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A Review on TRIZ Approach in Service Industry

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Abstract: TRIZ is the theory of inventive problem solving emerged from Russia in the 1960's has spread to over 35 countries across the world. It has been applied by a number of global organizations who have found it particularly useful for spurring new product development. However while its popularity and attractiveness appear to be on a steady increase, there are practical issues which make the use of TRIZ in practice particularly challenging. These practical difficulties have largely been neglected by TRIZ literature. In this study, researcher after explaining the theory of TRIZ and demonstrating its relevance to non-technical issues, tools and techniques of using TIRZ is presented.

Key words: TRIZ, service, problem-solving, method, demonstrating, techniques

INTRODUCTION

In 1946, Genrikh Altshuller and his colleagues began to develop TRIZ in Russia. The primary axiom is that technological system evolution is being governed through objective laws that are named as Laws of Technological System Evolution by Altshuller. They could be employed rather than blind search to develop technological systems consciously or solving the problems. In order to initiate such laws, Altshuller studied 400 descriptions of invention from various engineering fields gleaned from global patent databases. He chose and studied the highest effective solutions as breakthroughs (Fey *et al*., 2001).

TRIZ or the theory of inventive problem solving was promoted by many enthusiasts as a toolkit or systematic methodology which suggests a logical method to result in innovation creativity and also inventive problem solving (Shirwaiker and Okudan, 2007). The emerged methodology from Russia back in 1960s was spread over 35 countries globally. Now, it is being taught in many universities and has been employed by many international organizations that particularly have identified it helpful to spur novel product developments. But when its attractiveness and popularity seem to be increasing remarkably, there are some practical challenges that make the utilization of TRIZ specifically hard in practice. Such practical issues significantly have been ignored by previous studies on TRIZ.

The key condition for TRIZ in order to solve challenges is improving one or more aspects with no damage on other aspects. On the other hand, if it is the solely tradeoff among contradictory mutual attributed resulting problems so it cannot be a good solution for such issues. Some of the contemporary explanations for TRIZ demonstrate that it goes beyond just a theory or a series of principles as it seem by its name. In fact, TRIZ is a systematic methodology which is knowledge-based for inventive problem-solving (Savransky, 2002). According to Fey and Rivin (2005), TRIZ is a methodology for efficient development of new systems which are technical, moreover, it is a series of principles which define how systems and technology evolve. Besides, it has been defined by Gadd (2011) as a toolkit which includes methods that contain all of the problem recognition and problem solving dimensions. This toolkit is known as the most organized, systematic and comprehensive tool for creative thinking and invention methodology identified to man yet (Ilevbare *et al*., 2013).

Critical to TRIZ is a category of conceptual solutions for the technical issues. This group of solutions is a set of inventive principles, standard solutions and technical evolution trends as suggested by TRIZ (Gadd, 2011). In order to employ one of these solutions, a factual and specific technical issue is minimized to its essentials and provided as a conceptual structure. In terms of its conceptual form, this issue then could be fitted with one or even more conceptual solutions. The recognized conceptual solution later can transform as a factual and

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specific solution which can provide answer to original factual issue. As mentioned by LariSemnani *et al*. (2015), his study analyzes the TRIZ in aspects such as quality improvement and prioritizing in service quality. By means of qualitative approach, the goal of action study is supported and problem of study will be solved. It will provides guidance in general laws of issues as same as those defined by Lewin (1946). This study formulated a conceptual framework as a result of investigations.

The relevance of TRIZ to services and non-technical problems: Until now most of the applications of TRIZ were mentioning the engineering disciplines and technological areas. It is clear because TRIZ has been developed by engineers for the engineers. But at the end of 20th century, it was clear that TRIZ had more potential rather than just a technical creativity theory. At first, it was understood that individuals who specifically investigated TRIZ have been improving their skills on problem solving as well as creative thinking in none technical areas too. Second, many different studies revealed that fundamental principles of TRIZ can be seen in many various fields for example advertisement and arts (Souchkov, 2010). Studies conducted by Zlotin *et al*. (1999), Zlotin and Zusman, (2002) regarding the assessment of organizations demonstrated patterns and also trends which are similar to those that have been identified in technical TRIZ. Later, Fey and Rivin (2005) understood how some main principles of TRIZ were employed by remarkably creative individuals in order to solve different social contradictions and issues and also to generate a creative personality (Souchkov, 2010).

TRIZ is significantly becoming more critical for service and production organizations both. Based on methodology of TRIZ, most of the issues have some contradictions. A common contradiction is a kind of conflict because of two requirements of conflict to similar variables in systems. It can be the result of two conflicting variables in systems. Identifying an inherent contradiction can be an important phase in analysis of TRIZ problem. After generating a contradiction, the chosen TRIZ tools which are knowledge-based could be utilized to remove contradictions. Usually, the contradiction resolution results in resolution of main issues and also other main issues.

Because of limited knowledge in technical and non-technical differentiation parameters as well as due to inability of Altshuler's matrix of contradiction to solve service issues, the concept of developing none technical contradiction matrix for designing the service will be developed. Due to TRIZ can remove any contradiction and also develop breakthrough solutions, it can be possible to utilize TRIZ to identify novel win-win solutions. TRIZ can contribute to remove psychological inertia in minds of designers of a service, hence increasing the capacity of generating service idea within service design. The provided knowledge-based toolkit via TRIZ exactly fulfills such requirements of contributing problem solvers in order to deal with their personal psychological inertia that is usually assumed as the hardest part to solve challenging issues (Savransky, 2002). In addition, Mann and Dewulf discussed that in case of its method and toolkit, TRIZ is the best comprehensive compared to other models. Zhang *et al*. (2003) made comparison to traditional idea development approaches for example lateral thinking, brainstorming, mind mapping and also morphological analysis (Savransky, 2002) noted that TRIZ is the only helpful tool to solve most challenging issues that are categorized toward the type which has unclear causes and also searching directions. Due to such traditional approaches are usually employed in service idea creation, it is possibly that TRIZ could be used and also service design benefits (Edvardsson *et al*., 2000).

It is clear that TRIZ has the most influential method to solve contradictions through using the available resources of space, time, energy, material, super system, structure and others. In most of the occasions, resources are available and they always have been employed by the innovators in order to solve the contradictions or else revolution of artificial systems will come to the halt. But, a lot of problem solvers consider it hard to remove those contradictions that need some out of the box thinking and so they are interested in trade-offs and compromises instead of emphasizing on resolving the contradiction and shifting a system into a new evolution level.

MATERIALS AND METHODS

Main tools and techniques in TRIZ: During the years of revolution, developers of TRIZ presented many tools and methods that can support various stages of a process in order to solve innovative issues as well as innovation road mapping. Generally, these days, regardless of problematic issues, TRIZ techniques and approaches could be utilized as:

To resolve a certain challenge that is developed as a not preferable or negative impact such as fast degrading of the product, break of an engine, customer leave, project fail and sales drop or as a limited required control or performance for instance too low speed, improper sales and weak supply chain management.

To generate a technological or business system, identifying the current obstacles and bottlenecks that can be eliminated through developed innovative solutions with TRIZ techniques and tools.

To study the evolutionary potential of business or technological systems and suggest strategies for providing future generations of systems. To forecast potential problems in new processes and products and contribute with prevention.

Many techniques and tools have been presented by Altshuller (1988) in order to promote TRIZ (Mueller, 2005; Souchkov, 2008) suggest a concise timeline and overview of TRIZ concepts and tools development from 1946-2008. The most prominent ones are.

The 40 inventive principles conceptual solutions to physical and technical contradictions. About 76 standard solutions in order to solve issues in a system without requiring understanding contradictions. Usually they are used to correct the not preferable interactions among two specific parts of a system.

Effects database that includes almost 2500 extracted concepts from body of scientific and engineering knowledge and used in order to solve the problems. Separation principles in order to solve and understand physical contradiction and mentions the solutions based on inventive principles related to challenges.

Contradiction matrix a matrix including 39 parameters technically which are organized on horizontal and vertical axis in order to interact with each other. It is utilized to explain inventive rules which could be used in order to resolve technical contradiction.

Patterns of evolution of technical systems to understand technology development directions which have been mentioned before. IFR and ideality an arbitrary system which has all of its necessary parts to perform with maximum capacity possible, suggested by Altshuller. In fact IFR acts as a beacon which helps us to reach the innovative solutions.

Fitting, it will be a procedure of taking back a step from IFR that is a not reachable and conceptual ideal toward a strong and realistic solution within barriers of current real-life context (Altshuller, 1996). Function analysis in order to realize the interactions among all of the system components and to identify arising problems from these interactions. This method will contribute to realize insufficient, weak and negative uncontrollable actions in a system and then put the "sore" points in different types of systems. The methods could be used in supply chains, technology, business services, organizations and other sectors. The important point is that functional interactions study will contribute to demonstrate "hidden" and not preferred interactions that might reduce the performance of system or could be a resource of potential errors, hence will uncover potentials for more improvements.

Substance field (Su-field) analysis as same as function analysis, contributing to map the whole system and also specifically mentioned all of the problems without including details which are not necessary. The substance field or the Su-field studies have been utilized as a key TRIZ tool in order to minimize costs of patented engineering system (Cho *et al*., 2004). According to case study has been performed by Samsung engineer regarding the activities of cost reduction employing Su-field analysis. This instrument assessed the interaction among these two substances. There are four types of Su-field which are generally employed in order to model a specific problem (San *et al*., 2009). They are ineffective, incomplete, harmful and also detection and measurement Su-field models.

Analysis of system resources, it is a search which is systematic and study of resources outside and inside a system in order provide benefit for problem situation and recognized solutions will be similar to ideal final outcomes as much as possible (IFR).

Nine windows which is known as system operator, inventive system thinking or the multi-screen diagram of thinking utilized to realize technical system or problem regarding the environment or context in which it is available as well as details of the system parts. It will contribute to realize how the issue (its details and context) might alter during time and it is helpful to locate different solutions.

Creativity tools to encounter psychological inertia (those mental habits that avoid innovation, clarification of thinking and thought out of the box). Such tools have method of little men and size-time cost (or else known as the "Smart Little People"). Cause Effect Chain (CECA) or the CECCA (Cause Effect Contradiction Chain) could be employed to understand most important disadvantages. The CECA begins from a core disadvantage in which the key point is to sort out systematically the causes of negative consequences which lead to surface sore point. The negative consequences which at the bottom line of hierarchy are known as the main disadvantages (Sheu and Hou, 2011). The critical key disadvantages are in fact the minimum series of key disadvantages that if being removed then will remove all of the concerned target disadvantages. In addition, CECCA is as same as CECA that also include related parameters for each single negative consequence that are recognized to make the identified contradictions able.

ARIZ (the algorithm for inventive problem-solving) a group of phases using a range of TRIZ tools that some of them have been explained earlier in order to identify innovations and solutions. It was known as the most appropriate tool for complicated and challenging problems.

In addition, Moehrle suggested a framework in order to structure tools based on application fields which are necessary for studying and solving the problems. These key fields are as follows:

- Current state; What is our current situation?
- Intended state; What is the future situation is going to be?
- Goals; Which goals will be met and to what extent?
- Transformation; How current situation could be transformed as intended situation?
- Resources; Which are the available sources that can be utilized?

According to Table 1, those tools have been put in different groups in which they were considered as being most relevant.

Table 1: Classification of TRIZ tools according to application field

Application field	Concept/tool/technique
Current state	Function (and object) analysis
	Contradiction
	Substance field analysis
	Evolution analysis
Intended state	Strong solution (or an ideal outcome achievable)
Goals	Ideal Final Result (IFR)
	Fitting
Transformation	Inventive principles
	Contradiction matrix (and inventive principles)
	Separation principles
	Substance field analysis
	Evolution analysis
	Resource analysis
	Effects database
Resource analysis	Resource analysis (system analysis, substance field analysis and performing a systematic search for resources)

Techniques integrated with TRIZ: Now a days in a highly complicated market with increasing pace, problems also are becoming more complex and various. The existed information to solve them is complex and thus in the future those individuals who are trained in generating creative solutions and problem solving significantly become more important. There are a lot of problem solving methods, tools and also approaches which have been compared and integrated with TRIZ. Some of the well-developed ones among them are the Six Sigma, Quality Function Development (QFD), Robust Design, Design For Manufacture and Assembly, Theory of Constraints (TOC), Axiomatic Design (AD) to those techniques generating pure psychological foundations for example De Bono's theories, Brainstorming, Neuro-Linguistic Programming (NLP), Mind Mapping TM.

Quality Function Deployment (QFD) TRIZ: TRIZ is a helpful tool which could solve the issue of HOW TO DO efficiently in process of innovative design and the Quality Function Deployment (QFD) can solve the problem regarding WHAT TO DO (Wang *et al*., 2005). It seems that QFD is the most appropriate method to be combined with TRIZ (Hipple, 2000; Domb and Corbin, 1998; Eversheim *et al*., 2001; Tan and Kraft, 2002, Yamashina *et al*., 2002; Park, 2003; Tsai *et al*., 2004; Hipple, 2005; Lai *et al*., 2005; Wang *et al*., 2005). QFD demonstrates what the problem through translation the customer's voice is as engineering parameters and TRIZ will provide solutions in order to satisfy such requirements.

Taguchi-TRIZ: TRIZ is considered as an appropriate approach in generating the solutions in process of design problem-solving. Using the Taguchi's robust design results in possibility of improving the implementation details of the developed solutions through TRIZ and also makes the design specifications of products insensitive regarding not controlled impacts. Such integration has been described in many studies conducted by Verduyn and Wu (1995), Novick (1999), Schulz *et al*. (2000), Park (2003) and Xinjun (2003). As noted by Dr. Elter of Xerox Corporation explained by De Prado, understanding the customers and making them satisfy; providing robust designs totally and also developing innovative creations are three main conditions which put a company in ranking of world class companies (Hua *et al*., 2006). These three main conditions are respectively fulfilled by QFD, robust design as well as TRIZ. The developer of axiomatic design, Professor Suh, revealed two axioms in specific ineffective product designs. The independence axiom keeps the function requirements independence and also information axiom reduces the content of information for design. Moreover, a lot of theorems and corollaries were generated from such axioms. The output of its integration with the TRIZ is the fact that Axiomatic Design (AD) principles are as same as TRIZ principles. In addition, Won and Lee mentioned that AD is helpful in order to define both problems and structures of system but such methodology will not bring certain tools in order to create ideas.

Six Sigma TRIZ: Six Sigma includes few phases of problem solving which are Define, Measure, Analyze, Improve and Control, respectively (DMAIC) (Zhao, 2005). It is confirmed that Six Sigma is appropriate for process improvement projects as well as problem solving cases. On the other side, Design for Six Sigma known as (DFSS) that fits a new product design, employs phases as Identify, Design, Optimize and Verify (IDOV). Even if there exists various versions for such phases, the important factors are same. Other researchers explained the contributions of TRIZ to such phases in process of design (Smith, 2001; Park, 2003; Slocum, 2003; Hipple, 2005; Zhao, 2005; Averboukh, 2006; Azis and Osada, 2013).

Zhao (2005) pointed out to more studies, however with no example, how the Six Sigma methodology can integrate with Ideation-TRIZ (I-TRIZ) specific tools and asserted that this integration will remarkably improves total Six Sigma potential in business development and improvement. Zhao (2005) utilized design of experiment that is a device includes Algorithm for Conflict Elimination (ACE), Six Sigma, TRIZ derivation in order to solve issue of long standing nozzle clogging. Here, it couldn't be a true integration due to both of these tools has been utilized sequentially.

Theory of Constraints (TOC) TRIZ: TOC presented by Goldratt is a philosophy in management which emphasizes in performances of constraints and also limited resources in order to promote the system's performance as a whole. There are possible relations between TOC and TRIZ (Rizzo, 1997). In addition, many investigations revealed how some tools of TOC could be fitted with TRIZ in designing the activities for problem solving (Novick, 1999; Mazur, 2000; Luke, 2002; Pfeifer and Tillmann, 2003; Stratton and Mann, 2003; Stratton and Warburton, 2003; Conradie, 2005). Moreover, in phase of analysis, TOC is employed to generate Conflict Resolution Diagram (CRD) and Current Reality Tree (CRT). Also in phase of improve, TRIZ can help a lot in developing breakthrough solutions.

Value analysis TRIZ: One of the effective problem solving systems is Value Analysis (VA) introduced by Lawrence Miles back in 1954, according to function analysis application to product's component parts. Probably lawrence miles is the first scholar explaining the TRIZ and VA together in a same context (Mann, 2002), although there is a misunderstanding regarding TRIZ. Sawaguchi (2002) in other studies defined how TRIZ and VA successfully have been implemented in activities of product development. In addition, the definition for "value" in VA is as same as to ideality concept in "TRIZ", thus, there is a significant relationship between these two tools. Besides, some investigations attempted to combine together more tools in different processes (Cavallucci and Lutz, 2000; Schulz *et al.*, 2000; Smith, 2001; Hua *et al.*, 2006). Handling too many methods together in a similar process cannot improve the process efficiency necessarily.

Design for Manufacturing and Assembly (DFMA) TRIZ: The DFMA concept was introduced by Geoffrey Boothroyd and Peter Dewhurst in 1980. Its core responsibilities are prioritizing and identifying design features in order to assembly and generate with low cost, more yield and also shorter cycle time (Bariani *et al.*, 2004). In addition, TRIZ is employed to solve the technical issues taking place in implementation process of such features. This is used for designing the satellite antennas (Bariani *et al.*, 2002, 2004). Other studies by Cavallucci and Lutz (2000), Luke (2002), Smith (2001) and Park (2003) used DFMA and TRIZ in line with other innovative tools for example axiomatic design, robust design, VA and Failure Mode Effects Analysis (FMEA).

Failure Mode as well as Effects Analysis (FMEA) TRIZ: Failure Mode Effects Analysis (FMEA) in fact is known as a structured method to study the process or design in order to understand opportunities and limitations for improvement. Another similar tool named as Anticipatory Failure Determination (AFD) has been provided by Zlotin and Zusmann (2002). So, this tool suggests answer for this question that "how a person can make systems to fail?" rather than "What can go wrong with systems?" which was answered by FMEA. Although, there is such similarity, some scholars (Cavallucci and Lutz, 2000) preferred to use FMEA rather than AFD in problem-solving process of their design in which TRIZ and other tools could be utilized.

Global-8D process TRIZ: Global 8 Disciplines process (G8D) is known as a step-by-step methodology for problem solving employed in Ford Motor Company. Its structure is developed as eight key disciplines and their name is initiated from these disciplines. Also, Frenklach and Savransky utilized the G8D in phase of problem formulation of 'diagnostic problem solving' in which proper TRIZ tools are applied in order to solve the issues.

Also, Bauer-Kurz *et al.* (2000) conducted a study in which they explained how TRIZ contributes to G8D. In case of such comparison, TRIZ only intervenes in three out of eight steps of the G8D (D2, D4, D5). Regarding the first two disciplines in which TRIZ intervenes, it is related to formulation of problem through which TRIZ is less effective. Thus, the primary contribution of TRIZ for G8D can be in D5 in which it is utilized to provide an appropriate solution for the problem which should be resolved.

RESULTS AND DISCUSSION

TRIZ in technical and engineering problems

TRIZ in transportation: In automobile sector, a lot of scholars by Cavallucci and Lutz (2000), Luke (2002), explained the TRIZ application and also other integrating tools for finding solutions for problems of automobile parts deployment. By means of innovative design process, the main issues regarding their shapes will be solved. Also, other applications could be identified on mountain bike (Verduyn and Wu, 1995), aircraft wing (Mann, 2002) as well as hybrid bicycle (Luke, 2002).

TRIZ in manufacturing: Manufacturing is a field in which a person is able to conveniently find TRIZ applications and also integration tools for problem solving (Stratton and Mann, 2003; Stratton and Warburton, 2003). Here, the main issue would be designing the manufacturing procedure or product's shape. In case of application, it is necessary to identify conflicts and then according to conflicts, provide innovative solutions. The TRIZ integrations and also problem-solving tools were used to heat exchanger (Kowalick, 1996), vacuum cleaner (Eversheim *et al*., 2001), equipment of wine production (Thimothy, 1998), metal seated ball valve (Tsai *et al*., 2004), mechanical crimping process, mechanical crimping process (Hu *et al*., 2000), agricultural machines (Zhao, 2003), wheel cover (Mann, 2002), paper handling mechanism (Yang and Zhang, 2000), gas-driven heat pump (Sawaguchi, 2000) and house manufacturing (Sawaguchi, 2002).

TRIZ in nontechnical and services problems: The service sector is a field in which TRIZ cannot be applied easily, however together with its rapid pace of development and integration with tools for problem solving, the integrated approaches have been used in this regard (King, 2004). The target of application is to generate a service system in order to fulfill customer requirements. The issues and challenges in healthcare have been explained by Azis and Osada (2013), Domb and Corbin (1998) also problem of human relations has been studied by Mann and Stratton (2000). In addition, the universities are not the sole service areas which have attracted attention of few scholars (Kitto, 2000).

Referred to the viewpoint of TRIZ, a TRIZ survey has been conducted. It demonstrated some of the challenges and issues regarding the application and acquisition

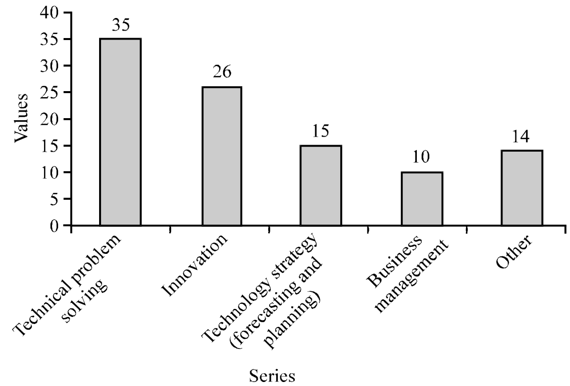

Fig. 1: A number of respondents indicating how they have applied TRIZ (Ilevbare *et al*., 2013)

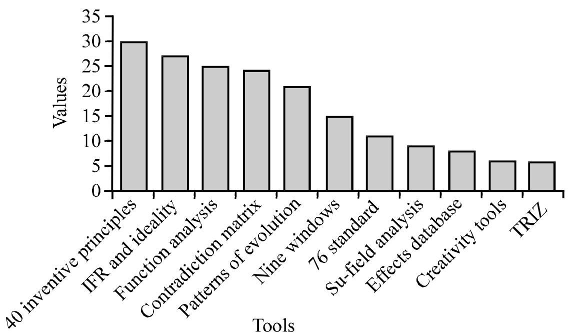

Fig. 2: Degree of usage of some TRIZ tools (Ilevbare *et al*., 2013)

of TRIZ knowledge toward limelight according to experiences in real-life. This survey has been accomplished by means of online instruments of survey that made the questionnaire accessible conveniently to potential participants (Ilevbare *et al*., 2013).

According to this investigation, the participants have been asked to realize the ways through which they have used TRIZ as well as asked to demonstrate how often they used a range of TRIZ toolkit devices. According to the achieved outcomes, Fig. 1 and 2 have been generated. As presented in Fig. 2, most of the participants used TRIZ in fields which are technology-oriented including strategy related fields, innovation and problem-solving cases. Only 10 of total participants used TRIZ to the managerial problems and issues. The other application sectors which categorized as "Other" particularly were cultural arts, book translation and book writing, teaching and training, process improvement, business model redesign, logistics, government and sports. Also one of the participants demonstrated using the TRIZ in order to deal with personal issues. The collected responses from survey presented in Fig. 2 demonstrate which of different

TRIZ concepts and tools were used most often. All of these participants revealed that they had used 40 inventive principles that seem to be a used tool most often. The other tools in this category of tools utilized often were IFR/ideality, technical evolution matrix, contradiction matrix, Su-field analysis and function analysis.

CONCLUSION

To sum up, TRIZ contributes to study a situation, modeling a problem, identify a pattern or principle from knowledge base of TRIZ that contributes to help the issue and also provide many new and novel ideas according to pattern or principle. Therefore, many errors can be prevented and trails that are the most effective variables helping to make wrong decisions and also lead to wasting the time.

RECOMMENDATIONS

Working with the TRIZ requires major amounts of knowledge as well as paradigm shift, however, significantly helpful. It contributes to save money and time for identifying new breakthrough solutions and concepts. TRIZ remarkably can improve the innovation process and also significantly improves the personal creativity coefficient and increases the skills of problem solving (Ilevbare *et al*., 2013).

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