or not. Obviously, political, religious and tradition for example influence these elements and generate, more or less, hard constraints over the designers. An immediate example of these elements is for example the way that one can tackle the haute-couture for example. Readers can refer to the works of De SOUZA and DEJEAN in [DeS1].

According to this point, the top management puts a "cursor" on a scale going from low-level constraints to high-level constraints (see 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. Putting the cursor at the left side means that there is no specific constraint on the product.

Figure 2: Social and cultural positioning.

Listing all these constraints, even the creation of the product may seem as an error.

6.2- 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 specially by taking account of 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). For instance, a computer can be used not only for doing things (usage) but also to understand the facility that human has in putting his/her fingers rapidly on the buttons of the keyboard.

6.3- Customers of the product

Putting the cursor on the right side, top managers mean that the product is used mainly for usage. On the other extreme point, a product is just for learning.

Figure 3: C The use of a product by customers

In both cases, the final "customers" of the product can be either users and/or learners.

That is the reason why, another scale is added to this part of the grid (see Figure 4). This new scale is however closely related to the goal of the product: primarily learning or using.

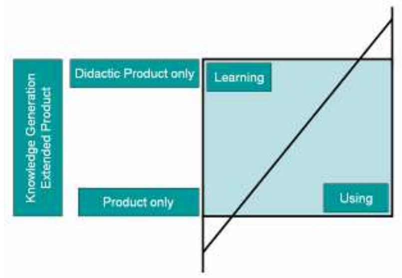

Figure 4: Learning or using.

The right side of the Figure.4 shows that, generally, even if a product is basically designed for usage, some potential learning purposes can be identified for it (remember the personal computer) and that a learning-oriented product can be used for usage purposes too.

We would like to underline that a usage-oriented product can be used for learning purpose but evidently the results would not be the same in comparison to learning-oriented products (think of an industrial pneumatic-cylinder and a learning translucent cylinder). This simple observation shows a part of the reasons why sometimes, teachers and lecturers cannot transmit the knowledge to their students!

6.4- Product lifecycle

Now, let us take account of the lifecycle. Various phases are shown at the bottom of the grid (see figure.5). Any learning purpose of the firm can be put within the product lifecycle's phases.

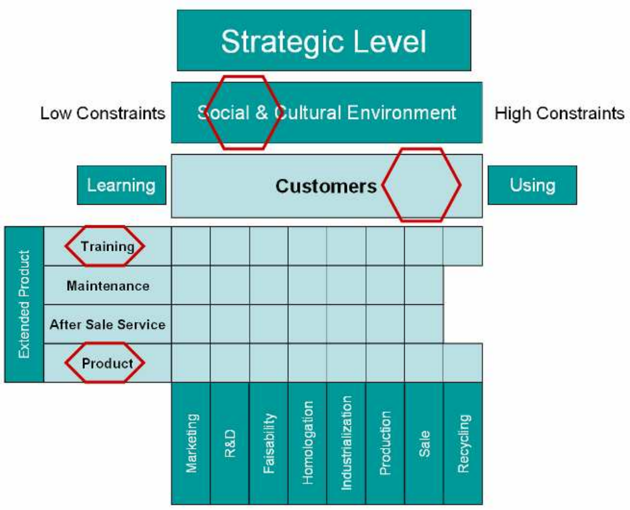

Figure 5: Product's lifecycle

6.5- Learning tools

Whatever the lifecycle's phase is, the learning tools are:

- *generic* tools (word processing software for example) and *specific* tools (a CAD software).
- *generic* knowledge (mechanical laws, …) and *specific* knowledge representing the firms' know-how (laser cutting, …), and
- Human resources.

Not all these elements belong to the firm. Managers have to find them, inside or outside the company. They can buy them or they sign contract with sub-contractors to "borrow" them or buy some services.

Doing so, the bottom of the grid will include two sets of tools, knowledge and human resources (see. Figure.6). Obviously, at this point, we can see that this grid allows us to put the answer of the most complex questions in firm's life "Make or buy".

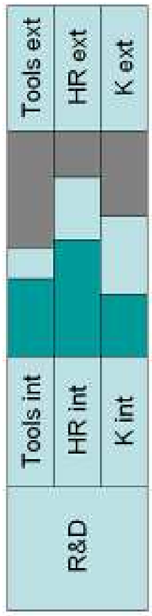

Figure 6: Tools Human Resources and Knowledge.

The complete grid is then represented in Figure.7.

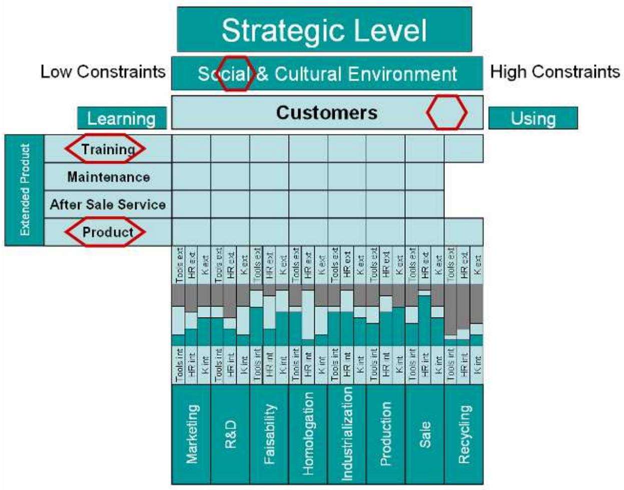

Figure 7: Strategic level with all characteristics.

7- Illustration

Let us now take an example, illustrated in Figure.8.
The top management of a firm looks for a product which allows training for employees inside the firm on automatic machines. The product is a hydraulic cylinder which is in

general used just for usage. This objective is fixed and shown on the grid. The impact of cultural and social environment is negligible. The firm is a French subsidiary of a German company. The cursors' position shows main elements for these training decisions.

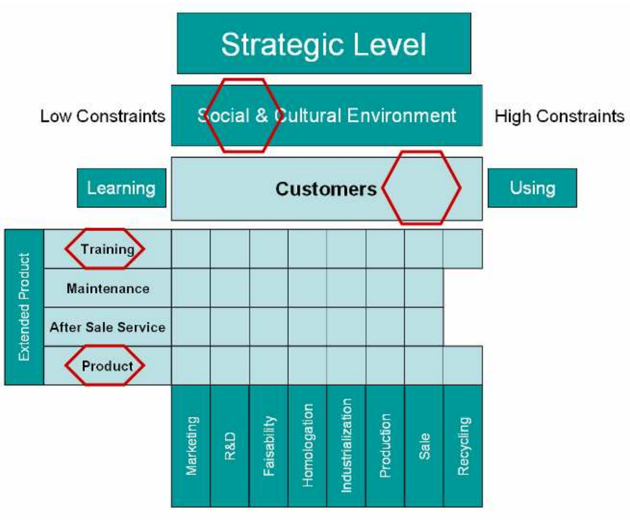

Figure 8: Application 1.

Another cursor is positioned on the customer scale. It means that the training will be focused on operators who manufacture the cylinder (if the curser was on the left side of this bar graph, the training would be prepared for students).

This high-level decision should be detailed taking account of various interactions between departments of the firm. This level should define those technical and human resources necessary for the training's preparation. In this grid, other product's services than training are eliminated from the extended product.

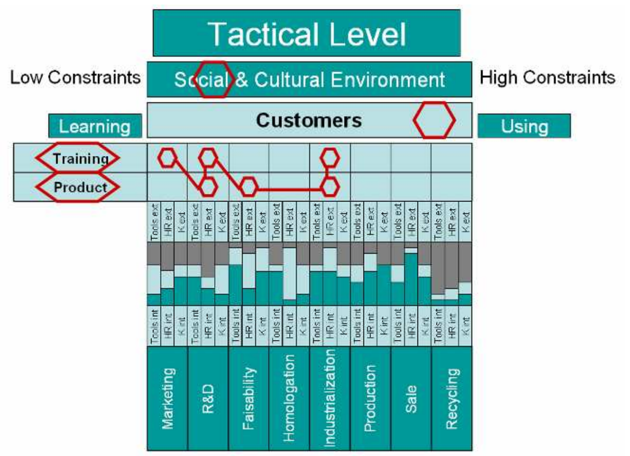

Figure 9: Application

The training is focused on marketing, R&D and industrialisation.
The production unit is not in a specific place. We know that the firm is in France. The social and environmental references will be French. The dimension of firm is not a problem in first time. All indexes about this environment are low. Netherless, it is not a reason to forget them. They will not intervene like essential elements of decision making.
Their relative weight thus is undervalued compared to criteria more precise in future. The final weigh will be more weighing in the final decision

It is necessary to focus on the learner: the operator. We can define a fine-tune list of competencies and know-how of the operator. This list may contain not only his/her scientific background but also his/her work experiences such as its roles, activities and various trainings. Other aspects: social and cultural elements of the operator may be included. This highly detailed description provides a crucial knowledge about the product design.

Our methodology contains a model which captures relationships between various competencies of various design actors.

Finally, we should measure the difference between the goals of the firm and the achieved targets of learning purposes. These differences must be memorized as a fundamental knowledge capitalisation of the product design of the firm basis.
By eliminating unnecessary elements, the learning decisions model or grid can be obtained (see figure 10).

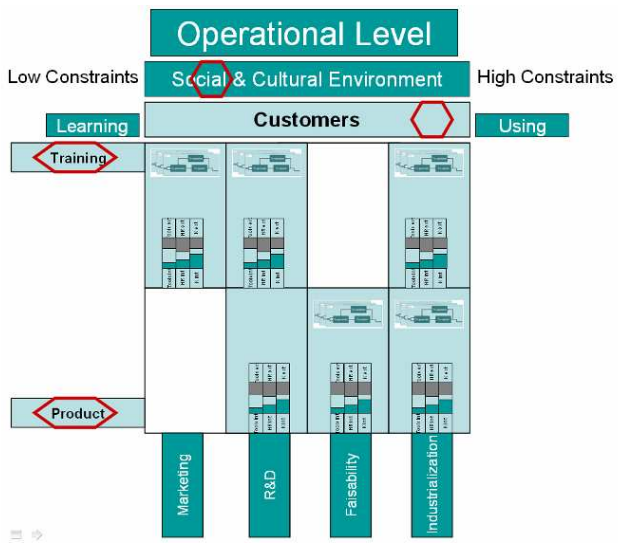

Figure 10: Final simplified model of learning decisions.

8- 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 represent not only an important internal innovation source but also, the firm can use the learning and generated knowledge as a tool for positioning of the firm on the market. After a state-of-the-art, we propose a learning positioning tool for firms. An illustrative example is presented at the end.
In short, 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 or using or something in between.

- to keep track of Knowledge generated in relation with the activity considered.

- to measure the variations between what the firm can do in-house and what it should 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.

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