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EVALUATION OF THE POTENTIAL PERFORMANCE OF INNOVATIVE CONCEPTS IN THE EARLY STAGES OF THE NEW-PRODUCT DEVELOPMENT PROCESS (NPDP)

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1. Introduction

The world changes quickly, launching new challenges incessantly. Innovation is incontestably one of the big responsible of companies' growth and a crucial element for competitiveness. Modern organizations are dedicated to innovation, exploitation of ideas, and new discoveries. A recurrent issue is the consideration of relevant and intensive new approaches of innovation which is able to continuously feed the market with new products.

Innovative concepts must always be acceptable by end-users and correspondent to their needs and necessities. Evaluating the impact and the potential of new ideas before developing it, implies taking into account a wide duration scale and different public targets. Promptly estimating the relevance of the objects resulting from idea generation in the new-product development process (NPDP), or "evaluate their potential performance" is essential to innovative companies. This phase corresponds to the early stages of the process, i.e. from the birth of ideas, before the embodiment design. At this stage choosing the right idea to be developed is crucial for the project deployment.

Despite the relevance of an effective evaluation, this stage is currently carried out in a subjective way. The majority of the tools available are designated to a posterior phase, i.e. where the amount of ideas to be evaluated is lower (since this ideas come from a first raw selection), and the option to confront end-users can be pictured. The main challenge of this research project is to evaluate new ideas in a fast and reliable way very early in the innovation process. In this phase, many ideas can be represented in several ways, for example, an idea-card. On one hand, evaluating them without taking the risk of wasting good ideas, and in the other hand, not wasting time and money developing an unsuccessful idea, is primordial. An adapted evaluation tool, which can help decision makers during the fuzzy front-end of the innovation process, proves to be important and useful in this stage. It is pertinent to formalize and rationalize this first selection, since it generally precedes projects that require high investments and are particularly risky.

2. Scope

2.1 Work Positioning

Precisely evaluating ideas which come up during the design stage is essential in order to avoid over costs. The evaluation is considered to be the most critical stage in the design of new products, due to

its various constraints [Ozer 1999]. However, two evaluations seem to be possible, one carried out by the experts and one by the users. The two ways to accomplish it are [Senach 1990]:

1. The empirical evaluation consisting of evaluating the users' performances, and interpreting their behaviours, attitudes, and opinions;
2. The evaluation by inspection, which is carried out by experts who apply "in a more or less explicit way the evaluation criteria".

Usually the methods and tools that exist to help the evaluation, for example: COOPER, O'MEARA Matrix, INNOSCRREN, PUGH Matrix, VEITCH diagram, buying intention, focus group, analogy, multi-criteria analysis, information speeder up, etc. are empirical evaluations. To carry out the evaluation, these tools require ample amount of time, often requesting customers' opinions, which are usually dedicated to a reduced quantity of ideas. Nevertheless, this kind of evaluation becomes inappropriate when facing a high amount of ideas. It is necessary to formalize and reduce the subjectivity of this evaluation in a fast enough manner. The decision makers are missing a tool for doing this but they do not want to spend more time evaluating ideas at this stage.

We can conclude that there is a lack of existing tools and methodology to carry out the evaluation by inspection. This kind of evaluation is pertinent when we have an important amount of ideas which need to be screened quickly and the method frequently involves the instinctive judgements of experts (decision makers). This task often lacks precision and the confidence levels on the judgement contribute to various degrees of uncertainty. The lack of a precise reasoning results in a purely subjective evaluation.

Using an Innovation Platform called Cré@ction, these problems have already been treated at ERPI Laboratory (Team of Research on Innovative Process) in the INPL (Institut National Polytechnique of Lorraine). In the framework of a partnership with companies acting in the "innovation" field, particularly in the early stages, Cré@ction is a place where real cases are treated. The platform supports innovation and methodological research on this subject. Its activities relate to methods, tools and competences, allowing for the optimization of innovative projects management.

Cré@ction represents a fundamental position in our research. It is a place of confrontation and cooperation between researchers, students, businessmen and communities in a sense of mutual exchange of work methodologies and experience sharing. It enables us to carry out pedagogical projects and industrial experiments in order to consolidate this study.

Researches in the early stage of the innovation process, carried out previously by the Cré@ction team evoked the necessity of new development tools and evaluation methods very early in the design process. In our research, we focus on evaluating the ideas that are represented by an idea-card format. This is a common manner to represent ideas on this phase of idea generation.

2.2 Innovation issues

At the beginning of innovation projects, the numbers of variables are very high; therefore risk and uncertainty are important. That explains why the "rationalization" is moving to the early stages of design, i.e., towards the research stages and preliminary drafts. This movement to the early stages implicated important evolutions in project management during the last years. In addition, this fact clarified the need for new approaches and instrumentation [Miller 1999].

The uncertainty in innovative projects is not only technological and economic, but also organizational. That is due to the fact that we do not know precisely in advance, which are the tasks to be carried out, neither the resource allocation. Uncertainty is also cognitive because it will be necessary to develop new knowledge and competences. Consequently, controlling the innovative projects with traditional project management methods has proven to be difficult. The challenge is to learn how to manage uncertainty.

The beginning of an innovation project is the only moment when individuals can guide the flow of events. The choices tend to become irreversible when a great number of actors are already involved, and it's difficult to come back the traversed way (path dependency). The decisions taken during the early stages of the process are more significant than the ones taken afterwards (development stage). It is suggested to eliminate as soon as possible the projects with low potential, because it is less expensive to choose concepts than to note a commercial failure later on. In the early stages, the ideas

are first generated, then selected, and then will finally be developed. It is necessary to highlight that there are several evaluation sections, starting from the one where there is a high number of ideas to be evaluated, then on to a more specific evaluation of the ideas coming from such first selection, and finally, only a few ideas are going to be developed. We are especially interested on evaluating the initial set of ideas and to define the collection of pertinent ideas to be able to carry on the process.

2.3 Evaluation

The term "to evaluate" basically means to help make decisions. It is a process that allows to define and to obtain useful information. Evaluating the acceptability of an innovation in the early stages of the design process means to predict if a product or a service will be well perceived by the market before the product is even developed, i.e., when a new idea or concept has just been generated.

Anticipating the acceptability of a product or service by the end-users is, for a company, a source of profit but evaluating the acceptability in this stage is a complex task. The product or service is not yet entirely described. Moreover, evaluating a product not inserted into a context, i.e. not present in its environment of use brings a bias, in particular, on the level of value attributions to the products or services. Evaluate a concept acceptability means to evaluate what does not yet exist, at least not completely. This set of uncertainties constrains the evaluation during the fuzzy front end.

During the first concept selection, just at the end of the idea generation stage, these ideas/concepts can range from a few to hundreds. Also at this stage, we handle the "product concept" or the "service concept" [Roussel 2001], which have not solidified characteristics yet. However we consider a concept as "an idea that is sufficiently developed to evaluate the physical principles that govern its behaviour" [Ullman 1997]. However confronting these concepts with users is very difficult and would require resources, especially time. In consequence, on a first assumption, we consider that a first evaluation should be carried out by experts or decision makers.

The evaluation by experts is a communication on the ideas' value, this is essential to estimate the quality of the concepts once they are created. Normally, there is not a standard on the profile of the people who take part of the evaluation team and neither in the manner in which the selection is carried out. The real context in industrial environment is very unequal; companies do not proceed the same way. The concept representations modes are also very diverse, different formats are possible depending on the creativity method that was employed or on the amount of time that was devoted to the development of concepts. Formalized in different ways, a concept remains a general mental and abstract representation of an object. There are several tools for formalization: textual representation, rough, idea card, data-processing representation 2d and 3d, functional model, aspect model, prototype and preproduction. These objects make it possible to communicate about the idea.

The idea card, very often employed by the companies, presents briefly the idea, detailed by text, diagrams or drawings. Our preceding works carried out in collaboration with EDF, enabled us to formalize a specific idea card named "IdéeFix" [Maxant 2004] (see example in figure 1). This card permits to formalize the concept environment, to describe the idea by texts, and adds a situation sketch where the product/service is described during its utilization, and furthermore to position the concept compared to what exists. This card allows the text reinforcement by an illustration (photo assembly, drawing, rough...). Hence, this first simulation allows for diffusing and for better communicating on the use and functions surrounding the idea. Its primary objective is to present the idea according to various stages; its secondary objective is to gather information to select ideas and to prepare their evaluation.

Formalizing the concept in the shape of idea card, allows:

1. a presentation in a formalism appropriable by other actors than the participants of the creativity meeting
2. the concept to be confronted effectively because it is necessary that the experts understand what it is proposed since the idea generation
3. to connect the designers world and the real world, by proportioning the idea evaluation
4. to choose a single idea support using the same structure. This has the advantage of capitalizing the ideas in an "ideas" database [Piat 2004].

Figure 1. Idea-card example

3. Research

Interested in evaluating as soon as possible the relevance of the objects resulting from the idea generation stage, we perceived that designating to these objects the notion of performance (success and failure criteria) is a difficult task.

Research showed that the early stages' evaluations were limited, because the experts had difficulties in evaluating the product as a whole, and were concentrated only on certain criteria [Klopfenstein 1989]. It is proven that without a precise procedure which is structured and based on defined criteria, the possibility of making an unsuccessful or a false evaluation increases considerably. Then, considering the importance of these decisions and their consequences, the use of an effective methodology is justified.

Needing to be evaluated quickly, the amount of ideas to be treated is also an obstacle for concepts evaluation. The option of confronting the idea with potential users or applying panel tests reveals to be almost impossible to be done in this phase. We noted that the decision to continue or not the development of an idea hardly lasts more than a few seconds. Moreover, it is apparent that experts' behaviour can persuade a decision. According to these observations, we listed the main factors which generally make it difficult to evaluate the ideas in the early stages of design:

1. The evaluations are subjective and there is not a methodology to follow
2. Experts character/personality can influence the decision
3. High amount of ideas to be evaluated
4. The evaluation (at this phase) must be done fast

The purpose of this research is to evolve from a subjective evaluation to a reflected and instrumented evaluation. This way the teams are confronted to their choices, allowing the regulation of the action, valorising and facilitating its diffusion. We aim to develop an evaluation methodology which can make the originality of the procedures intelligible. For this, we consider an evaluation where speed and enhancement are well suited with the organization's objectives. Supported by the literature exploration and by the experience of the execution of research projects in "laboratory" conditions, industrial conditions and in pedagogic conditions, it seems to be interesting us to investigate the hypothesis that **an evaluation structured by a methodology which gathers a set of rational procedures according to performance criteria allows to determine effectively the performance potentiality of the innovative concepts in the early stages of the innovation**.

3.1 Evaluation criteria

In projects carried out at the Cré@tion Innovation Platform in the INPL, we noted that the context of ideas selected in the early stages of design generally evokes three points to estimate the characteristics of a concept: sales performance, industrial feasibility and economic viability. Based on these indexes, we used as a support the "ZEITGEIST Theory" of Davenport and Prusak [Davenport 2003] to develop our evaluation procedure. The ZEITGEIST is a German word used in English vocabulary which means "the spirit of time", i.e. timely. This principle explains that "an idea cannot be a good fit unless it is also well timed". "Good fit" referring to the technological and economic aspect and "well timed" is a reference on the political and social aspects. This theory reveals the economic, technological, political, and social environments in which an idea is founded upon.

This conjecture enables us to postulate that the key to success of an innovating product or service is the interplay between the success on the technical, economic and social aspects. It is the complex crossing of these environments that can determine "which ideas will flop and which ideas will fly". Evaluating the power of an idea in the early stages consists in estimating the potential on these three principal aspects. Each aspect is composed by various important criteria responsible for the success of an innovating product/service and they must be considered in order to ensure that all aspects are integrated.

The set of various criteria that have been proved to be important during the idea selection is expressed on figure 2 according to their classification, based on the three principal aspects indicated in this paper. This figure is a non-exhaustive list that presents the set of criteria considered as the most important by our research team. They are not independents, as said before; it is the interplay of these criteria that can determine the concept acceptability.
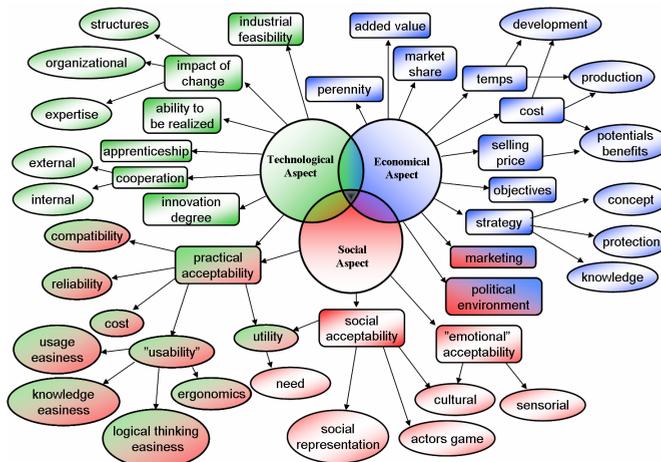
Figure 2. Evaluation criteria deployment

It is very important that this group of criteria is well defined to allow the experts to use them at the time of idea selection. For this reason, we studied attentively these criteria so we could identify them suitably.

Each criterion listed in figure 2 corresponds to an aspect (technological, economical, and social) and they are related to a colour (green, blue, and red respectively). Some criteria can correspond to more than one aspect at the same time, as we can observe in the figure (colour intersection).

3.1.1 Technological aspect:

Technologically, not only industrial feasibility must be considered, but also the impact of changes within the organization and some other criteria showed in figure 2. These organization changes can be at three different levels: on the structure level, at the organizational level, and the business exerted by

the company. Also, it's interesting to estimate in advance if developing an idea can build up activities of cooperation between companies or internal services of the organization, or if it amplifies an expertise.

It is also necessary to identify what is the innovation degree of a concept proposal, because an idea that does not show new characteristics compared to what already exists, is not interesting, it has a strong risk to failure, and tends to be rejected.

3.1.2 Economical aspect:

To look further into the economic character during the idea evaluation, it is essential to estimate the selling price and the potential benefit. It is also important to evaluate according to the company objectives and estimate the production and development costs, as well as the time to market that it will take.

The identification and targeting of the potential market cannot be ignored during the evaluation of the ideas. Likewise, the industrial protection of the concept must be considered because it is very important for the future of a product or service. Based on these criteria, the expert creates elements to estimate the potential of an idea. The marketing aspect of an innovation proves to also be fundamental to its success and must be taken into account from the beginning. The rejection from a marketing point of view can put an end to the development of a concept.

3.1.3 Social aspect:

Concerning the social aspect of a product or service the term "acceptability" must make it possible to give a first positioning of a concept compared to the users. The social aspect is divided into three sub-criteria [Nielsen 1993]: company acceptability, which takes into account the social and cultural representation, the "emotional" acceptability that also considers the cultural concept but takes into account the sensorial perception and the practical acceptability (like ergonomics, utility, reliability and also the cost, among others factors).

This set of sub factors represents the main criteria used to determine the potential success of an innovative concept. It is essential that the criteria be studied as a whole and not separate by studying each factor [Maxant 2004].

3.2 Method

The method created from our research is going to be presented step-by-step and its synthesis is shown in the following figure:

Step 1: *Indication of company's objectives and strategies*

In our new idea evaluation system, before initiating the selection, the experts must indicate the objectives and strategies of the company and project. In doing this, they will be better able to fit the choices which they're going to make on step 2 with the corporation profile.

Step 2: *Selection of main evaluation criteria*

The people in charge of the evaluation have to choose the main criteria (between 3 and 6 by category), which represent each principal category; technological, economical, and social, according to the intentions of the company. These choices are made among the criteria presented on the figure 2. In a few words we expect to have about 14 criteria to be analysed on step 3.

Step 3: *Designing criteria as an opportunity or a risk*

This step is inspired on the SWOT matrix. The SWOT analysis (or SWOT matrix, coming from the words Strengths, Weaknesses, Opportunities, Threats) is a tool for strategic planning. SWOT makes it possible to analyse the external and internal environment of a project, helps to identify opportunities and threats, and also distinguishes the strengths and weaknesses that the company transmits to the project.

Based on this reasoning, we ask to the experts to place each criterion, chosen on step 2, as an opportunity or a risk. The experts must always have in mind the company's objectives and strategies during this choice. This classification is going to be used to calculate a potentiality index of the ideas on step 5.

Note that in steps 1, 2, and 3 are carried out only one time for a specific group of ideas. From step 4 we start the specific evaluation of each idea.

Step 4: *Criteria grade classification*
In order to formalize the confrontation of criteria, during the idea evaluation, each criterion is imposed to the experts in the form of questions and numerical answers (scale from 1 to 5). .
Following the logic of step 2, we are going to have about 14 questions to be answered (one for each chosen criterion). The expert has only to notch the more adequate answer. These questions permit the experts to think about the points that they would probably not consider at the time of the idea evaluation. It also allows "to discover" some positive or negative aspects relative to the new idea very early in the design process.

Step 5: *Acceptability Potential Score*
This index is calculated through a ratio between the grades allocated on step 4 considering the classification as OPPORTUNITIES or RISKS done in step 3.This is done for each category:
1. Technological Potential Score (TPS)
2. Economical Potential Score (EPS)
3. Social Potential Score (SPS)

Clarifying, each and every one of these indexes is the grade point average of the criteria, considered as an opportunity divided by the grade point average of the criteria considered as a risk for each category.
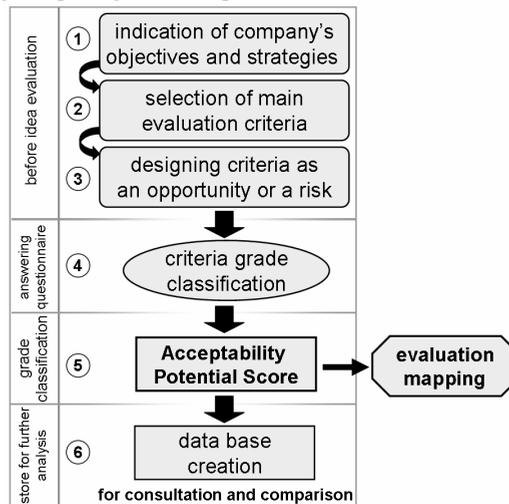
Figure 3. Method steps

These formulas are used to create scores for each category, and with these figures we can calculate the index of acceptability "APS":

$$Acceptability\ Potential\ Score\ (APS) = TPS * EPS * SPS \tag{1}$$

If one of the indexes is lower than one (1), it means that in this aspect the risks outweigh the opportunities. In doing this, the less interesting aspects of the idea are quickly identified, and we can conclude that the idea is obviously risky. According to the indexes a decision can be made in harmony with the organization's objectives.
Using these scores, the ideas can be classified and compared one to another according to the several chosen criteria. To support the visualization of the results, we propose a table (mapping) for each idea. We can see the placement of the various aspects and their category, their grades attributed on step 4 (and represented by the balls size), and their classification as risk or an opportunity (done on step 3).
We give an example of this mapping with real values of an idea evaluation on the following figure:
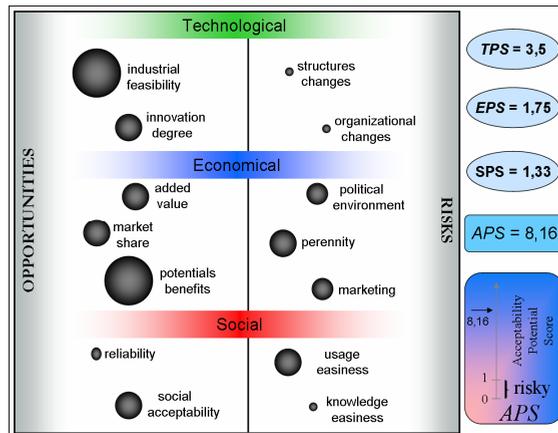
Figure 4. Evaluation mapping

In addition, we consider that the answers can be given manually on paper, or numerically on computer. Currently, we are studying the integration of our evaluation method with IdéoFil©.

IdéoFil© is a computer software which is a collaborative WEB application that is being developed in association with "Le Plateau des Innovations" (service ICAME-EDF R&D) and ERPI. This application is designated for creation, communication, transfer and capitalization of concepts, and innovative ideas in the early stages of design. In its 2.0 version, it will allow us to create a database with the ideas and its criteria, and to have a history and an interesting visual interface. With this application it will be possible to share, formalize, and to capitalize the information enclosed within the ideas. It will also allow the carrying out of an evaluation with experts who are geographically separated.

When the questionnaire is answered by hand, we use a digital pen (first developed by Logitech©) and ANOTO© Paper, which consists of numerous intelligent small black dots that can be read by the digital pen. This tool identifies the coordinates' position on the paper making it possible to send instantaneously handwritten information to a computer that calculates, thanks to our application, the potential of each idea evaluated. By doing this, the data processing is facilitated and accelerated.

In summary, the described method wants to ensure that a set of fundamental criteria is taken into account from the start of the process. The objective is to make the evaluation reliable and to make it possible to announce the good or the less interesting points of an idea. This method is an important assistance tool to the idea selection in a first approach of evaluation, because it permits the attribution of various scores and to classify the ideas.

In order to test our proposal, we carried out some experiments in a pedagogic environment and also in an industrial environment. This empirical observation will be further detailed in the following section.

4. Experimentation

We carried out our experiments at EDF, a French company that produces, transports, and distributes electricity. Our application took place, more precisely, in their research and development department (EDF R&D) and in the service ICAME (Commercial Innovation, Markets and Environment Analysis), which works with the design of products and services related to electricity. Leader of the French market, EDF is a company attentive of innovations evolution. EDF is concerned with the anticipation of offers in terms of products and services related with the supply of electricity, to propose customers satisfaction, and maintain their place on the market.

A total of 380 ideas concerning electricity, a priori innovative, were presented to the experts of EDF R&D. These concepts come from creativity meetings carried out by engineering students from ENSGSI at INPL during a pedagogic creativity training called "48h for innovation©". All of these concepts were then presented to the experts in the form of idea cards.

Initially, the intention of this experiment was to observe the current manner used by the experts of this company to evaluate and select the cards. For this, we recorded the whole work using a digital camera. Following, we then questioned the experts about the aspects of the current evaluation method and what they wished to improve. We then proposed to them to use our evaluation method, in order to test and to try it out in a real situation. Afterwards, we confronted and compared the current method used by EDF R&D and our method. The analysis and the validation of our hypothesis remained our crucial purpose.

To validate the hypothesis mentioned above, we were particularly focused in examining the criteria's coherence and the cadence of evaluation. Finally, we quantified the time used to select the ideas on the current method and the one used in our proposal.

5. Results

In their evaluation, the experts of EDF have chosen to classify the ideas under three categories: those which are good, those with potential, and finally, those which were concluded non-interesting. During three hours of selection, they evaluated 218 cards, and consequently, they spent an average of almost a minute per card. Among the idea cards analysed, a little less than 87% were judged uninteresting, which represent 191 cards. Among the remnants, 16 have been classified good and 13 with potential.

This experiment was very important to our research and allowed us to make several conclusions. Preliminary, we confirmed with the experts the need for an idea evaluation method better organized and structured. They affirmed that there is not a precise formalization, and that each meeting is different, which brake a better performance of their actions. They confirmed that the subjectivity degree of their analysis is very high and that there is too much uncertainty. The experts expressed the desire of having a reliable and formalized evaluation method. They would like to have the possibility to take trainings, helping them to carry out a credible and well-supported selection.

During this experiment, it was revealed that once an idea is not selected, it is abruptly abandoned and it will no longer be reviewed. Taking into consideration the ZEITGEIST principle, which postulates that an idea must be launched at the right time to become a success, it is possible that an idea rejected today will be accepted tomorrow. Consequently, it seems to be interesting to create a database which can be consulted from time to time. Besides, in the system that we propose, the ideas would be classified and a specific research could be carried out later.

It was verified that the experts use some excluding criteria, which allows "to disqualify" an idea very quickly. These criteria are the degree of innovation, technological feasibility, and the economic viability and the strategy of the company. These criteria are very easily identifiable, they automatically appear to the experts, and consequently, they don't waste too much time with ideas judged not good on one of these criteria.

At the end of the evaluation carried out by the R&D experts from EDF, they were exhausted. They confirmed that the last ideas analyzed were penalized, because the attention was not the same from beginning to end, therefore, the risk that they have wrongly evaluated is greater. After a few hours, the selection becomes almost mechanical, and it is possible that good ideas were excluded.

Afterwards, the method developed in our research was proposed. The experts said that the method proved to be useful, making it possible to identify the ideas characteristics and to classify them comparing with others. However, when applying our method, it takes significantly more time. The average time to answer the proposals was 3 minute per idea and the experts were dissatisfied with this aspect. Despite the desire to have a more structured evaluation tool, they do not agree to take more time to evaluate the ideas.

The best selected ideas using our proposed method were not necessarily the same ideas selected in the previous subjective evaluation done by the experts. This can be explained by some criteria that was not imagined and considered in the subjective evaluation.

The main advantage of our method was the possibility of having rankings for each criterion. In addition, having a numerical index which allows for the classification of ideas showed to be pertinent. If an idea does not have a good classification in some criteria, it does not mean that it must be rejected, but the points to be improved are already identified and it is easier to execute further analysis.

We think that the selection method suggested by our research is able to change the evaluation subjectivity, by formalizing the procedure and fixing precise criteria. Furthermore, it can contribute to the prevention of the influence of different expert's opinions. And finally, proportioning the creation of an idea database where the ideas are classified proved to be very interesting. On the other hand, the time necessary to carry out the evaluation showed to be a disadvantage compared to the current method.

6. Conclusion

The need for a decision-making tool to evaluate and classify ideas starting at the early stage of design was confirmed. Today, the experts use their sensitivity and experience to evaluate the ideas generated by creativity. It is possible that a good idea escapes their sensitivity. Besides, it is not necessarily good to precipitate a product's launch, because the innovation is not efficient if people are not ready to accept the changes required to prepare it. To develop a concept until its commercialization requires large investments. Screening starting at the birth of ideas is fundamental for the innovative company.

Through this research we present a first approach of an evaluation method that aims to support the early stage in the NPDP, particularly the ideas selection. The experimentation carried out at EDF enabled us to develop the criteria which were considered to be the most important and to help identifying the improvements to be made. In our perspective, we are working on the insertion of our procedure in the WEB collaboration tool IdéoFil. In this interface, the databases will be indexed and it will be possible to carry out research on an "idea" database.

Reducing the time necessary to carry out a selection is one of our primary objectives. To do this, we are studying the definition and the integration of excluding criteria in our procedure.

Developing this tool to support the early stages of innovative product design remains our main objective, aiming to minimize errors and to avoid that the companies launch unsuitable offers.

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