Title: An Improved Method for Teaching the Theory of Inventive Problem Solving to Students

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ABSTRACT

The vision of the authors is that TRIZ should be as popular a tool for people in business and education for solving challenging problems, as Excel is for solving spreadsheet problems. Their experience has been that introductory training of business and university students in the United States of America on the many tools embodied in TRIZ (S-Field, Chemical-Physical Effects, Technological Evolution, ARIZ, etc) does not leave these newcomers with a ready process that they are comfortable using. Part of the reason for this is that there is no parallel to native processes such as the Scientific Method. A solution has been found by focusing on the core process of "Ideal Vision-Function-Resources" where Inventive Principles are used for brainstorming ways to maximize the useful functions, minimize the harmful functions and resolve contradictions. With this process in mind, they can analyze and solve some functional problems quickly with minimal analysis and use available resources only. Other times, inventive principles stimulate idea generation. Once the confidence in the method develops for less complex problems, they are in a position to absorb the additional tools of TRIZ. This approach has been used successfully with companies, university staff, and students.

INTRODUCTION

With ever increasing pressure for innovation in a globally expanding and competitive market place, many have been driven to examine TRIZ (The Theory of Inventive Problem Solving) as a method for innovation. In the United States in particular, engineers and students have struggled to embrace TRIZ as a tool for their innovation[1,2,3,4].

The authors believe there are answers for this and recent improvements to TRIZ software have been developed[5] which will create an acceleration of TRIZ understanding and utilization. The basis for this development arises from TRIZ history, the TRIZ structure, and the concomitant method by which it is taught. In order to create a foundation of understanding from which the improved method was developed, a short history of TRIZ will be presented. It should be added quickly that the authors could not possibly do justice to a complete history of TRIZ when one considers the significant sacrifices and efforts made by Altshuller, his students, and some of the early pioneers throughout the world.

The beginning of TRIZ (1946) was in a sense the “Dark Ages” of TRIZ when the government did not support the expansion of TRIZ[6]. This began a misconception of slow growth. When TRIZ debuted publicly in Petrozavodsk, Russia in 1980, it continued an appearance of slow growth due to factors beyond control of the TRIZ specialists. The growth of TRIZ in the early 1980’s was halted by the deterioration of the Russian economy and the failing of many TRIZ specialist businesses that were training government-owned businesses. This forced many specialists to leave Russia and immigrate to USA and other countries. Organizations, consultancies and private businesses such as Invention Machine, Ideation and the Altshuller Institute were formed in the USA to develop English language versions of TRIZ.

With some exceptions, the initial TRIZ training in the USA followed along the lines of Classical TRIZ[7] as was developed by Altshuller and his students. It was too complex for beginners, since TRIZ training in Russia took many years and was aimed at sophisticated users and scientists. Furthermore, the specialists tried to improve on the technique[8] and this introduced some confusion among students. This approach has slowed the adoption of TRIZ in the USA although it has enjoyed some growth among some larger companies due to the efforts of the TRIZ specialists. “According to commercial promoters of TRIZ, as a collage of concepts and tools TRIZ has been employed by many Fortune 500 companies in the United States and abroad to solve manufacturing problems and create new products.”[9]

With many different texts and specialists teaching TRIZ in the USA, there has been limited standardization. Thus student attempts to absorb the science have been stifled[10]. Many of these approaches are the result of a natural evolution of a new science, are intended to simplify pedagogy, and thus are justified. However, the financially driven American management culture and temperament is not patient or appreciative of the value that TRIZ could bring. There appears to be some parallel here to the quality sciences that had some origins in the USA and were not appreciated until the Japanese adopted them and changed their own quality image.

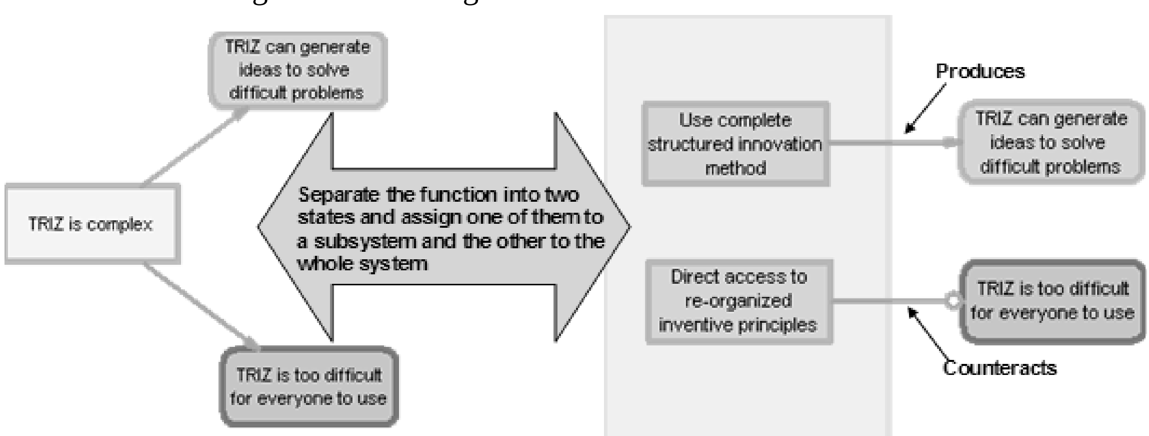
One of the most successful approaches to teaching TRIZ has been the utilization of 40 Principles by Altshuller[11]. Coates has seen success in using it as part of his course on technology management[4] and has observed others using it[12]. 40 Principles, however, still lacks the guidance and an aide a student needs in analyzing a typical problem such as is shown in the example in the text (Ibid. pp 109-112). It has been observed[4] that many students still struggle to arrive at an inventive solution with this tool. Also, the approach has a limited inventory of inventive principles, and does not have a process for analyzing and dissecting more complex problems.

Because of the foregoing history, it is arguably understandable that the past TRIZ methods have the following teaching problems:

1. Advanced and complex structure is challenging for new students;
2. Confusion due to multiple versions due to advances being made;
3. A long time is needed for students in industry and universities to become capable;
4. Disparate collection of tools which complicates teaching further;
5. Difficult to apply manually;
6. No simple process to solve problems of intermediate complexity.

The basic teaching problem is represented diagrammatically in Figure 1, as a contradiction, of "TRIZ is complex" and should produce "TRIZ can generate ideas to solve difficult problems" and should not produce "TRIZ is too difficult for everyone to use". Stated differently, TRIZ must be both simple and complex. This can be resolved with the "separation in structure" by using a simplified methodology via a computer program for many of the moderately complex inventive problems and reserving more sophisticated tools and programs of TRIZ for the most challenging problems.

Figure 1. Resolving Fundamental TRIZ Contradiction



Contradiction: "TRIZ is complex" **should produce** "TRIZ can generate ideas to solve difficult problems" **and should not produce** "TRIZ is too difficult for everyone to use".

TRIZ needs to be presented in a simplified, memorable, and intuitive approach so an average student or worker can identify with it and relate it to their normal problem solving processes.

THE SOLUTION TO TEACHING TRIZ

FIRST SOLUTION. A solution began to appear when Zlotin, Zusman, Malkin, Haimov, et al made a major step forward in 1994 with Patent # 6,851,663 that introduced function diagramming into the TRIZ methodology via a computer program.

Function analysis was first developed by Larry Miles and later extended to the FAST (Function Analysis System Technique) by Charles Bytheway in 1965[13]**.** This method became popular in the USA through the efforts of Larry Miles of GE during WWII[14] for value analysis and material substitution. Function analysis as used in Patent # 6,851,663 uses "verb & noun"[15] descriptors for the activity, action, process, operation, or condition of elements of a system. For instance, an engine in an automobile can be characterized as "provides power" to other parts of the system. This satisfies Altshuller's requirements to make the description general and avoid focus on the current mechanism.

Extension of FAST based on fundamental TRIZ concept of Ideality. All systems tend to evolve toward increased Ideality over time. Ideality has been expressed as the ratio of a system's Useful to its Harmful functions (shown in Figure 2[16]):

Figure 2. Definition of Ideality

$$\textbf{Ideality} = \frac{\textbf{All Useful Functions}}{\textbf{All Harmful Functions}} \rightarrow \infty$$

With this definition, one can define an Ideal System as one that performs the function but the system does not exist.
Useful Functions are defined as all useful outcomes (activities, actions, processes, operations, or conditions) of the system functions, products, etc.
Harmful Functions are defined as all harmful outcomes (same as above and including factors such as the cost, the space it occupies, the noise it emits, the energy it consumes, the resources needed to maintain it, etc.) of the system functions, products, etc.
Contradictions are defined as the conflict that develops when a useful function also creates a harmful outcome.

Function Model. A function model represents the various functions involved in creating an overall system function. It is composed of two main elements: functions and links. A function is represented in the model by a box containing simple English text (preferably verb & noun) that describes something related to the situation or system under investigation. Once again, the text in a box represents an activity, action, process, operation, or condition about the situation. A link describes the relationship between two functions, and is represented by an arrow connecting two boxes. There are two types of links in the function model represented by arrows (shown in Figures 3).

Figure 3. Links

Function Produces another Function

Function Counteracts another Function

The following types of functions can be seen in the Table 1 (note color not shown):

Table 1. Definition of Functions and Links Used in Method

	Description	Picture
1)	Useful function (Green)	
2)	Harmful function (Red)	
3)	Useful function, with some harmful outcome (Contradiction – yellow with green border)	
4)	Harmful function, with some useful outcome (Contradiction – yellow with red border)	
5)	Link "produces the useful effect" (Green)	
6)	Link "produces the harmful effect" (Red)	
7)	Link "counteracts to the useful effect" (Red)	
8)	Link "counteracts to the harmful effect" (Green)	

Zlotin, Malkin, et al[17] also introduced some of the first successful IWB® software[18] that not only facilitated the use of function modeling, but also inventoried many inventive principles that were hard to remember with simple examples.

In the IWB®, the concept of a computer program to implement TRIZ tends to be a more consistent self contained approach and a tireless tutor of inventive principles accompanied by examples. The program is a constant companion to the student after finishing the class. The function modeling facilitates the creation of easy to understand block diagram models, thus reducing the manual labor. The software also provides documentation of the function diagram and problem description versus manually created documents by other methods.

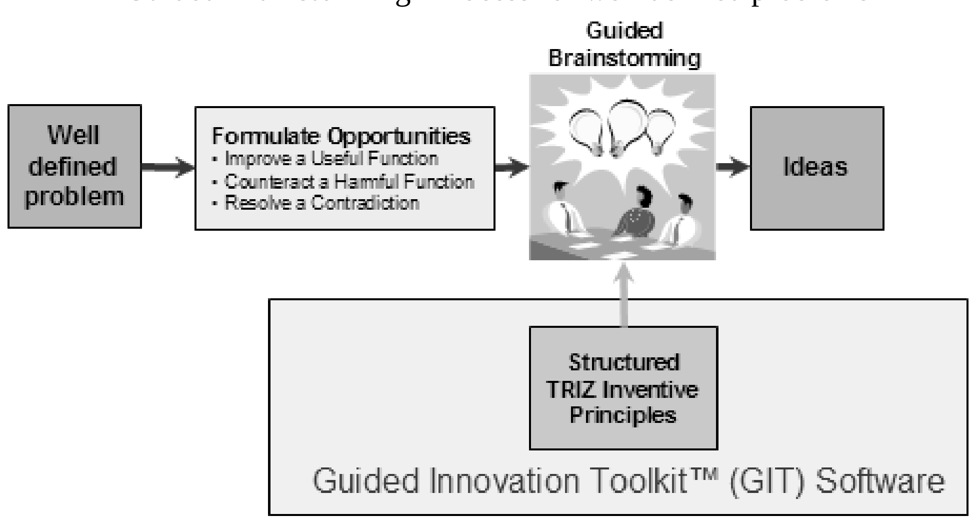
SECOND SOLUTION. A solution to teaching TRIZ was resolved when Malkin introduced a methodology implemented in Guided Innovation Toolkit™ software in 2006[5] that goes further to the "solve complexity versus simplicity" contradiction. This is the "New Method for Teaching TRIZ".

The new process draws a similarity to the Scientific Method[19] of: 1) Define the Objective for a Created or Observed Problem, 2) Analyze and Model the Problem, 3) Brainstorm Ideas and Formulate a Hypothesis, 4) Test Hypothesis and Evaluate Results, and 5) Draw Conclusions about the Concept/Hypothesis and solve subsequent problems to approach ideality. This creates a pathway to avoid becoming lost in the various tools of Classical TRIZ[20].

The initial TRIZ training focuses on the first three steps: objective, opportunities and "Guided Brainstorming" using a well defined inventive problem. This focuses the student on the core parts of this TRIZ methodology: formulating the opportunities, and utilizing the inventive principles in a new way for brainstorming. This brainstorming is called "Guided Brainstorming". The process for this training is shown in Figure 4. Later in the training, this process is broadened to include all the steps, in the Scientific Method, for more complex problems with challenging definition. The full process is called "Structured Innovation."

A well defined inventive problem is one where the cause of the problem is evident and the effect of the problem is clear. Thus the skills in defining the problem are not emphasized here. Also there is a small set of elements in the system so there is no need to create a complex functional model.

Figure 4. Resolve contradiction: complexity versus simplicity
"Guided Brainstorming" Process for well defined problems



This new approach is easy for new students to learn in a short time since it is not encumbered with many of the additional tools of TRIZ such as Physical and Chemical Effects, ARIS, S-Field, Standard Solutions and Technical Evolution. It does, however, utilize the Inventive Principles organized in a new way, called Vision-Function-Resources, is very insightful for utilizing them to brainstorm new ideas.

For well defined problems we use the following steps:

1. Imagine an Ideal System.
2. Formulate opportunities by using questions that will create a focus on functions (remembering that a function should be described best as an active verb and measurable noun, such as "illuminate area"[21]):
   - Question: What function do we want to maximize?
     Opportunity: Find a way to improve the useful function.
   - Question: What function do we want to minimize?
     Opportunity: Find a way to counteract harmful function.
   - Question: When we try to apply known solutions, what undesirable outcomes result and thus create contradictions?
     Opportunity: Resolve the contradiction: Function should produce useful results, and should not produce harmful results.
3. Brainstorm around formulated opportunities using inventive principles.

In the Guided Brainstorming step, the Guided Innovation Toolkit™ software contained the three groups of Inventive Principles specialized for each opportunity. The opportunities are:

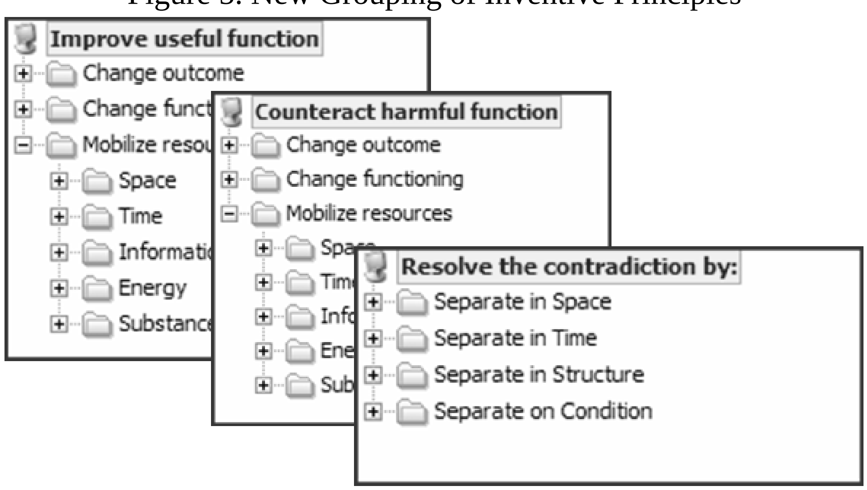
- Improve useful functions
- Counteract harmful functions
- Resolve contradictions

The opportunities are subdivided into three <u>directions</u>:

- Change Outcome (Vision)
- Change Functioning (Principle of operation)
- Mobilize Resources (Find and apply new or latent resources)

The result is shown in Figure 5.

Figure 5. New Grouping of Inventive Principles



The reason for these directions is that every function can be considered as combination of three things, as shown in Figure 6:

- Vision – How it is used?
- Functioning – How it operates?
- Resources – What does it take?

Using this approach, a new structure of TRIZ inventive principles, Vision Functioning and Resources (VFR), was developed to help brainstorming and is called Guided Brainstorming.

Figure 6. Categories of Inventive Principles for Changing Outcome, Changing Functioning, and Utilizing Resources for a Given System Function[22]

Inventive principles help you to change your point of view and find new ideas. Changing an outcome can call for changes in functioning and different types of resources. Each change in functioning can utilize different resources and provide for various outcomes. The availability of some resources might modify functioning and influence outcomes significantly. This is why a circular view of the directions was considered. This also leads to inventive principles being concatenated, just as atomic elements make up molecules. The result is an expansion in the total number of inventive principles from the core set embodied in the following tables.

Applying the VFR directions to various inventive principles for useful and harmful functions produces the following categorization:

Table 2 Inventive Principles for Improving Useful Functions[23]

Change Outcome (Vision) How can I improve the outcome of this function?	**Change Functioning** How can I change the way this function is performed?	**Mobilize Resources** How can I better utilize system resources?
Intensify	Matching	Space (4 principles)
Disposable	Synchronization	Time (6 principles)
Universality	Opposite action	Information (3 principles)
Specialization	Inside-out	Energy (5 principles)
Exclude	Partitioning	Substance (5 principles)
Add	Exclude element	
Provide easy way	Sorting	
Dynamism	Integrate	
Partial action	Bi-or poly system	
Excessive action	Mediator	
	Multiple actions	
	Dynamic elements	
	Feedback	
	Controllable element	

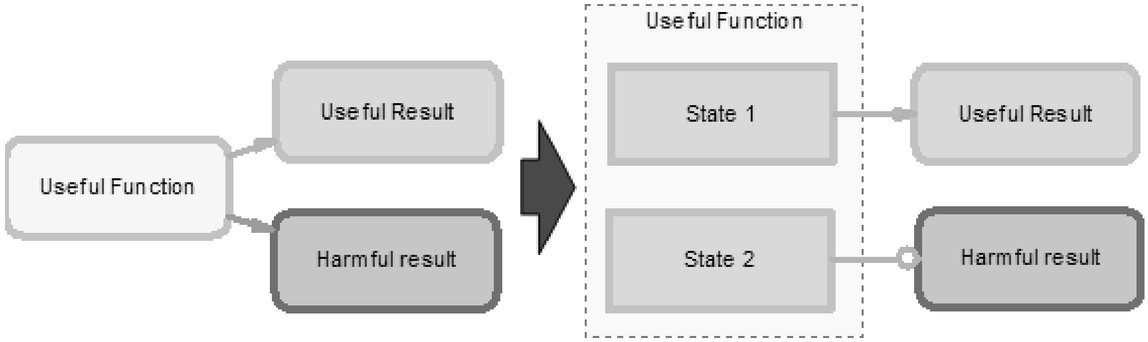
Table 3 Inventive Principles for Counteracting Harmful Functions[24]

Change Outcome (Vision) How can I change the outcome of this function to reduce its impact?	**Change Functioning** How can I change the way this function is performed to reduce harm?	**Mobilize Resources** How can I better utilize system resources to reduce harm?
Eliminate the cause	Mismatching	Space (4 principles)
Vaccination	Selective isolation	Time (6 principles)
Isolate	mediator	Information (3 principles)
Counteract	Opposite action	Energy (5 principles)
Stretch out	Inside-out	Substance (5 principles)
Redirect	Partitioning	
Localize	Take out the source	
Hide	Replace with a model	
Restoration	Integrate	
Convert harm to benefit	Combine harmful functions	
	Repeat counteraction	
	Dynamism	
	Feedback	
	Controllable element	
	Anti-process	

It is known from Classical TRIZ that to resolve contradictions the vision is: Separate contradictory requirements in 2 states. State 1 provides a useful outcome; and state 2 counteracts a harmful outcome (shown in Figure 8). This can be done in four ways:

- Separate in space
- Separate in time
- Separate in structure
- Separate on conditions

Figure 7. Separating Contradictory Requirements



A part of this new methodology is that the TRIZ four separation principles can now be extended and supported by four subsets of inventive principles, as shown in Table 4, that help to develop change in functioning and mobilize resources to keep system integrity.

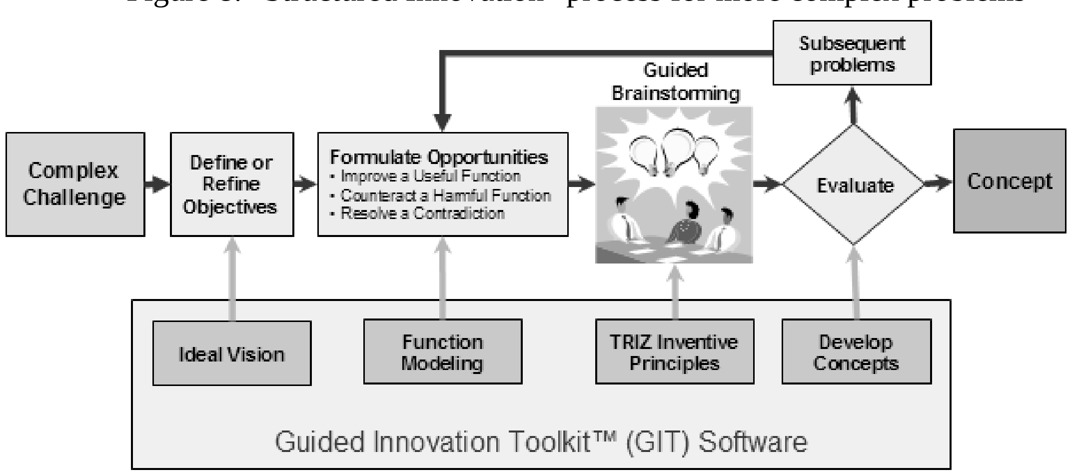
Table 4. Inventive Principles for Resolving Contradictions

Separation in space	**Separation in time**	**Separation in structure**	**Separation on condition**
Different location	Mismatch in time	Elements and whole	Find condition
Asymmetry	Preliminary action	Between subsystems	Environmental conditions
Extract the impeding part	Use pauses	Integration	Transform condition
Remove the required part	Dynamicity	Mediator	Create condition
Another dimension	Rushing through	Use the culprit	
Nesting	Use post process time	Use a model or copy	

In summary, the new organization and system of inventive principles presented here is a good guide for brainstorming and producing many ideas.

<u>Structured Innovation process for complex problems</u>. This process has all of the steps as discussed for the Scientific Method. The process is called “Structured Innovation” and is shown in Figure 8.

Figure 8. “Structured Innovation” process for more complex problems



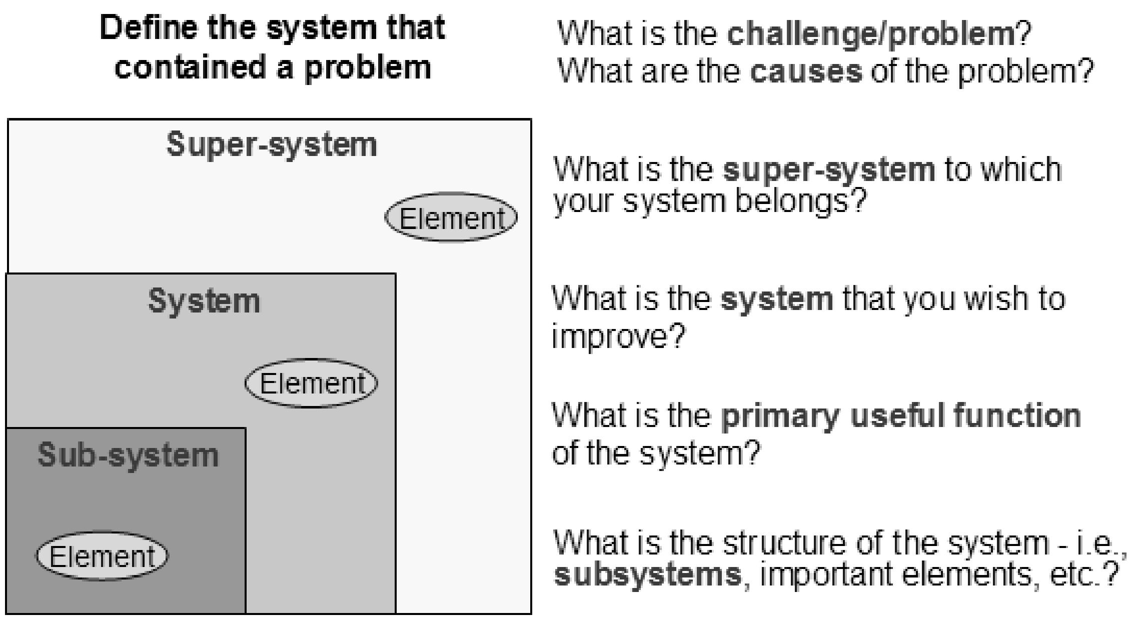
Structured Innovation process begins by defining the problem or challenge. In performing this step, we employ key questions to help define the problem.

- Review the background of the problem
- Ask a line of questions to clarify issues
- Collect available data
- Get a total picture
- Redefine the problem

We then define objectives using a system approach. A system here is a set of entities, real or abstract, comprising the whole, where each component interacts with or is related to at least one other component and they all serve a common objective. Any object which has no relation with any other element of the system is not part of that system but rather part of the super-system or system environment. A subsystem then is a set of elements, which is a system itself, and is a part of the whole system.

Systems' thinking is an approach to analysis that is based on the belief that the component parts of a system will act differently when isolated from its environment or other parts of the system.

Figure 9. Defining Objectives via System Approach



Then we use the concept of Ideality to refine the objectives. A purely or infinitely Ideal System would deliver all of the useful functions with no harmful functions. Cost is one harmful function in any real world system and the only way to get to zero cost is for the system itself not to exist physically. This is theoretically an Ideal System. Starting from the Ideal System, we form an Ideal Vision. The Ideal Vision is a mental image of a particular solution achieved by innovating in the direction toward the Ideal System. The Objective is a quantitative description of the Ideal Vision (i.e., a metric for it).

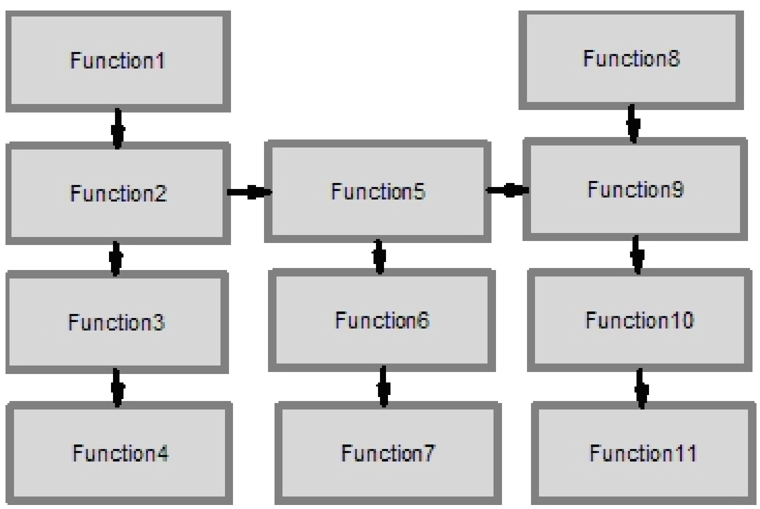
Next, we identify opportunities to move the system in the direction of the Ideal Vision. This is done by building a function model of the system which reveals cause and effect. The function model contains both useful and harmful functions. In many cases, a useful function produces a useful result but also produces a harmful effect. This is a contradiction. Engineers and designers generally compromise “around” contradictions, but if we can find a way to resolve a contradiction, it often results in a paradigm shift in system performance.

A short introduction to Function Modeling is presented here, but the reader is referred to Malkin[25] for additional descriptions.

The software system for Function Modeling has been developed with an artificial intelligence algorithm that simplifies the process of building the function model.

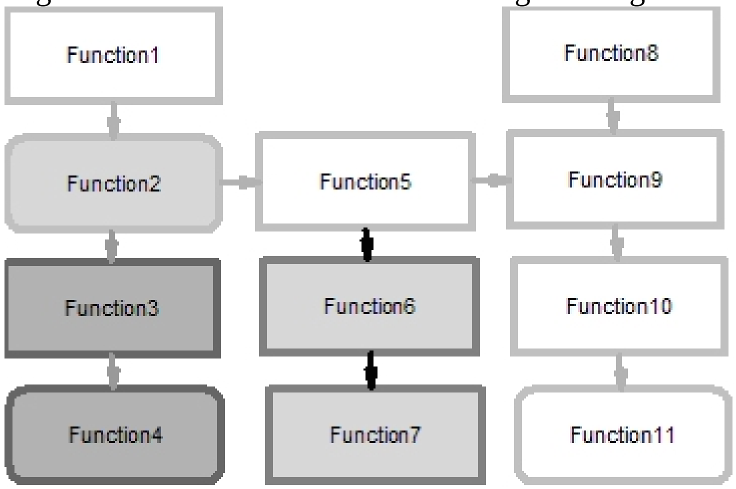
To start building the Function Model, create the first box with text describing a key issue or starting function of the system. Then ask yourself the following control questions:
1) Does the selected function produce or counteract another function?
2) Is the selected function produced by or counteracted by another function?
If you answer yes to at least one question, introduce a new function and link it. When you finish building the diagram it might look like Figure 10 where all boxes are gray:

Figure 10 Initial Function Model



Some boxes may be irrelevant to solving the problem. The artificial intelligence algorithm automatically distinguishes between functions relevant and irrelevant to the desirable improvement, as well as distinguishing between useful, harmful and contradictory functions based on user input of key useful and harmful functional outcomes of the model.
For example selecting Function 4 as a harmful function and selecting Function 11 as a useful function in Figure 10, the artificial intelligence algorithm produces Figure 11.

Figure 11 Results from Artificial Intelligence Algorithm



Function 2 is recognized as a contradiction (yellow), Functions 1, 5, 8-11 as a useful (green), Functions 3 and 4 as a harmful (red), Functions 6 and 7 are irrelevant (still gray) to the problem. The color coding of the functions helps to select the functions to formulate opportunities for:

- Resolving contradictions,
- Counteracting harmful functions,
- Improving useful functions.

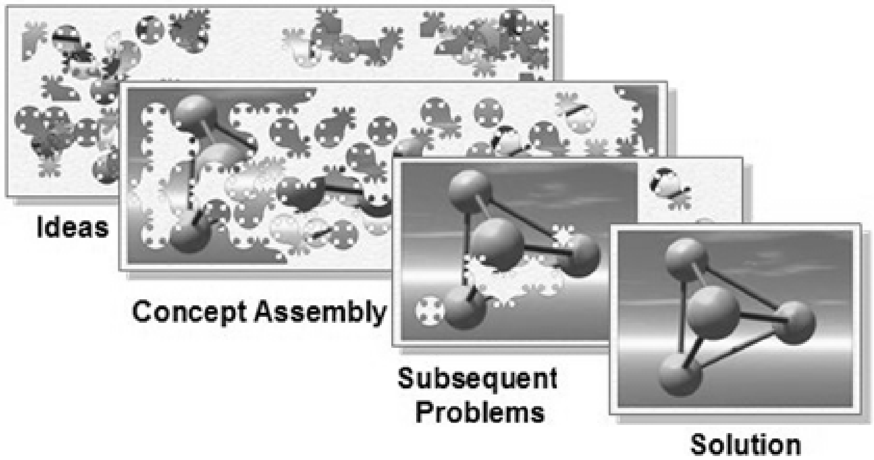
After opportunities have been selected, we apply the system of TRIZ inventive principles in a Guided Brainstorming session. Because the system of TRIZ inventive principles covers 95 inventive principles, the brainstorming session produces a highly exhaustive set of ideas for improvement.

The last step of the brainstorming is to develop the concept (formulate the hypothesis) that solves the major objective. This provides opportunities for improving ideas by combining them into concepts. Many people make the mistake of stopping their problem solving efforts once ideas are generated. In this process, the user learns that individual ideas very seldom solve the complex problems. Most complex problems require the resolution of several inter-related problems which is this is often why a problem has been so difficult to solve. In this step the user leverages ideas into solutions not previously found, by:

1. Listing and categorizing ideas and grouping them under headings according to the functions they perform.
2. Combining ideas into concepts and apply the software tools to address subsequent problems where a continued lack of functioning, or lack of availability of resources to achieve the objective vision is identified.

This process is similar to assembling a picture puzzle (see Figure 12).

Figure 12. Developing a Solution is Analogous to Assembling a Picture Puzzle



Evaluation of Concepts. The techniques for design of experiments and proper execution of the experiments will permit the proper evaluation of the concept. The evaluation step is certainly not trivial and the brevity of discussion here is only meant to mean that there are no improvements with respect to the conduct of this step at this time.

In conclusion, it is hoped that the more rapid adoption of TRIZ through this methodology will motivate the users to pursue mastery of additional tools of TRIZ.

Example Using the New Methodology.
The following problem situation is a wonderful example and could be packaged into an "elevator speech" if someone asks what is TRIZ. It also demonstrates the concept of Vision-Function-Resources for a Guided Brainstorming.

In the late 1970's a dozen fishing boats were capsizing in rough seas and sinking in the North Sea during a storm due to ice freezing in the rigging making the boats top heavy.

Figure 13. Fishing Boat in North Sea Ice Storm Example

1) The Ideal Vision and Objective is clear: Stop boat from becoming unstable.

2) A function model starts here with the key issue “Boat unstable”. Since “Removing ice” is a key to counteracting instability, add the function that counteracts it, such as “Removing ice”.   For this function, “Chipping ice” or “Melting ice” are the results of brainstorming alternatives.   “Melting ice” was chosen as the alternative. This produces Figure 14.   By choosing the “Boat unstable” as harmful, the AI algorithm identifies the rest of the boxes as useful, as is shown in Figure 15. At this point, stop modeling and brainstorm ideas to melt the ice.

3) Brainstorm “Melt ice”: Using the VFR approach leads to Table 2 for useful functions, there is at least one suggestion via structured inventive principles of “Mobilize Resources” utilizing a latent resources “energy” (in this case the system or environment). Reasoning that the ship may not have enough thermal energy, while unfrozen sea water might, the subsequent problem ensues as how to put seawater on the rigging.

The subsequent problem to “put seawater on the rigging” follows the same steps through modeling and brainstorming.   While brainstorming the opportunity “Improve Useful Function” and using the direction “Mobilize Resources” again a “substance resource” “pump” might logically be suggested to put sea water into the iced rigging. This is a very probable idea since most fishing boats have onboard pumps. The function model of Figure 15 has been extended by these functions, as is shown in Figure 16.

4) and 5) The concept to pump the sea water onto the rigging from the pumps was quickly <u>evaluated</u> and <u>concluded</u> to work. As a result, the remaining fishing boats were able to de-ice their rigging and the rest of the fleet was saved. This is a true story.

Using the Vision-Function-Resource approach, one can evaluate rapidly a function for ideas.   Having a computer program to produce the function diagrams and remember the various principles with examples makes it much easier and more powerful for a student and gives him/her the confidence to continue.

The function diagram capability of the program shown here demonstrates the Artificial Intelligence capability. Figure 15 shows that when the “Boat unstable” outcome is identified as harmful, the remaining functions are automatically identified as useful. The user can override these decisions if appropriate.

Figure 14. Fishing Boat Example without Functions Types Identified.

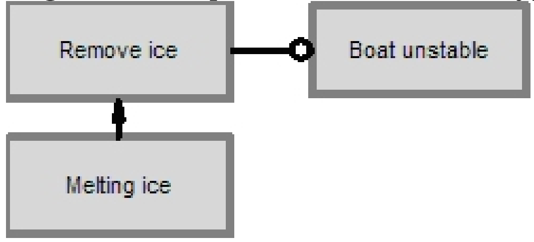


Figure 15. Fishing Boat Example with “Boat unstable” identified as a Harmful Function and Artificial Intelligence Identifies Remaining Functions as Useful.

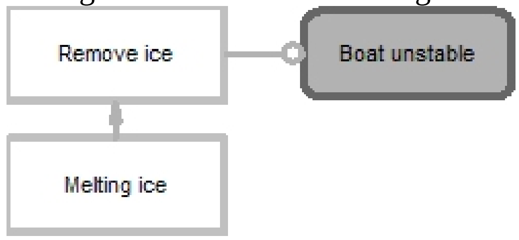
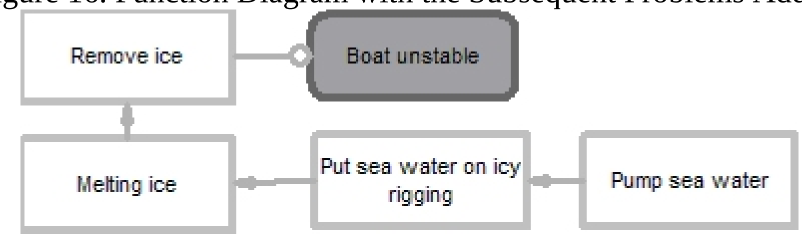


Figure 16. Function Diagram with the Subsequent Problems Added.



Teaching the New Methodology.

Success has been achieved using this methodology and certain observations have been made with respect to creating a syllabus:

1. Create introductory material that explains the basic concepts of TRIZ and Structured Innovation methodology:
   - short history of TRIZ
   - inventive problem definition
   - ideality and how it connects to useful, harmful and contradictory functions
   - inventive principles concept
   - VFR model and derivation of resources.
2. Explain the overall process as it relates to a standard approach such as a scientific method and compare it with the Guided Brainstorming and Structured Approaches.
3. Have students identify different inventive principles by creating their own examples.
4. Utilize the Vision, Function, Resource concept on simple examples.
5. Have students begin using the computer by the sixth lecture, so they have their own tutor. A program is considered a must for this method and is well accepted by contemporary students.
6. Have students do a major project of their own as a capstone for the class.

SUMMARY AND CONCLUSIONS

A subset of TRIZ technology has been developed for improved and more rapid student learning and initial efficiency of medium level problem solving that:

1. Utilizes a functional language according to a revised set of functional language rules to break a problem into subset of opportunities;
2. Uses inventive principles organized to brainstorm ideas that improve useful functions and counteract harmful functions:
   a. change the vision (outcome of a system function)
   b. change the functioning of a system
   c. find and mobilize new or latent resources for executing or change the system functioning;
3. Uses inventive principles organized to brainstorm ideas that resolve contradictions.
4. Utilizes a computer program that conveniently supplies these capabilities conveniently to the student in an easily retrievable manner.

Although the number of attempts to employ this technique is in its early stages, the results have been validating[26,27] that this technique can make TRIZ a standard tool for students possibly even more important than Excel for his/her life's work.

END NOTES

[1] Zlotin, Boris; Malkin, Sergey; et al, "Patent #5,581663, Automated Problem Formulator and Solver", Col. 1, ll. 64-67; Col. 2, ll.19-34; ll.48-50; ll.53-54
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[7] Classical TRIZ hard to capture in one spot, since it has gone through constant evolution, but an original work by Altshuller is a good start: Altshuller, Genrich (1984). *Creativity as an Exact Science*. New York, NY: Gordon & Breach. ISBN 0-677-21230-5
[8] "Function analysis is simpler to teach. I had problems with teaching Su-Field in an old traditional (standards) way. Therefore I have developed a new approach, which works well both in academia and with corporates."
Belski, Iouri, Email 2/19/2007, Assoc. Prof. of Thinking & Problem Solving, School of Electrical and Computer Engineering, Royal Melbourne Institute of Technology, Melbourne Australia.
[9] "TRIZ", Wikipedia, op cit.
[10] Training both at Hoover[2,4] and at Kent State University[4] has shown that
[11] Altshuller, Genrich; 40 Principles: Extended Edition: TRIZ Keys to Technical Innovation, Technical Innovation Center, Inc. Worcester, MA .

This document was originally a brochure written by Altshuller, entitled: "Basic Methods to Remove Technical Contradictions" circa 1974. Since 1997 it has been translated, and enhanced by Lev Shulyak, Leonid Lerner, Uri Fedoseev, Steven Rodman, and Dana Clark.

[12] Hipple, Jack, "The Integration of TRIZ with Other Ideation Tools and Processes as well as with Psychological Assessment Tools", Creativity and Innovation Management, Volume 14 Issue 1 Page 22 - March 2005
[13] Wixson, James, "Function Analysis and Decomposition using Function Analysis Systems Technique", , http://www.srv.net/~wix/622_p113.pdf, (accessed 3/11/2007).
[14] Snodgrass, Thomas, Kasi, Muthiah, Function Analysis, The Stepping Stones to Good Value, Board of Regents University of Wisconsin System, 1986
[15] Verb-noun descriptors do not always have to be two words but the closer the description is to this the higher the level of abstraction is. This is what Altshuller wanted in ARIZ so as to avoid psychological inertial. 40 Principles, p. 19, op cit.
[16] Ideality is defined per the equation on the Ideation International web site, <http://www.ideationtriz.com/home.asp>, (accessed 3/11/2007)
[17] Ideation International, http://www.ideationtriz.com/home.asp (accessed 3/11/2007)
[18] Innovation WorkBench®, Ideation International, Inc., ibid.

[19]Although the definition of the Scientific Method varies somewhat the following reference: http://physics.ucr.edu/~wudka/Physics7/Notes_www/node6.html gives the five steps referred to in the text. (Accessed on 3/16/2007)
[20]Altshuller, Genrich (1984). *Creativity as an Exact Science*. Op cit.
[21]Wixson, James, "Function Analysis and Decomposition using Function Analysis Systems Technique", , http://www.srv.net/~wix/622_p113.pdf, (accessed 3/11/2007).
[22] Malkin, Sergey, "Guided Innovation Toolkit", ibid.
[23] Ibid.
[24] Ibid
[25] Malkin, Sergey, "Guided Innovation Toolkit", http://www.pretiumllc.com/soft.htm (accessed 3/11/2007).
[26] Coates, Donald, "Tech 61095/33095, TRIZ: Theory of Inventive Problem Solving", Kent State University, Spring 2007
[27] John Borza, Rick Gour, Sergey Malkin "TRIZ - Theory of Inventive Problem Solving", Presentation to Detroit Chapter of Institute of Industrial Engineers, Feb. 28,2007, http://www.iiedetroit.org/programs/2007/02_2007%20TRIZ%20presentation%20and%20Dinner.htm (accessed 3/11/2007)

Biographies

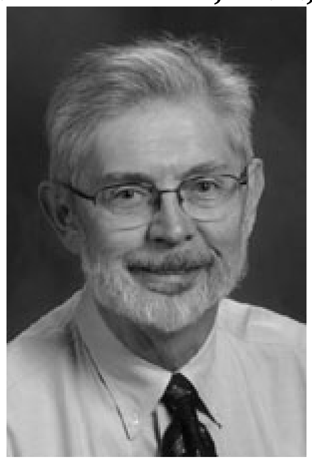
Sergey Malkin

Sergey Malkin VP-Technology, Pretium Consulting Services, LLC is a well-know TRIZ Expert, trained by the method's founder, Genrich Altshuller and has more than 22 years experience of TRIZ application. He has held positions of Director of Software Development, Ideation International Inc.; CEO, Private Enterprise Eurotecton; VP TRIZ&VE, Foton Corp. Sergey holds a MSEE from Sevastopol University and an MBA from Simferopol Business School.

Galina Malkin

Galina V. Malkin TRIZ Specialist, Pretium Consulting Services, LLC has been working with TRIZ for more than 20 years. Mrs. Malkin has taught TRIZ to students of different ages, including engineers, college students and school children. She had also taught the adapted elements of TRIZ to preschool children. Based on her experience working with younger children, she developed an educational program to teach TRIZ to elementary school students in Lithuania. Mrs. Malkin has also worked as a TRIZ specialist on numerous industrial projects. In 2006 she began her collaboration with Pretium Consulting Services. Mrs. Malkin's subject matter expertise is in biological research. She has worked in various industrial and academic labs and for the last 5 years she worked at Wayne State University. Galina holds an MS degree in biology from Simferopol State University.

Prof. Donald Coates, Ph.D., P.E.



Professor Coates teaches courses on innovation, energy power and industrial controls at Kent State University's College of Technology. Previously he was Vice President of Engineering at the Speed Queen Division of Raytheon, Director of Corporate Primary Development and Director of Dishwasher Engineering at the Frigidaire Company of AB Electrolux, Director of Research for the Hoover Company of the Maytag Corporation and Manager of Whirlpool Automatic Washers at the Whirlpool Corporation. He received a Ph.D. and MSME for Purdue University and a BSME from the State University of New York at Buffalo. He also received the Distinguished Engineering Alumnus and Outstanding Mechanical Engineer awards from Purdue University. He holds 16 patents with another 8 pending and has authored eight papers. He is member of the American Society of Quality and the National Society of Professional Engineers.