COMPARING AND COMBINING VALUE ENGINEERING AND TRIZ TECHNIQUES

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ABSTRACT

Value Engineering (VE) has been used for over 50 years as a formalized tool to achieve cost effectiveness for products and projects. TRIZ has been used for the last 35 years as a systematic methodology to promote technological innovation and inventive engineering. (TRIZ is a Russian is acronym Theory of the Solution of Inventive Problems.) This paper will point out some of each method's strengths and weaknesses and suggest which technique is optimal for different kinds of problems. Finally, this paper will point out how the two techniques can be merged for maximum effectiveness and greatly enhanced problem-solving power.

INTRODUCTION

Formal VE and TRIZ studies have rarely been combined. This is perplexing because each methodology has strengths that can greatly enhance the effectiveness of the other. Recently, Amoco Chemicals (now BP-Amoco) initiated parallel VE and TRIZ studies of several of their key chemical intermediates and feedstock products. Each successive parallel study revealed a strong symbiotic relationship between the two methodologies and a procedure to combine them evolved. A more formalized combined effort was accomplished for the Department of Energy at the Rocky Flats Environmental Technology Site.

The author has assumed most of this paper's readers are already familiar with VE and has therefore only provided a very cursory explanation here so that his terms can be used for comparison to the TRIZ methodology. The author has also assumed that most of the readers are less familiar with TRIZ and has therefore provided a more detailed explanation of its methodology. Next the two methodologies' strengths and weaknesses are compared. Finally, a proposed job plan for combining these two very powerful tools is explained.

THE VALUE ENGINEERING JOB PLAN

A VE analysis provides a consistent systematic approach that is efficient and less susceptible to oversight than simple cost cutting measures. The framework of that approach is termed the VE Job Plan. This paper will refer to the six-phase VE Job Plan. The following table gives a summary description of each step of the VE Job Plan:

TABLE 1 –GENERIC VALUE ENGINEERING JOB PLAN

STEP	PROCEDURE INVOLVED
Information	The VE Team reviews the proposed project, item, or system to identify basic functions where effectiveness could be improved or potential cost savings could be significant. These basic functions are organized into a Function Analysis Systems Technique (FAST) diagram. (FAST diagrams serve as tools to help the VE Team visualize the functions that different portions of a project must perform.) The FAST diagram(s) set priorities for analysis and for assessing the compatibility of alternatives with the total project design package.
Creative	The VE Team selects specific functions for further analysis on the basis of cost and potential for improvement. Formal brainstorming sessions (and sometimes other creativity techniques) are used to generate many alternative methods for achieving the selected basic functions.
Analysis	Analyses are performed by first passing or failing the brainstormed ideas, then combining or grouping similar ideas. The VE Team as a whole discusses and records the relative advantages and disadvantages of each idea. The ideas surviving these discussions are selected as candidates for further development.
Development	Detailed technical examinations follow, including specific quantities, costs, and calculations for ideas shown to have potential for significant savings. Economic analyses of technically feasible alternatives are made. Ideas that pass the technical and economical analyses and, in the opinion of the VE Team, should be incorporated into the project are prepared as formal proposals.
Presentation and Report	All ideas, calculations, and cost analyses recorded during the VE process are compiled to present the results of the study to the key decision-makers. A report is prepared to documents the analysis methodology, the results of the VE analysis, and proposals' disposition.
Implementation	Accepted proposals are incorporated into the project and actual savings are recorded.

Additional Creativitv Techniques

VE's most commonly used creativity technique is brainstorming. However, there are many other creativity techniques available to a VE Team. Edward DeBono, James Hggins, James Adams and others have written excellent texts on the subject. Techniques espoused by these experts include: the impossible question, concept fan, escape exercises, random word exercises, the "what if" exercise, describing the ideal process, and conceptual blockbusting and many nore. However, a common drawback to all of these techniques (including brainstorming) is that the intellectual prowess is limited to the participants present and their collective imagination (albeit with excellent facilitating). Enter TRIZ.

WHAT IS TRIZ?

Теория Решения Изобретательских Задач

TRIZ is a Russian acronym meaning Theory of the Solution of Inventive Problems. The practice of TRIZ leads to the rapid invention of next-generation products and processes. TRIZ makes use of a global patent collection and the known effects of science (physics, chemistry and geometry) as a database that supports the inventive needs of designers. The approach is used to greatly enhance the innate creativity and productivity of problem solvers. It brings the creative power of many previous inventors to bear on the problem.

A BRIEF HISTORY OF TRIZ DEVELOPMENT

Knowing about the history of TRIZ development helps one better understand TRIZ. The "father" of TRIZ is a Gengrich Altshuller. His relationship to TRIZ is very similar to Larry Miles' relationship to VE. After World War II Altshuller was employed by the Russian Navy's patent department. During his tenure there he looked for commonalties of thought process in inventing. He identified three major patterns: 1) regularities in design evolution, 2) the concept of Ideality, and 3) patterns of inventions.

Altshuller theorized that invention is nothing more than the removal of a technical contradiction with the help of certain principles. After studying 200,000 patents, Altshuller concluded that there are about 1,500 technical contradictions that can be resolved relatively easily by applying fundamental principles. His refined research resulted in 40 Inventive Principles and 39 Engineering Parameters.

As in VE, Altshuler's original work has been refined and advanced by others to a much more sophisticated system. The advent of the personal computer has further enhanced TRIZ and removed much of the tedium.

HOW DOES TRIZ WORK?

There are six basic tools available for a TRIZ analysis. Each TRIZ tool in turn has its own strengths and weaknesses. The six tools are:

Contradiction Analysis

This tool is most commonly associated with "classical TRIZ". It works for a problem defined as a contradiction that fits in the format of the 39 parameters (problems that are physical contradictions).

Ideality

This tool is one component of the larger analytic tool called Algorithm for Inventive Problem Solving. It is good for stimulating nontraditional thinking.

Algorithm for Inventive Problem Solving (ARIZ)

This tool is good for formulating and resolving contradictions. It focuses on the most ideal solutions. ARIZ begins with a problem formulator. The problem formulator (claimed by TRIZ experts to be the next evolution of the FAST diagram) identifies harmful or negative (undesired) functions as well as positive (desired) functions. Combined VE/TRIZ team members greatly prefer the problem formulator over the FAST diagram for its clarity of problem presentation, ease of construction, and identification of harmful effects.

Patterns of Evolution

This powerful tool facilitates designing the next (or several future) generation(s) of a product or process.

Substance-Field (Su-Field) Analysis

This tool is used for generating ideas for existing designs. It uses other fields of energy and knowledge for generating ideas for existing designs.

Anticipatory Failure Determination

This tool is used to identify design modifications to reduce the likelihood of critical failures.

The remainder of this paper will concentrate on Contradiction Analysis and ARIZ tools for comparison to and inclusion in the VE Job Plan.

A GENERIC TRIZ PROCESS STEP-BY-STEP

(This generic process is adapted from information supplied by Ideation International, Inc.[4])

Step 1. Identify the problem.

Identify the engineering system being studied, it's operating environment, resource requirements, primary useful function, harmful effects, and ideal result.

Example: A beverage can. An engineered system to contain a beverage. The operating environment is that cans are stacked for storage purposes. Resources include weight of filled cans, internal pressure of can, rigidity of can construction. The primary useful function is to contain beverage. Harmful effects include cost of materials in producing the can and waste of storage space. Ideal result is a can that is able to support the weight of stacking to human height without damage to cans or beverage in cans.

Step 2. Formulate the problem: the Prism of TRIZ

First, restate the problem in terms of physical contradictions. Identify problems that could occur. Could improving one technical characteristic to solve a problem cause other technical characteristics to worsen, resulting in secondary problems arising? Are there technical conflicts that might force a trade-off?

Useful effects include all the valuable results from the system's functioning. (These are the "normally" identified functions in a VE FAST Diagram). Harmful effects include undesired inputs such as cost, footprint, energy consumed, pollution, danger, etc. The ideal state is one where there are only benefits and no harmful effects. It is to this state that product systems will evolve. From a design point of view, engineers must continue to pursue greater benefits and reduce cost of labor, materials, energy, and harmful side effects. Normally, when improving a benefit results in increased harmful effects, a trade-off is made, but the concept of ideality drives designs to eliminate or solve any trade-offs or design contradictions. The ideal final result will eventually be a product where the beneficial function exists but the machine itself does not. The evolution of the mechanical spring-driven watch into the electronic quartz crystal watch is an example of moving towards ideality.

Example: We cannot control the height to which cans will be stacked. The price of raw materials compels us to lower costs. The can walls must be made thinner to reduce costs, but if we make the walls thinner, it cannot support as large a stacking load. Thus, the can wall needs to be thinner to lower material cost and thicker to support stacking-load weight. This is a physical contradiction. If we can solve this, we will achieve an ideal engineering system.

Step 3 Search for Previously Well-Solved Problem
TRIZ specialists now have extracted from over 1,500,000 worldwide patents 39 standard technical characteristics that cause conflict. These are called the 39 Engineering Parameters. To find the contradicting engineering principle, first find the principle that needs to be changed, then find the principle that is an undesirable secondary effect. Finally, state the standard technical conflict.

Example: The standard engineering parameter that has to be changed to make the can wall thinner is "#4, length of a nonmoving object." In TRIZ, these standard engineering principles can be quite general. Here, "length" can refer to any linear dimension such as length, width, height, diameter, etc. If we make the can wall thinner, stacking-load weight will decrease. The standard engineering parameter that is in conflict is "#11, stress."

The standard technical conflict is: the more we improve the standard engineering parameter "length of a nonmoving object," the more the standard engineering parameter "stress" becomes worse.

A COMPARISON OF VE AND TRIZ STRENGTHS AND WEAKNESSES

Both VE and TRIZ have relative strengths and weaknesses. For example, VE is more universal in its application but TRIZ can generate more far-reaching solutions to a problem. The following table summarizes the author's opinion of the relative strengths and weaknesses of each technique. Obviously, different practitioners will have different experiences and hence slightly different viewpoints.

TABLE 2 - COMPARISON OF VE AND TRIZ

VE	TRIZ
Applies to a very wide variety of problem types, e.g., construction, processes, management studies, project kickoffs, etc.	Is most commonly applied to technical problems and initially concentrated more on mechanical issues. Does not lend itself to management type studies or incorporation of political issues.
Can accommodate peripheral issues in the overall study, e.g., politics, labor contracts, etc.	
Does not measure the maturity of a process nor does it directly measure the overall efficiency of a system (although some conclusions about system efficiencies can be derived from a good FAST diagram).	Has a measure of a systems overall efficiency (ideality). Similarly, can measure the overall maturity of a process.
Is not as efficient as TRIZ at finding a core problem but may be more efficient at identifying "subjective" functions.	Can rapidly home in on the core issues and quickly offer solution paths and/or solutions.
FAST diagrams do not identify harmful functions and their relationships to other functions in the lucid format that the TRIZ problem formulator does.	The problem formulator (claimed by TRIZ experts to be the next evolution of the FAST diagram) identifies harmful or negative (undesired) functions as well as positive (desired) functions.
As is most often practiced, innovation is limited to the imagination and experience of the VE Team Members. (The author acknowledges that outside experts can also be brought into a VE Team).	Can bring many more specific solutions to a problem than just the experience base of the team members through a database of scientifically grouped problem solutions and/or statements.
Does not have the extensive patent database, nor physical and engineering parameters that TRIZ does.	Has outstanding software that "invents"
Can accommodate incremental (smaller) changes as well as entire system revamps	While TRIZ is usually used as an overall system improvement process it can be used on subsystems.
Has a more rapid and thorough series of evaluation tools (e.g., advantages/disadvantages/risks, paired comparisons, gut feel index, etc.) during the analysis phase	It does not have as rigorous a culling system and it does not have the ability to handle peripheral issues such as schedules, political influences, etc.

VE is very close to ideal for team building, especially with Function Analysis at Concept Development studies (FACDs), next generation process development, and/or "tweener" teams	At this point TRIZ does not lend itself to consensus building. If an outside TRIZ specialist(s) is used it is often viewed as an adversarial relationship between the TRIZ specialist(s) and the project team.
As a rule, VE develops proposals into a more implementable form by incorporating the development of the ideas into formal proposals with cost-benefit analyses	TRIZ usually only presents the alternative and its technical merits and leaves the development and cost-benefit analysis to the project team
Implementation strategies are inherent in the VE methodology	TRIZ does not normally include an implementation strategy

Table Summary

VE is more universal in its application, does more team building, and more thoroughly evaluates and develops proposals. TRIZ offers more solutions quicker and has better potential for more comprehensive technical breakthroughs, however, it has been more associated with mechanical system problems and only recently has been applied to a larger set of problems.

AN EXAMPLE MODIFIED VE JOB PLAN TO INCLUDE FORMAL TRIZ ANALYSIS

The best of both the VE and TRIZ methodologies can be combined if the owner/client is willing to commit the time and resources. (A combined study will need more of both.) A suggested combined job plan (one used successfully by the author) follows.

Of course there are several possible permutations to this combined VE/TRIZ job plan. (Refer to Table 3 for the referenced steps.) In one permutation, the TRIZ analysis is done "off-line" by a TRIZ specialist(s). The TRIZ specialist(s) would work with the core VE Team for Steps 1, 2, and 3, then do Steps 6, 8, 9, and 10 as a separate parallel effort. Next the TRIZ suggestions are combined with the VE ideas at Step 11. Finally both the VE and TRIZ ideas are analyzed, developed, and presented.

In a second permutation the TRIZ analysis is done as a completely separate effort. The VE Team members are used as subject matter experts (SMEs). The results of the TRIZ analysis are incorporated into the VE analysis at either Step 11 (beginning of the analysis phase), or Step 12 (development of ideas).

In a third permutation TRIZ can be used solely for resolving very promising VE generated ideas that would have been rejected due to an unresolved harmful effect – Steps 12 or 13.

TABLE 3 – MODIFIED VE JOB PLAN TO INCLUDE TRIZ

STEP	VE PHASE	VE JOB PLAN DESCRIPTION	TRIZ ADDITION
	Information		
1		Pre-Workshop activities	
2		Issue *Orientation Memorandum*	
3			Issue and receive Innovative Situation Questionnaire (ISQ)
4		Project management team briefing and questions & answers	
5		Function analysis	
6			Problem formulator
	Creative		
7		Brainstorming and/or other creativity exercises	
8			Select the most promising contradictions
9			Prioritize and refine directions for innovation
10			Develop concepts for innovation
	Analysis		

11		Make the first cull, e.g., pass/fail/risks, gut feel index, etc.	Include TRIZ concepts in the VE analysis
	Development		
12		Develop surviving ideas from the analysis phase, i.e., technical development, life-cycle cost analysis, implementation plan	
13			Use TRIZ on very promising ideas that have "unsolvable" roadblock
14		Finalization of ideas, i.e., peer review, grouping, pre-sell	
	Presentation		
		Present VE proposals to the Review Board	
	Implementation		
15		The accepted VE proposals are incorporated into the project per the Review Board's instructions and the VE Team's plan	

SUMMARY

Both VE and TRIZ have strengths and weaknesses. For example, VE does a better job of team building but TRIZ can offer more far-reaching solutions than the limitations of a VE Team's collective knowledge and imagination. VE usually results in more immediate savings while TRIZ usually results in larger breakthrough technologies for long term savings.

It is possible to combine the two problem-solving methodologies and obtain more comprehensive results than using either approach alone. However, it is easier to incorporate TRIZ into the VE Job Plan than visa versa. Combining the two methodologies results in immediate savings to justify and pay for the longer term research and development efforts required by TRIZ. To a company this means short-term profits, well-defined long-term strategies, and a constant competitive advantage. As explained earlier, there are several permutations of the VE/TRIZ combination available to match a given situation.

While some Fortune 500 manufacturers (3M, Ford, GM, Bendix) have used VE and TRIZ separately they have not reaped the truly outstanding benefits of using a combination VE/TRIZ study (like Amoco Chemicals and the DOE has).

A combination VE/TRIZ analysis is most applicable to technically complex projects or manufacturing processes. It takes a large project or process to sustain the resource expenditure for a combination analysis. The results however, are truly worth the effort.

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