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Measuring inventive performance of R&D teams

Ali Taheri^{a*}, Denis Cavallucci^a, David Oget^a

^a INSA Graduate School of Science and Technology, LGECO; Design Engineering Laboratory, 24 Boulevard de la Victoire, 67084 Strasbourg Cedex, France

Abstract

As any science on progress, there is no serious claim of mastering a process that is not carrying its own legitimized means of being measured. TRIZ world is now becoming a stable and progressing community where contributions of various levels, nature and depth will undoubtedly continue to appear. How can we contribute to its performance, how can we detect what is lacking and investigate in TRIZ world, new areas of contribution?

This paper proposes an investigation of the existing means in creative measurement applied to industry and draw a state of the art and discussion regarding its limitations. Then the paper reports about a survey we built to understand R&D director's expectations regarding an eventual indicator. This survey yet concern a narrow spectrum of the entire industry because we first wanted to analyze results out of a smaller sample and either by extension or with larger survey compare industries, then complete and fine tune our first conclusions.

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Keywords: Inventive design performance, R&D, Inventive efficiency, TRIZ, Inventive design method, Metrics, Indicator;

1. Introduction

During our last years of scientific investigations in TRIZ, we found out that critics often arrive from the side of the results offered by Inventive Studies. While ideas are not felt by companies as a clear contribution that comes from TRIZ itself, the fact that these ideas have a certain level of appropriateness to solve relevant tasks is not evident from an observer's viewpoint. If we add to this the old habitude inherited from Osborn to consider that quantity of ideas makes quality of this latter, the company is tempted to compare TRIZ to brainstorming if this is the only results we can propose. Here we need measuring inventive design performance (IDP) which is involved with the performances areas of the activities which are realized by actors (inventors/engineers) within a well-structured process such as inventive design method (IDM), derived from TRIZ, to solve problems and propose innovative products.

Indeed the capability of measuring performance of such inventive design method, if legitimized, will enable us to prove TRIZ power versus other methods. In fact this research investigation lies in the continuation of evaluation and measurement of creativity, creative processes, teams' inventiveness, and companies inventive abilities aiming at filling the gap in establishing a standard regarding these issues in our industries. This paper in the second section attempts to verify requirements of measuring the performance to assess the inventive design activities within a process. The third section represents a case study as a methodological approach of the research which is sent to R&D teams with the aim of building an inventive metrics and measuring inventive design performance.

2. Inventive design performance (IDP)

At the first stage for measuring inventive design performance, we need to find a way to evaluate inventive design activities (IDA). Inventive design activities in a R&D teams emerge by its actors in relation to a problem solving process to transform a problematic situation in an inventively solved one, eventually characterized by a product. Thus the evaluation relies on measuring the performance of problem solving process namely inventive design method (IDM).

Between various definitions of performance, in engineering design, defining performance by efficiency and effectiveness, profits, a classical definition which is the base to establish various definitions according different performance objects [4][10]. These two latter are the fundamental elements that can cover the overall aspects of performance. Due to this we need a detailed understanding of these two elements and their compliance with an inventive design method/process.

2.1. Efficiency

In fact efficiency is the ration of useful work performed to the total energy expended as expressed in [20]. Thus for an inventive design process efficiency is the relationship between what has been materially gained and the level of resources (material) used [4] (Figure1). Therefore it's necessary to evaluate the result about inventive product (artefact) as well as listing the resources used along inventive project in R&D teams. Inventive design process efficiency represents an integrated efficiency which consists in the efficiency of all activities of the process. Here, in a preliminary phase, we consider inventive design process as a robust design system with its input, output, resources and goal according Duffy et al. 2005 [4]. Defining type of input (I) and output (O) is a critical point which at the best state by considering the different definitions according related factors causes to expansion and evolution the dimensions of performance measurement.

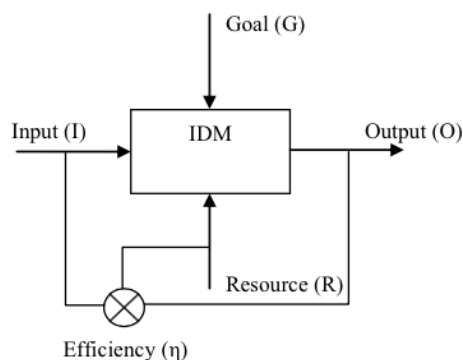


Fig.1. Efficiency of an inventive design method /process

Then we have:

$$\eta(IDM) = \frac{M^+}{R} = \frac{O - I}{R} \tag{1}$$

where:

Nomenclature	
η (IDM)	Efficiency of an inventive design method/process
M^+	Material gain
I	Input
O	Output
R	Resource used

2.2. Effectiveness

For inventive design method, effectiveness ensures having a definite or desired effect [20] to achieve a goal. Here the degree to which the result meets the process goal is the main objective in relation to inventive design method, i.e. comparison artefact (final product) with project goal (Figure 2). However it measures the results obtained from design activities in macroscopic scale. In microscopic scale it can define effectiveness of each activity which is included within the process.

Thus assessment of the inventive product (artefact) seems to be in this part and also can be as a raw material for measuring the efficiency of an inventive design method. Any effort to measure effectiveness of each activity within IDM is placed in the next phase of research.

Evaluation and measuring an inventive product is a vast field which involves technology and sociology beyond financial aspect. To achieve this, we rely on three issues which are acceptable in measuring inventive design studies and those that are main tangible criteria (like patents for instance). These three are ‘inventiveness’, ‘novelty’ and ‘usefulness’ that make sense with the assessment of an inventive product when you follow an inventive project (IP) in the midst of R&D. These assessment points are the major criteria when talking about an inventive design result when comparing the inventive result versus inventive project goals. Other criteria can be added and compared.

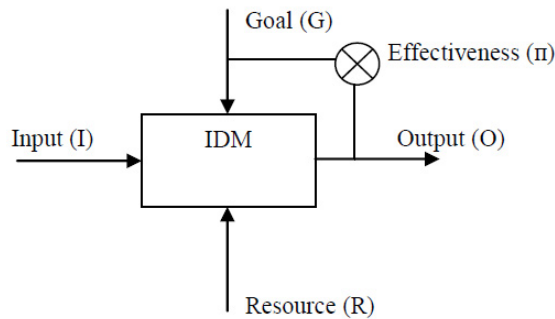


Fig.2. Effectiveness of an inventive design method/process

When we have:

$$\Pi(IDM) = r_c (M_o, M_e) \tag{2}$$

Where:

Nomenclature	
π (IDM)	Efficiency of an inventive design method/process
r_c	Relationship (comparison)
M_O	Input
M_G	Output

Here the basic problem in different studies turns around determining the basis of the comparison, its nature and its unit. In addition to detect each of these points about the inventive product, it is necessary to determine the intensity of each one.

2.3. Inventive design method efficiency

Along an inventive design method (IDM) which is applied in the heart of an inventive project for placing an innovation on the market, solution takes three forms respectively within conceptual, documental and physical object areas as the 'idea', 'invention' and 'innovation' (Figure 3).

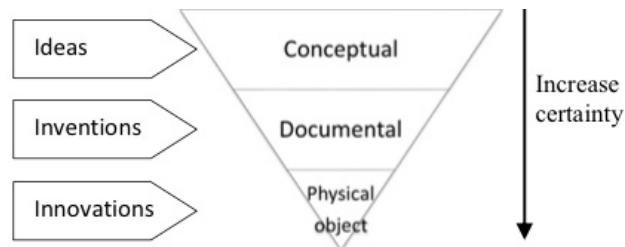


Fig.3. Solution areas along an inventive design method for innovation

Ideas as the first state of solution appear in the conceptual area to be transformed into the others solutions states (invention and innovation) which are the material gained of the design process (Figure 4). So the first questions that are asked are:

How many ideas can be transformed into results (invention and innovation)? Which one is more valuable? Up to which extents?

Figure 4 represents conceptual area that includes invention and innovation's areas. Each enterprise can transfer its own ideas to these two spaces.

In this paper we try to better formalize efficiency in combining ideas origins but carefully observing their trajectories. Determining the value of result is unavoidable to reliably measure the performance.

For determining the value of different results that emerges in the documental and physical object areas, it's necessary to define a series 'standard coefficient' of value for result in the results areas and a little farther in according to the objective of activities. i.e. levelling the enterprises with different administrative objectives for establishing results in the certain solution areas. Table 1 represents an example of three types of standard coefficient associated to results.

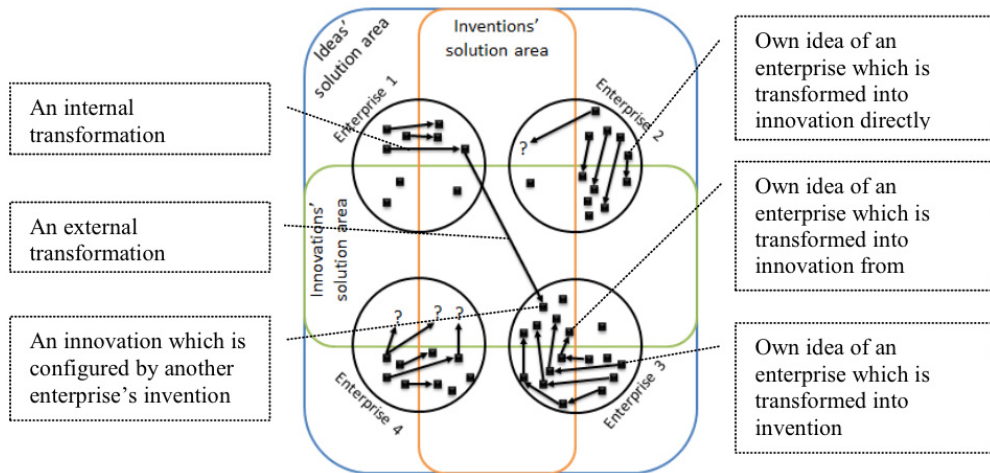


Fig.4. Result states and transformations between solution areas

The results valuation analysis in the third step considers the ‘coefficient of value’ in accordance with sector of activity. Frequency of inventive results in different technical sector is not the same and needs to equilibrate for a fair comparison. Thus a technological standard coefficient should be defined unique for each technical activity sector.

Table.1. Results leveling along three levels

Inventive results leveling		Enterprise i		
		Result Types (M^+_i)		
Standard coefficient	General	RT_1	RT_2	RT_3
	Administrative	g_1	g_2	g_3
	Technological	a_1	a_2	a_3
	total	$(g_1) \cdot (a_1) \cdot (t_k)$	$(g_2) \cdot (a_2) \cdot (t_k)$	$(g_3) \cdot (a_3) \cdot (t_k)$

Efficiency of an inventive design method can be calculated as follow according to R&D’s investment in enterprise as:

$$\eta \text{ (IDM of Enterprise } i) = \frac{M^+_i}{CA_i} \tag{3}$$

Where:

$(M^+_i) = (RT_1 \cdot ((g_1) \cdot (a_1) \cdot (t_k)) + (RT_2 \cdot ((g_2) \cdot (a_2) \cdot (t_k)) + (RT_3 \cdot ((g_3) \cdot (a_3) \cdot (t_k))$	
CA_i (%)	Investment on R&D in percentage

At the first step, with the aim of building indicators for characterizing the inventive activities in R&D and analyzing inventive design performance, we chose as methodological approach to establish a questionnaire. According Einsenhardt & Graebner (2007), this approach seems appropriate for understanding a complex phenomenon such as ours. The questionnaire is addressed to R&D’s managers and design departments to capture their collective perceptions related to their inventive activities and existing data which are necessary for quantitative performance measurement. This will allow us to draw a portrait of an indicator that characterizes the

creativity of inventive R&D teams after preparing a framework of the inventive design performance measurement. One hundred companies from different sectors (automotive, aerospace, electronics, etc.) have been selected by our team and each known R&D responsible received the questionnaire in person. This latter is available on the website of our project to gather data's on different elements considered as useful to characterize an inventive project (<http://defi-performance.org/limesurvey/index.php?sid=86898&lang=en>).

The questionnaire is composed of thirty-seven questions and often uses multiple choices with both qualitative and quantitative data. Appendix A summarizes the categories of questions and their aims (why have they been asked, what do we expect as resulting from the data's interpretation) embedded answers that are grouped into administrative matters (company, business type, company size, etc.), and the research questions that constitute the investigation body about different aspects of an inventive design project.

The questionnaire categorizes the researcher questions into six parts. A first group deals with the administrative questions. The second part asks questions about R&D department. The third category is dedicated to inventive project. The fourth part relates to process of inventive problem solving. The fifth takes in account inventive results characteristics and the sixth is related to resources (Figure 5). Moreover, an objective of this research is to identify existing terms in this field and distinguish what is the scientific and practical one to define an appropriate indicator of performance in the creative enterprises. In accordance with our objectives in second section, another aim of the questionnaire is the detection of the parameters which are tangible, visible and detectable by R&D's managers for measuring inventive design performance.

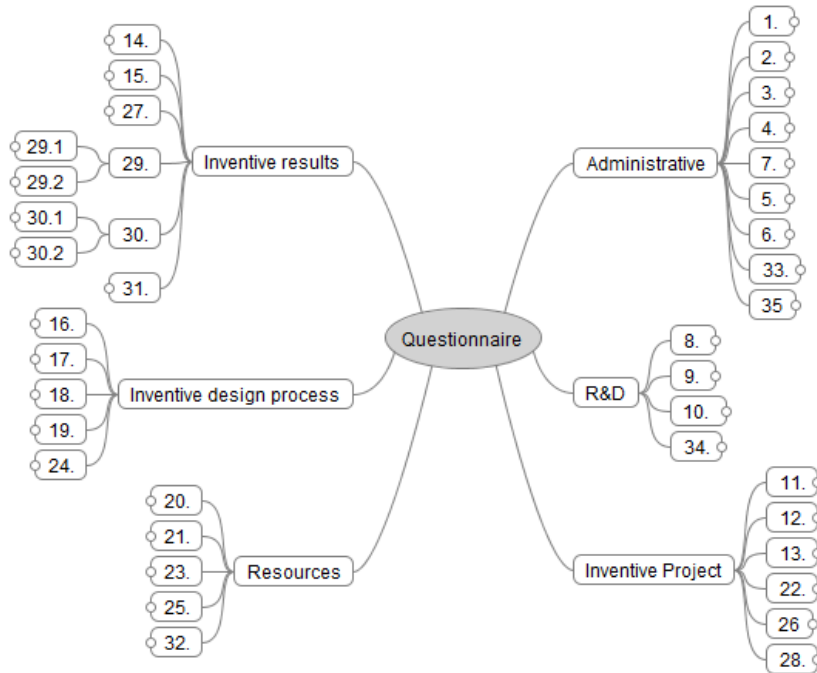


Fig.5. Questionnaire in six groups

3. Discussion

Determining the ‘standard coefficients’ which are proposed in this paper needs to make a statistical and analogic study around inventive results.

The current status is that we have completed 20% of the expected answers (out of the 100 R&D managers expected). Yet the quantity is not reliable enough to finalize our research project, but we can nevertheless advance some hypothesis based on quantitative facts.

The status of an idea in a company varies along time and becomes after existing facts, more credible. This adjective “credibility” attributed to ideas having reached a certain level of credibility is thoroughly gained after several facts: A raw idea in which nobody believes in has truly little chance to benefit from funds to be further defined by its author. To be pushed further along the line of credibility, an idea must obviously appear as solving a problem more than causing new ones. The problem that appears here is that at this level of maturity, personal interpretations of engineers can either kill or promote the idea. Thus, the idea is fragile; often the only defender of the idea is the author itself. To be pushed further along the line, the idea needs funding (either in terms of time-man month efforts or money) and pugnacity from the author. But then, funding and pugnacity directly depends on corporate acceptance of such status. If an idea is pushed forward, then it can reach the next level of credibility: invention. At this level, the status of invention is reached after either deep calculations and often prototyping and can in most cases be measured in patent investment. Of course, the quantity of patents directly depends on the size and the nature of a company’s activities. But there are means to monitor this change of status from idea to invention. At this stage we also have as, an hypothesis, that the time period separating both statuses is of importance. A company that favors the switchover between ideas and inventions must obtain a better indicator value than a company simply producing ideas while not doing anything valuable with it (with no transformation into inventions and innovations).

The objectives and the necessary arrangements which was presented in this paper, opens several argument around measuring inventive design performance. Activities are the fundamental components of the inventive design method/process that realize performance [4] by transforming input to output. Measuring efficiency and effectiveness of each activity within the process is a sensitive evaluation that reveals other new problems. How can follow the performance chain from an activity to another one? How can consider all input and output materials throughout the process? Which unit can recover all as the process performance?

4. Conclusion

Reformulation in the first phase by assuming a solid inventive design process might be useful to recognize principle axioms for measuring the performance of a chain or network activities which is applied in the process.

This paper represents the classical performance description by efficiency and effectiveness in according to measuring the performance of inventive design methods. To arrive this important, in the first step, case study such as questionnaire is prescribed as methodological approach of the research. The questionnaire was realized (Appendix A.) in destination about one hundred companies for their R&D’s managers. Defining a package of indicators to characterize inventive activities in the midst of R&D is the final research goal. Questionnaire helps us to capture collective perceptions expressed of industries on their inventive activities and real data which are necessary for feeding performance measurement.

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Appendix A. Summarizes the categories of questions and their aims

No.	Categories	Why have been asked	What does we expect as resulting from the data's interpretation
1	Administrative	to know general information as who answered to the questions from which company, from which activity sector	Target the appropriate sample of company and estimate the accuracy of answers
2	R&D	to be sure that R&D department exist and take in account row R&D's related statistical data	Target of making statistical analysis in relation to the other data
3	Inventive project	To define inventive project and understand organizational structure, verify their successful states and inventive results definition.	Target of defining inventive project and making analysis toward defining performance indicators
4	Inventive problem solving process	To verify problem solving process within R&Ds, their basic methods and define their activities and their characteristics	Target of analysis the characteristics of inventive problem solving process and measuring it's performance
5	Inventive result	To distinguish and define the states of inventive results, and take in account related statistical data and know their measurement systems	Target of recognizing inventive results characteristics and measuring the performance
6	Resources	To take in account statistical data of resources and make an analogy versus classical projects	Target of analysis resource characteristics and measuring inventive design performance

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