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Procedia - Social and Behavioral Sciences 195 (2015) 2689 – 2698

Procedia Social and Behavioral Sciences

World Conference on Technology, Innovation and Entrepreneurship

Triz Methodology and an Application Example for Product Development

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Abstract

Explanation of innovative products, processes and services is a complex process which is possessed of strategies that have modern designs and systems. Nowadays, companies want to be more productive and more efficient. However, rapid and big changes are happened in competitive conditions and to exist in this competitive and rapidly changing and flourishing world, scientific developments had to be followed. To gain competitiveness, the companies need to procreate new products or eliminating the existing contradictory states. In this case, TRIZ (Theory And Innovative Problem Solving) methodolgy is one of the most effective scientific method, used by managers or inventors. In this study, TRIZ methodolgy was described in detail with creativity and innovation concepts and TRIZ was presented in comparison with other creative techniques. In the last part, a sample about TRIZ application has been expressed.

Peer-review under responsibility of Istanbul Univeristy.

Keywords: TRIZ; Innovation; Conflict Matrix; New Product Development

1. Introduction

Today's businesses, have faced with significant challenges such as rapid changes in customer expectations, global competition, rapid technological innovation, shortening product life cycle and the socio-economic environment. The most important way of providing excellence is undergoing a change in the race conditions. Undergoing a change is possible with creativity and innovation that was realized for processes, products and

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Peer-review under responsibility of Istanbul Univeristy.
doi:10.1016/j.sbspro.2015.06.481

strategies. Companies must create dissimilarity to take an important and different place into the global markets that have very sharp competitive factors. Dissimilarity and favourite differences can be obtained by gaining competition power with creative solutions.

Creativity can be defined as follows: Creativity is to find unusual solutions for problems, to gather together in harmony original or called incompatible with each other ideas or to reveal new and useful product. In 1946 G.Altshuller a Soviet Scientist develop a technique known as TRIZ for which the technique and applications are easy to follow and to learn. However, being a systematic tool, TRIZ can be used as a useful method in new product development process to generate alternatives. In this study, the methods of TRIZ's charecteristics and tools will be defined and their use will be illustrated.

2. Creative Thinking and Creative Problems

Two types of problems are known solution problems and unknown solution problems. known solution problems are evidenced in technical books, articles or other scientific resource. Unknown solution problems are expressed as the creative problems.

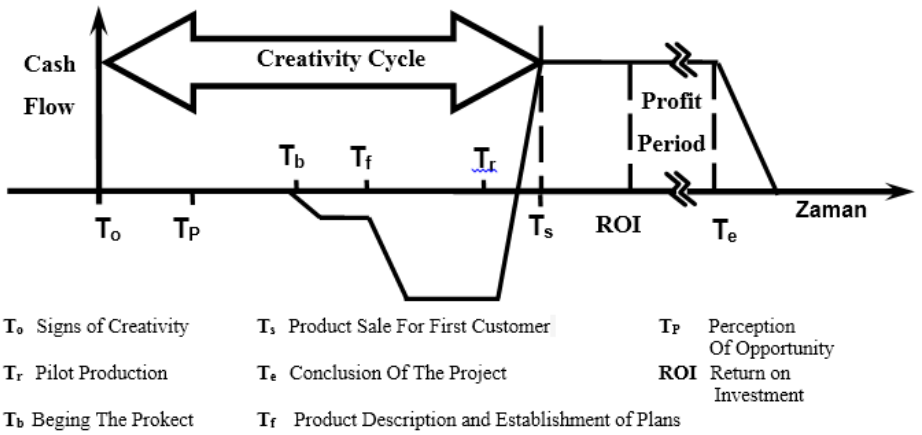

Fig. 1. Creativity Period

Creative thinking was developed and founded on its principles to reach non-classical solutions by Russian scientist Genrich Altshuller who didn't accept the concept of randomness. According to creative thinking of Altshuller;

1. Creative solutions eliminate contradictions.
2. Creative solutions is based on limited number of methods to eliminate contradictions.
3. It is possible to achieve effective tactics for finding a meaning between different types of contradictions and overcoming them

Table 1. Types of the Problem.

	Known Solution Problems	**New Problem**
New Knowledge (Scientific Problems)	The new knowledge is applied for known problem.	The new knowledge is applied for new problem.
Existent Knowledge (Engineering Problems)	The existent knowledge is applied for known problem.	The existent knowledge doesn't produce a satisfactory solution.

TRIZ, basing technology rather than psychological and socio-economic factors, developed by Genrich S.

Altshuller. Altshuller, chose mechanical engineering as a profession, worked as a patent expert in the Russian naval forces in the 1940s. His task was to help newcomers to get patents. However, he helped them to overcome their some problems. He wanted to search standard methods for the solutions of the problems. Nevertheless, reached all the tools based psychology and he searched a systematic problem-solving technique by examining existing patents. He examined 200 000 patents by himself. Only, he realized 40.000 pantents that were innovative. Accordingly, he separated spent five basic levels solutions that were developed:

Level 1 (Simple Solutions) : Adequated personal information solutions are equal 32% portion of all patents.

Level 2 (Improvements): Genrich S. Altshuller accommodated solutions which introduced little progress and improvements over the current system in this level. For instance: Bifocals. This level included 45% portion of all patents.

Level 3 (An Innovation Inside Of Studied Area) : Brought improvements and basic advances on the current system patents had a part in this level. For example: Cordless Phone. This level included 18% portion of all patents.

Level 4 (An Innovation Outside of Studied Area) : Patentes that found solutions for changes on principles that performed main functions of the current system, had a part in this level. For example: Jet Engine, Integrated Circuits. This level included 4% portion of all patents.

Level 5 (Extraordinary): Solutions were found for problems by creating new knowledge. That kinds of these patents are also the initiator of a new systems. For example: Laser Technology and Aircraft. This level of patents included 1% portion of all patents (Table 2).

Table 2. The Creative Process Diagram.

Levels	Selecting a task	Choosing the Concept of Research	Data Collection	Researching for Opinion	Finding Intellectual Solutions	Finding Practical Application
	A	B	C	D	E	F
1	Using an existing task	Using the concept of an existing research	Using existing datas	Using existing solutions	Using a prepared design	Producing a current design
2	Choosing one of many tasks	Choosing one of the research concepts amongs several concepts	Collecting datas from the many sources	Choosing one of the many opinions	Choosing one of the many desings	Producing altered version of an existing design
3	Changing the original task	Changing the research concept in accordance with the new task	Changing the the collected data in accordance with the new task	Changing he current solution	Changing the existing design	Producing new design
4	Finding a new task	Finding the concept of new research	Collecting new datas according to a new task	Finding a new solution	Developing new design	Using a new way of design
5	Find a new problem	Find a new problem	Collect new data according to new problem	Finding out the new concept(in principle)	Developing new structural concepts	Changing system that is applied the new concept

3. TRIZ (Creative Problem Solving Method)

TRIZ consists of the initials of the original named “Theoria Resheneyva Isobretatelskehuh Zadach” in Russian. translated into English as “Theory of inventive Problem Solving and used acronym” TIPS this method is described as “Creative Problem Solving Method” in Turkish. Altshuller obtained that similar approaches, used in many different areas, created very effective solutions in his investigations. The creators have explored these solutions over and over again. During investigations, Altshuller felt the necessity for the theory of creativity for the following conditions:

1. Being systematic.
2. Taking the lead for the placing of the ideal solution in very wide solution space.
3. Being repeatable and reliable. However, not depending on the psychological tools
4. Reaching creative information.
5. Adding creative acknowlegde.

The benefit of TRIZ is understanding that contradictions can be methodically solved with application of innovative solutions. Three fundamental principles of TRIZ conceived as follows:

1. The ideal design is goal.
2. Contradictions help to solve the problems.
3. Innovation process can be configured as systematic.

In this context, the model is presented to solve the problem in Figure 2.

TRIZ includes analytical tools that are necessary for problem solving and also it is knowledge-based tools that are necessary for system transformation and their theoretical foundations. Using all the information about the problems of the products, the analytical tools of TRIZ can be used for transforming, modelling and analyzing problems. Also, ARIZ is a special analytical tool that gathers substance-field analysis, conflict analysis, required function analysis and other techniques. TRIZ uses algorithmic approaches for improving legacy systems or designing new systems. Therefore, it includes to evaluate the available data rather than estimation. The main goal of TRIZ method is to find the ideal solution or perfection. TRIZ methodology depends on four basic paradigms;

1. Contradictions
2. Perfection
3. Functionality
4. Using resources

Altshuller also described TRIZ in the light of these paradigms by using a four-step process;

1. Describing the problems
2. Matching and comparing the general problem with TRIZ problems.
3. Finding TRIZ solutions
4. Developing the ideal solution for issues.

4. Basic Structure of TRIZ

TRIZ is a structure that has original inventive philosophy, methods and tools (Figure 3). The philosophy of TRIZ displays excellence, resources, and contradictions. The most important tool of TRIZ is ARIZ. ARIZ is an innovative problem-solving algorithm. The most used tool of TRIZ is Contradictions Matrix.

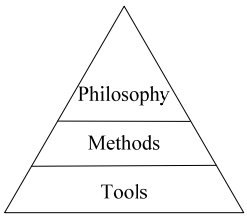

Fig. 2. Basic Structure of TRIZ

The philosophy of TRIZ;

- It is to estimate creative problem resolution and designed product development.
- It is to create principles that are common for all fields of technology.
- It is to eliminate contradictions.
- It is to use effectively materials, energy and knowledge for creating the beneficial effects.

Perfection occurs by using efficiently the available resources in the systems (Systems have been divided as upper and lower). Examples for the upper system: gravity, air, temperature, magnetism etc.

$$Perfection = \frac{\sum F_i}{\sum Z_i}$$

Another philosophy is "Contradictions". Altshuller proposed the definition of inventive problem in the first period of work. If a solution causes another problem this problem is heuristic. Conflicts contain heuristic problems. Contradiction is that an initiative, created for increasing value of system and improving quality of a system, decreases value of other system. As a result of examined patents, Altshuller have determined the 39-technical parameters that caused contradictions.

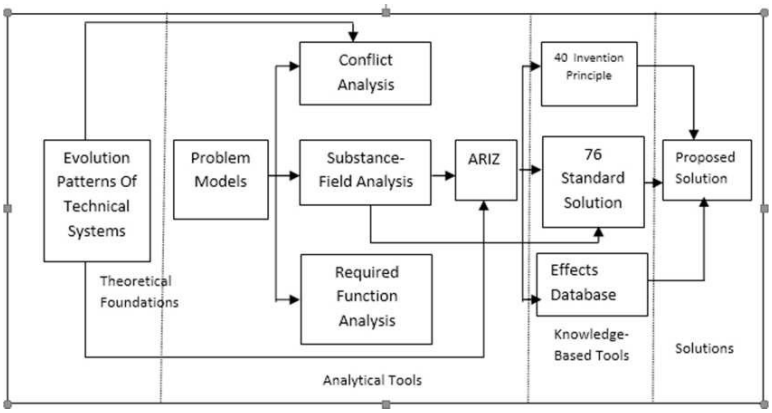

Fig. 3. Problem Solving Methodology of TRIZ

5. ARIZ - Creative Problem Solving Algorithm

ARIZ directs the inventor toward the most powerful solution which is available for the problem. Shown a structure as schematic in Figure 6 ARIZ, isn't an equation. Combining different parts of TRIZ by asking a series of questions, ARIZ is a multi-step process to find an inventive solution. Also, ARIZ doesn't find any solution, it is only a process. It introduces biased solutions from expression of problems.

ARIZ;

- It is a process to formulate solution for given problem again.
- It is a logical process that can be disciplined.
- It permanently provides reinterpretation of the problem.
- It is the main tool, used to solve contradictions of TRIZ

ARIZ can be used as a tool for the solutions of problems within the context of TRIZ;

- Perfection law to understand the ideal solution.
- First technical contradictions and then the physical contradictions.
- System resources.
- Scientific effects.
- Substance field modeling and standard solutions.
- The 40 - invention principle.

ARIZ process has 9 stages based on three main groups as follows;

A. Restructuring the original problem.
   1. The system / problem analysis.
   2. Resources / problem analysis model.
   3. Describing the physical contradictions and the ideal final result.

B. Elimination of physical conflicts.
   1. Separation of the physical conflicts, mobilization and utilization of resources.
   2. Using information database: Impacts, standards and principles.

3. Replacing or reformatting “micro-problem”

C. Analysis of the solution
   1. Re-examining the solution and analysis of method that abolishes physical contradiction.
   2. Improving maximum utilization of the solution
   3. Re-examining all the stages that conveys the solution in real-time practice.

6. The 39-Engineering Parameters of TRIZ Methodology

2.8 million patents were being investigated and problems have been classified, described and reduced 39 engineering parameters by Altshuller with TRIZ Methodolgy. These parameters have been defined for Moving and Stationary Objects as follows: Moving Objects: Objects which can easily change position in space, either on their own, or as a result of external forces. Stationary Objects: Objects which do not change position in space, either on their own, or as a result of external forces.

1. Weight of moving object
2. Weight of stationary object
3. Length of moving object
4. Length of stationary object
5. Area of moving object:
6. Area of stationary object
7. Volume of moving object
8. Volume of stationary object
9. Speed
10. Force
11. Stress or pressure
12. Shape: The external contours, appearance of a system.
13. Stability of the object's composition
14. Strength
15. Duration of action by a moving object
16. Duration of action by a stationary object
17. Temperature: The thermal condition of the object or system.
18. Illumination intensity: Light flux per unit area, also any other illumination characteristics of the system
19. Use of energy by moving object
20. Use of energy by stationary object
21. Power: The time rate at which work is performed. The rate of use of energy.
22. Loss of Energy
23. Loss of substance
24. Loss of Information
25. Loss of Time
26. Quantity of substance/the matter
27. Reliability: A system's ability to perform its intended functions in predictable ways and conditions
28. Measurement accuracy
29. Manufacturing precision
30. External harm affects the object: Susceptibility of a system to externally generated harmful effects.
31. Object-generated harmful factors
32. Ease of manufacture
33. Ease of operation: Simplicity
34. Ease of repair
35. Adaptability or versatility
36. Device complexity
37. Difficulty of detecting and measuring
38. Extent of automation
39. Productivity

7. The 40 – Invention Principles

Altshuller also present 40-Invention Principles after placing 39-Engineering Parameters to find inventive solution for the problem after investigating actual patent solutions and these principles can be explained as follows:

Principle 1. Segmentation

A. Divide an object into independent parts.
B. Make an object easy to disassemble.
C. Increase the degree of fragmentation or segmentation.

Principle 2. Taking out

A. Separate an interfering part or property from an object, or single out the only necessary part.

Principle 3. Local quality

A. Change an object's structure from uniform to non-uniform, change an external environment
B. Make each part of an object function in conditions most suitable for its operation.
C. Make each part of an object fulfill a different and useful function.

Principle 4. Asymmetry

A. A. Change the shape of an object from symmetrical to asymmetrical.
B. If an object is asymmetrical, increase its degree of asymmetry.

Principle 5. Merging

A. Bring closer together (or merge) identical or similar objects, assemble identical or similar parts to perform parallel operations.
B. Make operations contiguous or parallel; bring them together in time.

Principle 6. Universality

A. Make a part or object perform multiple functions; eliminate the need for other parts.

Principle 7. "Nested doll"

A. Place one object inside another; place each object, in turn, inside the other.
B. Make one part pass through a cavity in the other.

Principle 8. Anti-weight

A. To compensate for the weight of an object, merge it with other objects that provide lift.
B. To compensate for the weight of an object, make it interact with the environment

Principle 9. Preliminary anti-action

A. If it will be necessary to do an action with both harmful and useful effects, this action should be replaced with anti-actions to control harmful effects.
B. Create beforehand stresses in an object that will oppose known undesirable working stresses later on.

Principle 10. Preliminary action

A. Perform, before it is needed, the required change of an object (either fully or partially).
B. Pre-arrange objects such that they can come into action from the most convenient place and without losing time for their delivery.

Principle 11. Beforehand cushioning

A. Prepare emergency means beforehand to compensate for the relatively low reliability of an object.

Principle 12. Equipotentiality

A. In a potential field, limit position changes

Principle 13. 'The other way round'

A. Invert the action(s) used to solve the problem (e.g. instead of cooling an object, heat it).
B. Make movable parts (or the external environment) fixed, and fixed parts movable).
C. Turn the object (or process) 'upside down'.

Principle 14. Spheroidality - Curvature

A. Instead of using rectilinear parts, surfaces, or forms, use curvilinear ones; move from flat surfaces to spherical ones; from parts shaped as a cube (parallelepiped) to ball-shaped structures.
B. Use rollers, balls, spirals, domes.
C. Go from linear to rotary motion, use centrifugal forces.

Principle 15. Dynamics

A. Allow (or design) the characteristics of an object, external environment, or process to change to be optimal or to find an optimal operating condition.

B. Divide an object into parts capable of movement relative to each other.
C. If an object (or process) is rigid or inflexible, make it movable or adaptive.

Principle 16. Partial or excessive actions

A. If 100 percent of an object is hard to achieve using a given solution method then, by using 'slightly less' or 'slightly more' of the same method, the problem may be considerably easier to solve.

Principle 17. Another dimension

A. To move an object in two- or three-dimensional space.
B. Use a multi-story arrangement of objects instead of a single-story arrangement.
C. Tilt or re-orient the object, lay it on its side.
D. Use 'another side' of a given area.

Principle 18. Mechanical vibration

A. Cause an object to oscillate or vibrate.
B. Increase its frequency (even up to the ultrasonic).
C. Use an object's resonant frequency.
D. Use piezoelectric vibrators instead of mechanical ones.
E. Use combined ultrasonic and electromagnetic field oscillations.

Principle 19. Periodic action

A. Instead of continuous action, use periodic or pulsating actions.
B. If an action is already periodic, change the periodic magnitude or frequency.
C. Use pauses between impulses to perform a different action.

Principle 20. Continuity of useful action

A. Carry on work continuously; make all prts of an object work at full load, all the time.
B. Eliminate all idle or intermittent actions or work.

Principle 21. Skipping

A. Conduct a process , or certain stages (e.g. destructible, harmful or hazardous operations) at high speed.

Principle 22. "Blessing in disguise" or "Turn Lemons into Lemonade"

A. Use harmful factors (particularly, harmful effects of the environment or surroundings) to achieve a positive effect.
B. Eliminate the primary harmful action by adding it to another harmful action to resolve the problem.

Principle 23. Feedback

A. Introduce feedback (referring back, cross-checking) to improve a process or action.
B. If feedback is already used, change its magnitude or influence.

Principle 24. 'Intermediary'

A. Use an intermediary carrier article or intermediary process.
B. Merge one object temporarily with another (which can be easily removed).

Principle 25. Self-service

A. Make an object serve itself by performing auxiliary helpful functions
B. Use waste resources, energy, or substances.

Principle 26. Copying

A. Instead of an unavailable, expensive, fragile object, use simpler and inexpensive copies.
B. Replace an object, or process with optical copies.
C. If visible optical copies are already used, move to infrared or ultraviolet copies.

Principle 27. Cheap short-living objects

A. Replace an inexpensive object with a multiple of inexpensive objects, comprising certain qualities

Principle 28 Mechanics substitution

A. Replace a mechanical means with a sensory (optical, acoustic, taste or smell) means.
B. Use electric, magnetic and electromagnetic fields to interact with the object.
C. Change from static to movable fields, from unstructured fields to those having structure.
D. Use fields in conjunction with field-activated (e.g. ferromagnetic) particles.

Principle 29. Pneumatics and hydraulics

A. Use gas and liquid parts of an object instead of solid parts (e.g. inflatable, filled with liquids, air cushion, hydrostatic, hydro-reactive).

Principle 30. Flexible shells and thin films

A. Use flexible shells and thin films instead of three dimensional structures
B. Isolate the object from the external environment using flexible shells and thin films.

Principle 31. Porous materials
A. Make an object porous or add porous elements (inserts, coatings, etc.).
B. If an object is already porous, use the pores to introduce a useful substance or function.

Principle 32. Color changes
A. Change the color of an object or its external environment.
B. Change the transparency of an object or its external environment.

Principle 33. Homogeneity
A. Make objects interacting with a given object of the same material (or material with identical properties).

Principle 34. Discarding and recovering
A. Make portions of an object that have fulfilled their functions go away (discard by dissolving, evaporating, etc.) or modify these directly during operation.
B. Conversely, restore consumable parts of an object directly in operation.

Principle 35. Parameter changes
A. A. Change an object's physical state (e.g. to a gas, liquid, or solid.
B. Change the concentration or consistency.
C. Change the degree of flexibility.
D. Change the temperature.

Principle 36. Phase transitions
A. Use phenomena occurring during phase transitions

Principle 37. Thermal expansion
A. Use thermal expansion (or contraction) of materials.
B. If thermal expansion is being used, use multiple materials with different coefficients of thermal expansion.

Principle 38. Strong oxidants
A. Replace common air with oxygen-enriched air.
B. Replace enriched air with pure oxygen.
C. Expose air or oxygen to ionizing radiation.
D. Use ionized oxygen.
E. Replace ozonized (or ionized) oxygen with ozone.

Principle 39. Inert atmosphere
A. Replace a normal environment with an inert one.
B. Add neutral parts, or inert additives to an object.

Principle 40. Composite materials
A. Change from uniform to composite (multiple) materials.

8. Application Example of TRIZ

8.1. Application of TRIZ Method for Pizzas Packet Service to Prevent Moisture and Cooling

a) Problem Definition

Delivered to the customer's house pizzas package, pizzas have gotten cold and wet because of steam within the pizza box. Fastest delivery time have been tried to eliminate this undesirable condition; but the studies have been failed.

b) Advantages

Being warm and fresh pizzas that are served customers as a package, increases customer satisfaction and provides competitive advantage against opponents. Accordingly, delivered pizzas as packages, increases sales.

c) Definition of Level Excellence In The system

Surrounded pizza package to the customers with provided hot, fresh and dry pizzas package box in 45 minutes was defined as perfection level.

d) Problem Solving Studies

Manufacturer is requested being dry and hot pizzas that are delivered to costumers' houses. It is necessary closing the pizzas' boxes and not being air circulation inside the boxes not to being cold. Also, It is necessary to allow moving water vapor out of box inside the boxwes not to being moisture. Otherwise, condensing water vapor causes being wet and moisture pizzas inside the boxes. This situation is a conflict that ie required resolution. The bacis principles that have elinimated the problem of pizza by using the 39 * 39 contradiction matrix, has agreed as follows:

2 – 3 – 9 – 14 – 15 – 35 -17 – 22 – 24 – 31 – 33

Substances that may be related to the pizza-box question with the assistance of the bacis principles, has decided as follows:

Table 3. TRIZ Principles to Find tje Solution of Pizza Package Problem

Principle Number	Description	Solutions of Pizzas Boxes & Applications
2	Decreasing element	Disposal of the concentration inside the box
17	Dimensional change	Increasing the box base
22	To be transformed into benefits all damages	Using water vapor to increase the temperature
14	Sphericity	Remaking spherical the box base
5	Porous material	Being porous the box base

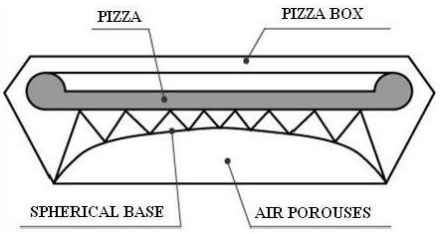

Fig. 4. New Product Design for Pizza Package

Pizza box must be closed to prevent heat dissipation. Being dry pizza has been provided by getting away condensed water vapor in a closed air porouses by raised basement of the pizza box and at the same time, with the elevated pizza base, inside temperature of the box that came into equilibrium as a result of condensation, extracted heat energy has been used to obtain hot pizza. While porous base papercorn was providing leakage of condansated water vapor, air porousity was helping slowly the heat transfer effect.

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