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A NEW APPROACH FOR THE GENERATION OF INNOVATIVE CONCEPT FOR PRODUCT DESIGN

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Abstract

Due to the competition, innovation is a necessity in product design for the companies. We propose the using of creativity tools to generate innovative solutions just before a classical design process. The tools used are known, but the way of their using in the proposed approach is original. After a review and classification of different creativity methods and knowledge acquisition tools, a new approach for the generation of innovative concept for production design is proposed. This way has been applied on several industrial or pedagogical projects, and an example is presented.

Keywords: Innovative products, Knowledge, Creativity

1 Introduction

In the current worldwide context, the companies have to be competitive. In the framework of product design, at least three points are essential: technological monitoring, innovation and pro-activity. The first one, technological monitoring, is the necessity for the company to collect in real time product data concerning the competing rivals, every new patent related to its activity domain, and generally speaking all pertinent information on design (new components, technical press articles…) [1][2]. The web gives them today powerful tools to have access to information.

The second point, innovation, is relative to the capacity of the design service to generate new product or variation of product in a continuous innovation process. It is essential in order to make difference with products in competition, and because the client requirement is increasing [2].

The third point concerns the dynamic of the two first; the company must anticipate, and not only react to the events.

We consider that in upstream of the traditional design process, it is useful to consider a phase relative to the innovating solution research. The question is also “how find such original solutions?”.

In this paper, we propose the utilization of creativity tools to generate innovative solutions (there are probably other methods). We pretend, after use on concrete industrial or pedagogical projects, that the use of creativity tools is interesting in a general process design; we propose in addition to merge these tools in an integrated consistent approach.

In the second part, we present the results of an inventory relative to different creativity methods and their classification according to several criteria. This sort of tool is often utilized to solve a particular problem, for example in a quality demarche context; we propose to use

them in a design framework, and we show that the procedure is very similar. However, the research of innovations requires professional knowledge to improve designer's creativity. Four sources of knowledge are identified, and associated with three class of tools.

The third part is devoted to the presentation of a new approach. Our proposal consist of i) a problem identification (essential condition because the correct level of design specification is often difficult to find), ii) an inventory of the ideas previously imagined (and the cause of their abortion), iii) a precise definition of the criteria and constraints for acceptation of a new solution, iv) an utilization of creativity tools to find new ideas, v) an evaluation of the potential solutions in connection with the criteria and constraints and vi) the combination of different solutions to optimize the respect of the criteria and constraints.

The fourth part presents an experimentation, and some screens of the application software are developed to support our method.

2 Creativity methods and knowledge

Design activity is necessary when we are dealing with any kind of a project. The design process can include problem solving and, if necessary, creativity [1][3][4]. Traditionally, creativity focuses on the problem solving, and a design (or project) is built around a system to be developed or improved. Problem solving is the process required when we seek some kind of a resolution, such as removal of a drawback or achievement of a specific enhancement or improvement [4]. Problem solving usually includes creativity as a part of the process.

2.1 Definition

According to James M. Higgins [5], creativity is the process of generating something new that has value. Creativity is the capacity to generate new and useful ideas and solutions. For most authors, it results from the action of combining previously separate elements and changing existing combinations[6]. On the other hand, the complexity of creativity can be illustrated by the various disciplines that study it: psychology, sociology, management and engineering sciences, philosophy, etc [7].

Although creativity is multiple and has various forms, it is especially a cognitive activity that implies collecting and analysing knowledge.

There are many descriptions of the different stages of the creative process; they have in common the four steps shown by Wallas [8]:

- Preparation: the person becomes aware of a problem and is oriented toward investigation and information acquisition;
- Incubation: a period of subconscious work on the collected data that sometimes gives the impression that the problem and its solution are getting more distant;
- Illumination: the heart of the creative process, the brief yet intense moment when the new idea or the new solution emerges;
- Verification: the new idea potential is logically evaluated and compared to reality.

As we will see later, our proposal is based on these stages. After a review of different creativity methods, we detail here the preparation (knowledge acquisition) step.

2.2 Classification of creativity methods

We have explored the creative process and the creativity techniques usually used in companies. Studying the natural creative process, psychologists defined it as the trial-and-error method and have identified the phenomenon of psychological inertia. Hence, breaking psychological inertia and various techniques for stimulating creativity became the main target, along with the development of various procedures and processes [4][9]. In summary, these efforts were aimed at the following: unleashing natural creativity, eliminating mental blocks, stimulating and mobilization of resources helpful for generating ideas in a group or individually [5][6][10]. Knowledge-based creativity includes various analytical steps to organize, restructure and exploit available knowledge and experience and, eventually, it also utilizes specially-developed and structured external knowledge (innovation knowledge base).

By looking at existing creativity methods, a classification can be made. This classification has to help us to choose between the different methods, which are the ones that are more useful and appropriated in every case or with every culture. We have studied 172 methods. We propose a classification based on 10 families (see Table 1).

Table 1. Classification proposed for creativity tools.

Family	Number	%	Description
Brainstorming	50	29	Group people meeting to discuss on a problem. It is forbidden to criticize and any kind of idea will be welcome.
Checking list	40	23	That is a listing of questions which help the design team to describe the problem with a systematically way.
Excursion	32	18.6	Imaginary escape from daily entourage which aims at stimulating imagination and the creativity.
Matrix of criteria	17	9.8	Ideas are exposed with the criteria which will allow the sorting. Ideas with the most point will be selected.
Notebook	15	8.7	Report card or another support on which one registers the ideas at each time they are presented.
Mind map	10	5.8	Intuitive representation of the problem and the possible implications of the solution with assistance of a graph or the relations is represented by a connection.
Role	7	4	Simulation of a role which is not the characteristic in the objective to approach the problem under the different angle to even increase the creativity.
Relaxation	5	2.9	Relieving aiming at releasing the spirit to allow him to better fall apart of reality and to facilitate the creative process.
Perseverance	2	1.16	Attitude which makes it possible to be constantly ready to innovate and to find new ideas by the observation of the innovations.
Others	3	1.7	Unclassifiable methods.

Among these tools, we have chosen some of them which are integrated in our proposal. These tools are Brainstorming, Checking list, Triz Matrix and Animal crackers for analogical thinking. So, we have combined intuitive approach with the systematical one. Other tools can

be used, and our choice has been made in consideration of cultural user's customs. They are well known by engineers, and more easy to be practiced.

2.3 Knowledge acquisition

We have sought to integrate knowledge with the aim of improving creativity in the design process at two levels. Firstly, by helping designers to extract information from the environment and to organise it in an appropriate way. Secondly, by assisting them in an optimal use of this knowledge, especially in the search for innovative solutions.

The investigation of the design process, particularly its earlier phases, has helped us to determine the different classes of knowledge designers need. We have found four different types:

- Product knowledge: obtained by analysing the company's products or those of its competitors. Products offer a large amount of information about the ways and means of translating functions into physical architectures [11];
- Practical knowledge: provides information about the company's know-how and the way problems are dealt with. It also gives indications about the technical production possibilities and their related costs [12];
- Principles of physics: giving all formal knowledge about materials and energy (their characteristics, their possible associations...);
- Electronic data and patent data: they are a lot of different information systems but we have focused on electronic data because they are easy to find and store. They are one of the largest sources of technical information indeed.

Our experiments led us to favour three tools: Knowledgist, BDF Software and TechOptimizer. Figure 1 describes the organization of these tools we propose as well as the way they are mobilized.

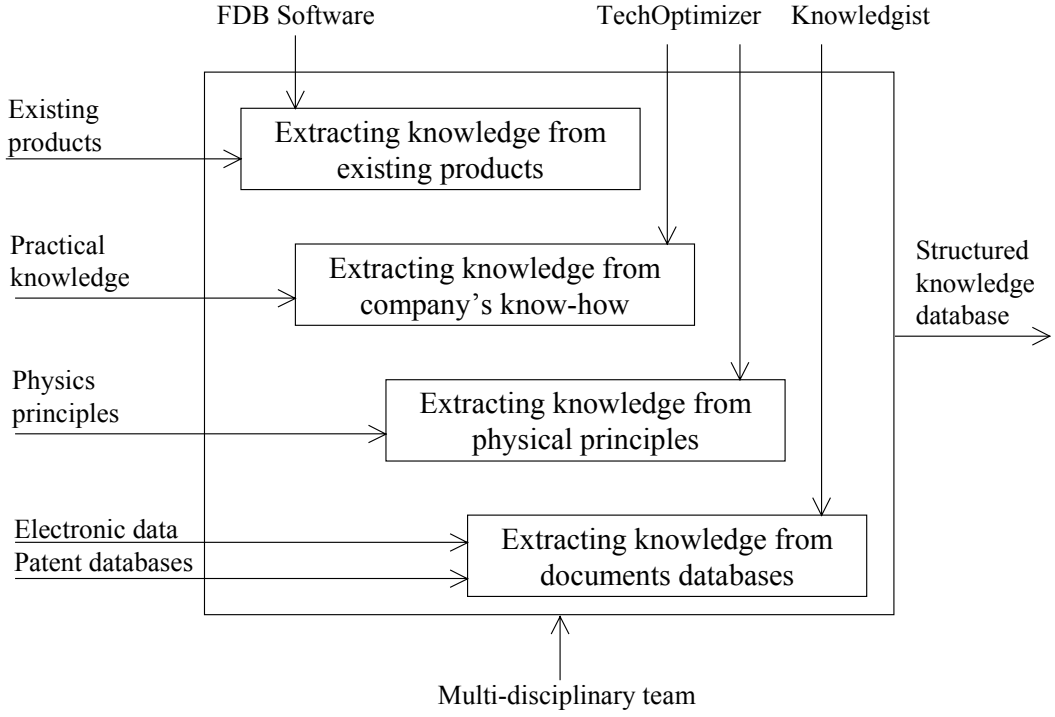

Figure 1: Process for the knowledge acquisition.

3 Proposal of a new approach

We are interested in the product innovation design process and especially in the phase of ideas generation. We propose a method which can enable us to integrate creativity tools in the early phases of design process. The approach we propose implies three different phases showed on Figure 2: knowledge acquisition, creativity and product design.

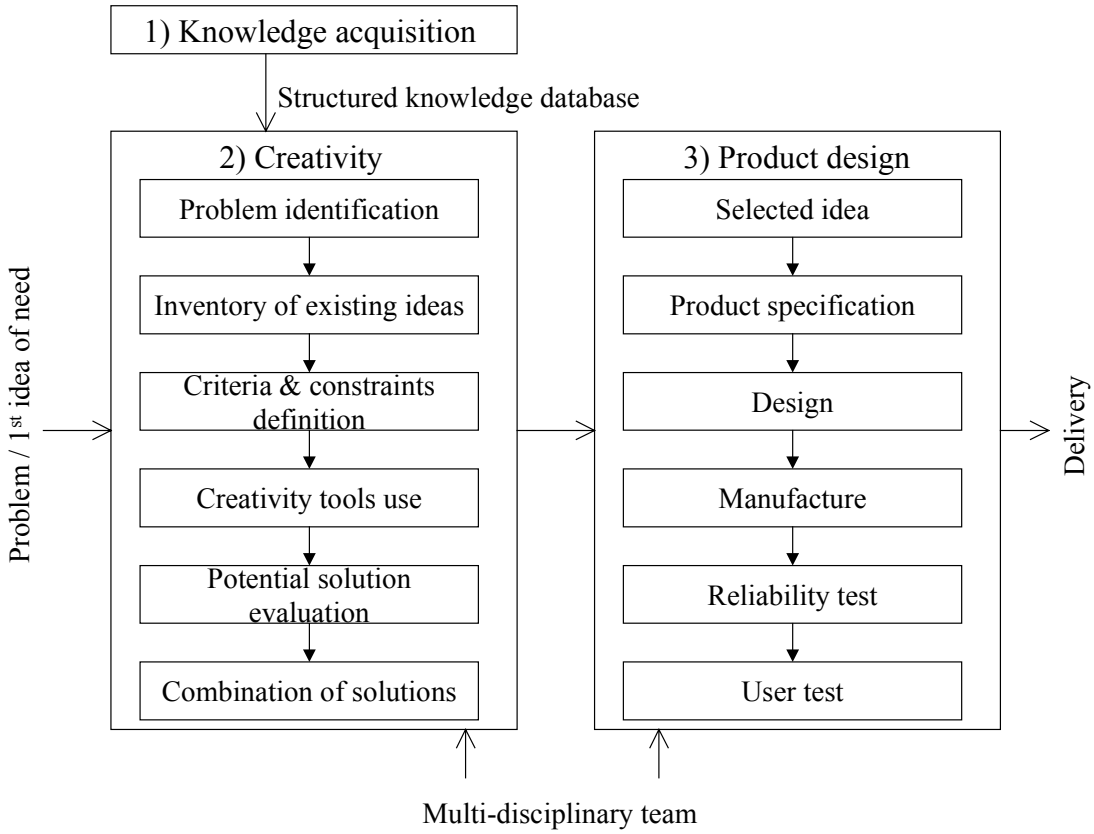

Figure 2: The three phases of the proposed approach.

The first phase has been previously presented, and the third is a traditional product design process, inspired from different known proposals[1][3], and will not be detailed in this paper.

The core of our method is based on the creative phase, in which we can find innovation. We have built this phase on six steps we detail hereafter. These steps are either individually or in group executed.

3.1 Problem identification

The first action is to define the need (i.e. the definition of the problem for the product or service design) expressed or not. We have to check that the problem is well defined and adapted to the context. The objective of this step is to clarify the true problem. It is justified by the difficulty to apprehend a correct level for the need specification.

We propose at this step a list of questions to help the design team to describe their problem and its context.

3.2 Inventory of existing ideas

Face to a problem to solve or a need to satisfy, each designer has often several solutions to offer, that have been explored previously. This step consists to list all these solutions and eventually the causes of their rejection, so as to avoid a designer hangs a precise idea up again, without ability to explore new opportunities. A technique of brainstorming is used.

3.3 Definition of criteria and constraints for solution acceptation

In this step, the team has to define the concrete, positive and measurable criteria and constraints a solution must satisfy to be relevant. These constraints and criteria will be estimated in a quantitative way. This step should be particularly well executed, because these criteria and constraints are required for the quality of the selected solutions.

3.4 Use of creativity tools

The fourth step is the production of original ideas. That is the really phase of creativity. The goal is to put the participants out of the context of the problem. We use here two tools of creativity. The ability to find idea is linked to the participant level of knowledge and to their imagination and abstraction power. In the aim to improve their level of knowledge (technical knowledge) we use the TRIZ method; the force of this method is based on its scientific bases [10]. And in the aim to improve their abstraction capability, we use “Animal crackers” of Grossmann.

3.5 Solutions evaluation

Each solution is then evaluated in regard to the criteria and constraints specified in step 2. A graphic representation in the form of histogram allows to facilitate quickly this evaluation of the ideas. Often, one rejects quickly the unsuitable ideas. The others seem "interesting" because they answer perfectly some criteria, but can manifestly violate some constraints. The designers can so search ideas combination to optimize the criteria respect.

3.6 Combination of different solutions

The last step consists in combining the ideas, so as to obtain an innovative idea which solves correctly the problem. Every selected idea is decomposed into independent points (5 maxi). These points are elementary ideas. Each point describes one characteristic of the principal idea. So each point of an idea, used separately, has not any significant, but they together describe the global principle of a solution. Our goal here is to build a new idea by a systematic crossing between each point of the ideas previously found. Several iterations can be so realized. We obtain an idea which has to be accepted by a study made by experts.

At the conclusion of this innovation process, we can begin a more classic process of conception of product / service.

4 Application: design of an innovative alarm

This study relates to the implementation of a innovative system to awake the people in the individual way (start idea). It is realized in the framework of engineers training in an engineering school (Ecole Centrale de Lille) renowned to be among the top 10 French “Grandes Ecoles” among 300 [13]. The students have a two years project to design and realize an innovative product’s prototype. But this approach isn’t only pedagogical: it has

been applied in several industrial projects, like a new concept of alarm signal in the train passengers transportation, in the aim to reduce the delay to re-start an immobilized train.

The practical application focuses on the second phase of our proposal, the new idea generation phase. We suppose that we already in the previous phase have gathered all the data and knowledge the design group could use in this phase.

- Problem identification: Table 2 shows the questions asked to the participants and some of their answers.

Table 2. Checking list of questions for problem identification.

Question	Answer
Briefly describe the situation which poses problem	When an alarm clock sounds, it awakes everyone.
Describe the situation (context, place, moment) where the problem appears	The morning, in a bedroom, the alarm clock sounds whereas people sleep.
Which are the current inconvenient of the situation (describe the principal points which must change)?	i) no selective alarm clock, ii) alarm clock of bad quality, iii) not very reliable alarm clock
Whose has more has to lose in this situation (which will lose ourselves if the problem is not solved)?	The person to be awaked. For the selectivity of the alarm clock, only the person concerned must be able to awake at time. Too much time wasted between the moment when the alarm clock is put in action and that when the person wakes up. Degree of stress of the awaked people.

- Inventory of existing ideas: The participants remember the existing solutions and why they do not work. Some of the ideas they found are: i) traditional alarm clock: no selective, ii) vibrating alarm clock: problems of reliability, iii) luminous" alarm clock: no selective.
- Definition of criteria and constraints for solution acceptation: Table 3 represents the criteria and constraints the participants have chosen (criteria and constraints aren't linked).

Table 3. Criteria and constraints for an alarm clock.

Criteria of success	Constraints
Selectivity: the system bust be selective	The system must be in conformity to the safety standards
Efficiency	The selling price of the product must be lower than 50€
Delay: time between the moment the alarm clock is put in action and that when the person awakes	The system must be reliable
Stress: the system has not to create stress at the wake up	The system must be adapted to the cultural context (sociology, comfort, ergonomics)
	The system must respect and do not disturb the sleep

- Creativity: The first tool used is animal crackers. This method makes link between our problem and an animal's behavior in several life situation (to find food, for example). In our application, this method showed the participants one animal to be observed: a bat. We can observe that a bat hunt when the night falls. It diffuses ultrasound. Some of the ideas issued are: i) to focus on the sound on the person to awake, the other sleeper is not disturbed, ii) to work on the nature of the sound to the alarm clock:

sound messages of various natures and various intensities, iii) adaptation to the personality of the sleeper: less stress, better quality of alarm clock, iv) to diffuse a noise (e.g. cicadas or music) and/or a colored light, which can facilitate the sleeping, v) to cut these sounds (lights) to awake the sleeper, vi) to diffuse an "odor".

The second tool is TRIZ: we use the principle matrix, a method that allows designers to link their specific problem to generic ones determined by an analysis of patents and scientific publications. The designers have to choice between several scientific parameter the which one they will improve and which one could be damage. This matrix gives generic solutions we can get inspiration from in order to generate a solution adapted to our present situation. In our application, we used for example principles of solution like temperature exploitation or preliminary action, who lead to several ideas like: i) to exploit the variation in temperature (to cool the bed and to heat the flat), ii) to envisage a phase of pre-alarm clock, preparing the sleeper with the alarm clock itself (i.e. soft music), iii) idea of a pedagogical alarm clock who helps the sleeping monitoring, iv) to diffuse in loop the objectives of the day.

- Solutions evaluation: This analyse is based on the already selected criteria and constraints. We note that criteria and constraints are randomly opposite in a graphical representation. The light zone corresponding to a criterion is proportional to the satisfaction of this criterion. In the same way, the dark zone corresponding to a constraint is proportional to the non-observance of this constraint. An "ideal" solution thus maximizes the light zone, and minimizes the dark zone. Figure 3 shows the evaluation of one of the twelve solutions founded.

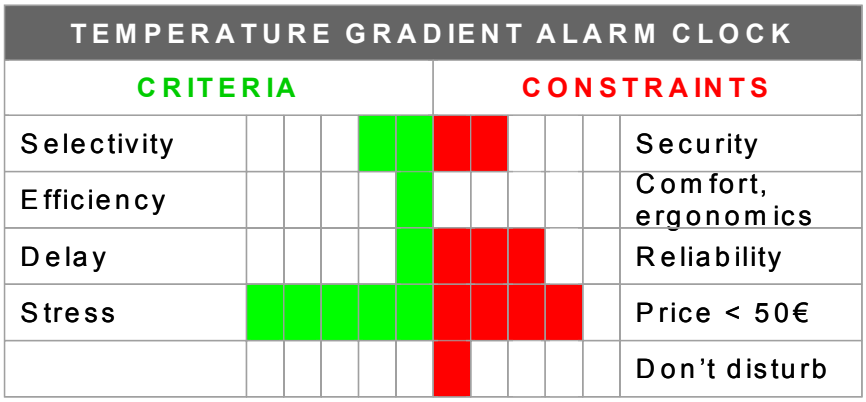

Figure 3: Evaluation of the solution "temperature gradient alarm clock": this solution does not answer well to the selected criteria and constraints (too much dark zone).

- Combination of different solutions: The participants try then to reconstruct new coherent ideas by combination of several ideas. These new ideas are again estimated thought criteria and constraints. One of the obtained solution has the following characteristics: i) the sound is precisely focused on the person to awake by an unidirectional loudspeaker, ii) the alarm clock gets under way approximately half an hour (adjustable time) before the alarm clock with a soft music and of progressive intensity, iii) a few minutes before the hour of the alarm clock, a system of voice synthesis states the appointments of the day, and work to be made (possible connection with an electronic message minder), iv) the sound of the music increases gradually and stops abruptly at the precise hour of the alarm clock (idea of the "anti-alarm clock"). Other more innovative solutions have been founded, and are actually in development.

SELECTIVE PLEASANT ALARM CLOCK											
CRITERIA						CONSTRAINTS					
Selectivity											Security
Efficiency											Comfort, ergonomics
Delay											Reliability
Stress											Price < 50€
											Don't disturb

Figure 4: Evaluation of a selected solution.

We obtain an idea which has to be accepted by a study of ground, and a more classic process of product design can begin (phase 3 of the Figure 2: Design process).

5 Conclusion and perspectives

In this paper we have proposed to use creativity in the design process. We recommend an overall approach that acts at different moments and takes into account the environmental, personal and technological dimensions. Our vision of creativity has a direct impact on the way we develop innovation through improving creativity in companies. This representation points out the importance of knowledge during the creative process.

A software tool was realized as a support of our proposal, which can give place to a presentation. It follows exactly the presented approach, and is open to receive new tools.

A global action does not simply mean action on separate levels. It also implies building bridges between them, to work on each level wondering how it is linked to other ones. In this sense, a global approach to creativity could lead to various actions:

- Designing ergonomic tools and methods that correspond to practitioners' reasoning and their problem solving processes: technology serves people (and not the contrary);
- Designing flexible tools or linking them in order to ease their implementation in the various organisational contexts in which they are supposed to be used: a form of environmental ergonomics;
- Designing training courses that develop individual skills to get increased benefit from the knowledge contained in the environment: learning to learn and also learning to be more open and receptive.

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