TRIZ – The Theory of Inventive Problem Solving

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Current Research and Trends in French Academic Institutions

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Preface

It has been two decades since the TRIZ theory overstepped the erstwhile Iron Curtain and spread into the world. Every continent, every country adopted it in a different manner, sometimes by glorifying its potential and its perspectives (the American way), sometimes by treating it with mistrust and suspicion (the European way) and sometimes by adopting it without questioning it further (the Asian way). Today, none of these models of adoption have really succeeded. Twenty years later, America is blaming the unkept promises that early TRIZ followers stirred up without much restraint. Asia caught up with the others and is even ahead now (TRIZ was developed there during the early 2000s) but is starting to get disillusioned about the way the theory was presented by people it trusted. As for the always careful Europe, it observes, analyses and tries to unveil the mystery of TRIZ, a model that amazes, disappoints and seduces those who see it as a new way to support the production of disruptive ideas. However, Europe's tergiversations and its timorousness of investing in research of methods made it lag behind Asia. I cannot compare us to the Americas (both North and South); however, in Europe, the TRIZ "wave" flooded the big companies with promises before interest began to decline due to a blatant gap between promises and reality.

The latest development is that Asia's fondness for TRIZ is also beginning to fade away, as the methods it employed were not the best, and by the time it tried to clear the negative opinion about it, it was already too late. In the end, Europe, because of the slowness of its decision-making process, has still a chance not to fall for the TRIZ model, like in the Americas or in Asia. It can learn from their failures, focus on the specificities of different countries (including countries within the same continent) and try to understand what went wrong with these models in order to better organize its approach in the years to come.

Before providing such an analysis and defining the trends that emerge from it, it is necessary to focus on our own progress. One preliminary question must be asked: within Europe, are there any differences or links in the way TRIZ was understood in France, Italy, Germany and England? I am convinced that this diagnosis, this assessment, this study about TRIZ practices in education, industry and research is necessary now that its decline has begun. What international indicators can be used to make these assessments? Insofar as multinational companies are concerned, specific attention is given to those that officially claim they are using TRIZ. The first is Samsung, closely followed by Posco, Hyundai, LG, Pioneer and Hitachi. With regard to the Americas, Intel, Boeing, Xerox and Ford need to be monitored carefully. In Europe, Whirlpool, Bosch-Siemens, PSA and Airbus can provide useful details on the way they have used TRIZ in the past few years. Regarding consulting practices, have they changed? Have they freed themselves from the classic TRIZ as the Russians have in order to reinvent it? Despite their association with numeric tools, only a few differences can be found besides the evolutions leading to oversimplification that have failed to make a compromise between being lighter and not losing the advantages produced by TRIZ. Another indicator regarding consulting practices is that in 20 years, not a single major actor in consulting has exploited it commercially. From this situation, we may understand that, on one hand, selling expertise about TRIZ would not yield enough money (its threshold is too difficult to reach and is too low), or, on the other hand, the preparation and the training of an expert would not be worthy in the end. Regarding scientific research, TRIZ is more critical. Either TRIZ preserves or even amplifies its capacity to become a subject for studies (in this case, its evolution seems unavoidable) or it is only seen as a packaged tool, thereby making its future bleak. Part of the answer resides in this work, at least with regard to the development of research in France. Another element of the answer resides in the indexation of scientific productions. When observing Scopus (one of the three leading international scientific production databases), the number of articles published in rank "A" journals (those with a decent impact factor) has grown since 2005, even though there has been a stagnation in the last 2 years. This means that the 150 scientific articles published annually by researchers in laboratories are supported by constantly developing knowledge, some of which will probably end up as a new practice/tool/method in companies after maturation. One can presume that TRIZ would have triggered something new, irrespective of the future acronyms that will come from research and that, in turn, will become the future of a discipline we call invention.

Invention is peculiar to human beings; some anthropologists argue that it distinguishes us from animals. Thus, it seems logical that a science of invention would offer a variety of digressions, each one likely to invade every discipline of the society. How does man invent (for human sciences)? How does the society assimilate these inventions (for sociology)? How do we invent new molecules (for chemistry)? How do we teach invention to the greatest number of people (for educational sciences)? How do we produce an algorithm to sketch the invention activity in the industrial process in R&D (for engineering sciences)? The list is almost endless, and it is understandable that no work can gather everything that has been accomplished in all of these areas as far as research is concerned.

The work that is presented in this book is compiled for engineers, educators at all levels, industrialists, managers, researchers and also political representatives. It provides a very partial and "snapshot" picture of the research conducted in the field of TRIZ. The span of the research encompassed all known francophone research laboratories producing regular research on TRIZ. Fifteen laboratories were questioned and thirteen out of them had indeed research tied to the subject of TRIZ that we were interested in for our project. Twelve accepted to send one or several of their postdoctoral researchers to present their work during a seminar, no matter its maturity or the completeness. Thus, we had a snapshot of the main research on TRIZ in French-speaking countries. Following this project was the idea to gather one chapter for every current thesis in order to observe and impart to the readers the breadth, richness and perspectives that research on TRIZ could bring to our society. Eleven research teams then proposed their achievements in the following chapters.

The first two chapters combines two fundamental aspects of invention: on the one hand, patents, of which we know that they gather a large amount of the traces of human inventiveness, and on the other hand, the laws of evolution of TRIZ, of which we know that the essential postulate makes it different from everything that is settled on in our consumer society—the demand from the customer that triggers the evolution of the product.

The postulate of the laws of evolution, a mix of Darwinism and Lamarckism, provides us with another scenario. What if the evolution of artefacts (i.e. what man conceives) was ineluctable? What surrounds the artefact (of which the customer is just a minor component) sets demands on the object and puts it under a whole set of constraints that makes its evolution according to a known scheme unavoidable. Chapter 1 attempts to analyse the potential links that would unite these contrains to the "roads" made by the laws of evolution of TRIZ, observable in the patents per population. Thus, in a meta-cartography, every patent could find its place in the phases of evolution of a technical object with respect to the laws of TRIZ. More, what if those markings created empty spaces seen as opportunities to question oneself about the opportunity of filling them? If such a thing were possible, it would get us some serious help in the scientific identification of opportunities for inventions yet to come.

Chapter 2 is also part of the exploitation of patents. In these authors' cases, different use is made of the mine of information called patents. In claiming that patents are mirroring human inventiveness and that they are a historical trace of technical progress, drawing a partial representation that allows artificial reasoning would considerably help the industrial R&Ds to address the true problems that have to be solved in a given context. We could thus avoid try-outs and time-consuming mistakes that prove costly and risky. This is the aim of Chap. 2: to model the knowledge in a given area as an introduction to creative thoughts. Just like networking can help numerical calculation, networking knowledge can help choice making in R&D. Patents seem to be, once again, a serious database for knowledge that has yet to be used.

Chapter 3 focuses at a macroscopic level on the design activity by returning to the basics of this exercise: defining a frame model. Complementary approaches of TRIZ are mentioned, such as C-K theory ("C" and "K" referring to Concepts and Knowledge) and its recent operational variations. Older models, such as the

Pahl-Beitz model, enlighten the chapter. A mix of the models follows in order to describe a new, hybrid, methodological approach that is still theoretical (the author incidentally reminds us that the approach still needs testing). An example concerning the design of a new street lighting system is provided to better grasp the sequence of underlying arguments of the approach. One can find in this example the difficulty linked to the multidisciplinary approach of this subject where design, technique, marketing and business considerations all combine. If C-K provides a concrete theoretical model about understanding the design of a creative act and TRIZ a set of methods to help the formulation and resolution of problems, these two approaches (TRIZ and C-K) have rarely cohabited within the same approach. The course choices given in this chapter based on a thesis are full of promises and could help the global efficiency in innovation progress.

Chapter 4 is about the inputs that TRIZ could bring to educational sciences. If invention training is still a significant challenge in that field of sciences, this chapter argues more strenuously for a contribution to the educational methods of teachers. Indeed, after an assessment of the educational methods on the inventiveness of young learners, the chapter deals with the teacher and his methods. For the first time in this work, an explanation of the acronym OTSM-TRIZ is provided, OTSM-TRIZ being an evolution of TRIZ towards an extrapolation of its basics in a generic form for education. When Altshuller was in his last phase of action, the idea of a discipline seen as a metascience of invention was born. Nikolaï Khomenko joined the adventure and led this line of research for many years. Some followed him and the acronym OTSM associated to TRIZ appears sometimes in the literature. This chapter provides an example of this ambitious project, which is centred on educational sciences. It covers the issues of education and provides a recap of its benefits to the learners. This chapter differs from others classic approaches directed at issues and provides experimentation in order for teachers to better grasp its inputs.

In Chap. 5, the reader is led to another universe: the universe of organization (or reorganization) of workshops. This chapter not only uses TRIZ to give its contribution but also one of its developments, Inventive Design Methodology, and especially one of its tools, the Graph of Problems. This tool usually used for the industrial design of a product/system was initially conceived in order to make an inventory of knowledge in a complex and multidisciplinary situation aiming at finding the contradictions. This chapter discusses its use in the reorganization of a workshop, with references to TRIZ and OTSM-TRIZ, which are the basics of the Inventive Design. The example given in this chapter shows that this approach improves the systematic nature of extracting information (a comparison with a classic approach is given with its results). With these results, the authors conclude that it is necessary to make this graph for its inputs in terms of efficiency in the global process are obvious, especially the risk of forgetting important issues and what that could lead to. There is no progress in research without a metric that allows the monitoring of the accomplished progress in regard to the goals aimed at. Such a metric does not exist yet when it comes to inventiveness in R&D (at least, those that exist are contested). This is the aim of Chap. 6: to understand and conceive indicators that will help create a metric of inventiveness for R&D project teams.

The chapter deals with the basics of the evaluation of performances and lists the criteria that allow a better understanding of how mathematics can help find an indicator that makes sense. The position of the research in invention metrics is transversal and is essential to the pursuit of research in Inventive Design. Indeed, how do we monitor and consider that a new method or a new practice is an input for the company? How do we state that what was produced is inventive or not, and in what proportions? How do we allow a company to enter in a logic of performance regarding the inventiveness of its R&D teams? All these questions are clumsily answered by measuring only the ROI, which we know diminishes the inventive dreams of project teams.

The next chapter deals first with the “contradiction” and formally highlights what a lot of TRIZ practitioners intuitively knew: using contradiction is indeed powerful but yet too intuitive. Chapter 7 concerns the basics of contradiction and the challenge of its resolution. However, it does not deal with it literally (as in most works on TRIZ) but mathematically and numerically so the description of mechanisms does not suffer from ambiguity. The mathematics of contradiction allowed the team that worked on this chapter to highlight the existence of a so-called generic form of contradiction. Authors explain how a set of components from a set of contradictions can be agglomerated in order to get a generic form and expression, the resolution of which impacts the process in a better way.

Chapter 8 covers another aspect of the process of Inventive Design: the feasibility of solution concepts. Numerous studies have already focused on the evaluation of ideas. They are often presented as statistical and matrix-like valuation (such as Stuart Pugh’s work), but there is always a doubt regarding the feasibility of the idea (due to the qualitative aspects of the process). This doubt leads the decision-maker in a company to anticipate failure, and there is thus a risk that one idea can only lead to a technological deadlock and therefore to a financial one. Chapter 8 proposes an original process to rapidly estimate the feasibility of ideas by formal computation. This can reassure the company regarding the feasibility of an idea. However, formal computation (3D, finite elements) is not currently possible due to a lack of time and often of multidisciplinary competences in order to judge the idea objectively. The authors of this chapter suggest using 1D and 2D equations in order to help reduce computing time since all concepts of solution do not necessarily need a 3D computation to be credible. Moreover, in Inventive Design, the number of solution concepts is less important than conserving those with an inventive characteristic. Regarding the multidisciplinarity of the approach and the risk of the lack of competences to do a 1D/2D computation away from individual core competencies, an access and a simplification process to semi-automatic forms has been created. This chapter deals with the impact of simplification and acceleration of precomputation of ideas with a dual objective: find bad ideas at once and avoid abandoning good ones.

Chapter 9 reminds us that our world has swung into an informative and collaborative mode. Information systems are becoming more important in our daily lives. It seems legitimate to wonder about the consequences of this evolution for TRIZ and the way in which these methods and techniques can be applied more efficiently and usefully for society. A community is often referred to in this chapter: the computer-aided innovation (CAI) community from the International Federation for Information Processing (IFIP) where such subjects are largely debated. The authors first offer a review of the numerical contributions for TRIZ and what they bring to the CAI. Then, just like in Chap. 3, they offer a new approach that includes these considerations. This approach is original for it is based on the authors' previous work on case-based reasoning and has been complemented by other works from researchers on ontology and semantic analysis. They discuss an investigation of real cases and a software interface (internet + server) to highlight their contribution.

In Chap. 10, the authors deal with one of the limits of TRIZ: its low capacity to model a problem at the beginning of a study. This limit has been highlighted many times by the community, and several contributions have been put forward in order to resolve it. Two more elements are put forward in this chapter and a solution is offered. The first one is that TRIZ representations are not dynamic in time. Often an observation at a given moment will prove that a contradiction is true, but the fact that this contradiction can evolve, disappear or, at worst, reverse is not sufficiently analysed. The authors highlight the non-linearity of relations between factors and the oppositions between factors that influence each other. They suggest using a well-known tool for the numerical analyses: system dynamic modelling. The authors aim at combining this approach and TRIZ in order to solve this deficit of TRIZ. A case study is presented in order to illustrate this suggestion. Last but not least, Chap. 11 concludes this work by discussing creative activity. It first deals with the various approaches of creativity by sorting them into two categories: structured and exploratory methods. TRIZ is clearly part of the structured methods. Exploratory methods are then dealt with in order to describe the necessity, in the digital era, to offer them a support to better organize and widen the frame of creative activities and what they produce. Even if the computation part is not developed in this chapter, it provides a sketch of its architecture and main features.

The assessment of the research presented in this work is convincing: TRIZ has entered many different scientific disciplines and has allowed young researchers to explore new possibilities in their field of research. Its basics are universal. Thus, the observation of a problematic, no matter what the discipline it comes from, through the prism of contradiction, fosters a new way to apprehend it. Contradiction is a kind of syntactic universal language that allows knowledge from various disciplines to coexist within the same model of representation. It induces subsequent inventive reflexes, and thanks to their common pattern, "solutions" from one discipline can help find "solutions" for another one. Finding the knowledge from patents to supply TRIZ representations (Chaps. 1 and 2), supplying a new method inspired by TRIZ (Chaps. 3 and 9), solving its issues (Chaps. 8, 9 and 10) or measuring its impact within a team (Chap. 6) all converge to one idea: theory is the core preoccupation for many researchers who truly form a community nowadays. Chapter 4 is about educational practices, and Chap. 5 offers to review the ways in which issues are identified in workshops to better grasp their complexity. Two more fields (education and warehousing) that were never spoken of coexist within the same work, thanks to this project, and reflect only a tiny part of what this iconic theory has to offer. Twenty years later, TRIZ still surprises us.

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