The Integration of TRIZ with Other Ideation Tools and Processes as well as with Psychological Assessment Tools

Jack Hipple

When TRIZ is introduced into an organization setting, it invariably encounters a host of processes and tools already in place. These can include enterprise tools such as Six Sigma, Design for Six Sigma (DFSS), QFD and Lean Manufacturing. It is fairly easy to combine TRIZ problem-solving and technological forecasting with these processes and tools, because most of these enterprise tools are problem-identifying processes that couple easily with the strong problem-solving capabilities of TRIZ. What is more difficult is to integrate TRIZ thinking with other psychologically based creativity and assessment tools. Users and trainers for these various tools tend to be very protective about each process and do not spend sufficient time thinking about ways to integrate the best of all tools. Organizations also frequently use psychological assessment tools to assist employees in career development, but they are seldom used in a proactive way to improve group problem-solving. These assessments can be used proactively within the use and implementation of TRIZ. This paper will review suggested ways to effectively integrate TRIZ innovation and problem-solving principles with these other tools.

Introduction

Since the mass production invention lab of Thomas Edison, people have been trying to improve the quality and productivity of the inventive process. New ideas and more efficient innovation processes are always sought within organizations. Prior to TRIZ, all of the improved processes were based on psychological stimulation – changing the thinking patterns and attitudes already existing within the problem-solving group in an attempt to generate ideas that were not seen earlier by these same individuals. These techniques bring no additional knowledge into the innovation session, but attempt to stimulate the knowledge already present within the problem-solving group.

TRIZ (Russian algorithm for 'Theory of Solving Inventive Problems') is a problem-solving, analysis and forecasting toolkit derived from the study of the global patent literature. Its basis, the study of patterns of invention in the global patent literature, was initiated by a brilliant Russian patent examiner, Genrich Saulowitsch Altshuller (1926–1998) in the 1950s. He reasoned that the way to improve the quality and pace of innovation was to study the patent literature where inventions are documented. His premise was that innovation did not need to be a psychologically based process, but a science that could be analysed and made available in a useful and practical way in the same way as any other science, such as physics. In his mind, it was illogical to assume that innovation was unique among the sciences in the sense that it could not be studied in a fundamental way. After a study of the patent literature (which continues today by various TRIZ consulting companies and academic institutions), Altshuller organized the inventive principles he found repeatedly used in a useful form such as a contradiction table, a list of inventive principles, a list of standard solutions and how to graphically describe problems in a standard fashion (substance-field modelling) that couple with standard solutions. A number of companies have also taken these tools and integrated them into software products. This paper is not intended to be a treatise on TRIZ, but will review the basic parts of its toolkits to facilitate the discussion of its use with other assessment and ideation tools. We will also review some of the major psychological assessment tools and psychologically based problem-solving processes and then present some preferred ways of integrating TRIZ with these assessments and processes.

Though TRIZ is relatively new (circa. 1990) to the West, it has been practised and been part of the education and training system in the former Soviet Union for over 50 years. Basic overview, history, and technological foundation of the TRIZ process are readily available (Altshuller, 1996; Altshuller Institute; Ideation International, 1999; Mann, 2002; Rantanen & Domb, 2002; Salamatov, 1999; Savransky, 2000; *TRIZ Journal*).

Basics of TRIZ

In reviewing the inventive principles used by thousands of inventors around the world, we find that some overriding inventive principles exist. Together with the inventive principles, there are five more tools to mention (for a survey of tools see Moehrle, 2003).

Ideal final result (IFR)

Systems and products evolve toward a more ideal state over time. This ideal state can be described as a system performing its function without existing, with no negative side effects, etc. Systems evolve toward this state over time through the resolution of contradictions and the recognition of and use of system resources.

Contradictions

Products and systems typically are not ideal because they need to serve dual functionality, creating conflicts in design and operation. The typical approach to these types of problems is to compromise on each function, creating a system that meets several requirements in a less than optimum way. The genius of Altshuller was to recognize that contradiction resolution was the key to inventive problem-solving. The most commonly used inventive principles used in resolving contradictions were captured within the framework of a contradiction table, using 39 physical parameters of a system as X and Y axes. The intersection of a conflicting set of parameters provides the number of appropriate inventive principles on which to focus problem-solving. This table, available from many resources, (Altshuller Institute; Mann, 2002; Savransky, 2000; Salamatov, 1999; *TRIZ Journal*) has continued to be updated via continuous study of the patent literature. New versions of the table, with expanded lists of parameters and updated examples, have also been published (Mann, 2002). This tool has become known as the '40 Principles', based on the original number that Altshuller identified. A separate aspect of contradiction analysis is focusing on conflicts within a parameter itself, as opposed to conflicts between parameters. When this is the case, TRIZ offers four specific 'separation principles', shown to resolve these kinds of contradictions. These are:

- separation in time (Can the conflicting parameter be separated in time?), for example, a delay in the time setting for an appliance;
- separation in space (Can the conflicting parameter be separated in space?), for example, different properties at various places in a toothbrush to achieve different hardness for teeth versus gums;
- separation between parts and the whole (Can a conflicting property requirement be achieved by separating the design requirements in space?), for example, a bicycle chain is very flexible at the macro level and very rigid at the micro level;
- separation upon condition (Can a property of a system be affected or controlled by differing conditions under which it operates or is presented with?), for example, a material whose viscosity responds to shear. This separation principle can frequently be a different way of viewing the other separation principles, i.e. separation upon condition is frequently also a separation in space or time.

It is possible to link these four separation principles indirectly with the original 40 principles (Mann, 2002).

Resources

Systems and products seldom use all the resources available to them. Methodical processes to identify and use system resources were developed as part of the TRIZ methodology. These resource classifications include:

- time (including before, during, and after);
- space (at all levels of a system);
- material;
- information (including that being generated but not necessarily recognized or collected);
- energy;
- fields (including those indirectly generated).

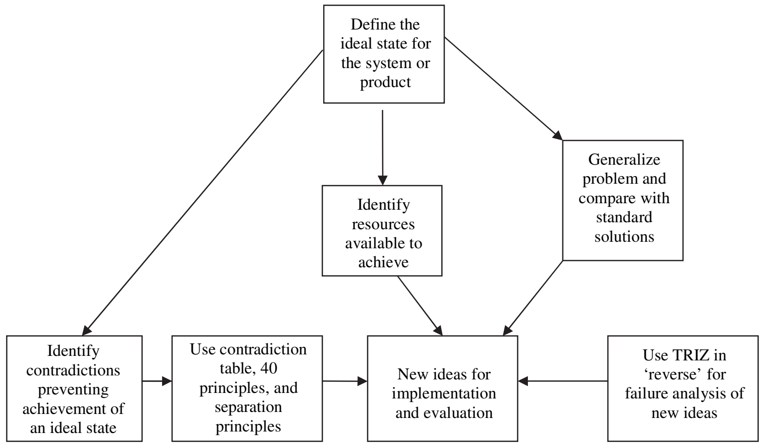

Figure 1. The Basic TRIZ Process

In TRIZ problem solving, it is not unusual to find the problem solution contained within the identification of resources initially not seen by problem owners.

Standard solutions

In analysing inventive problem solutions, Altshuller was also able to make general models of problems and couple these with 'standard' solutions that could be used independent of the specific nature of the technology or industry. These models and standard solutions are captured in a number of references (Ideation International, 1999; Salamatov, 1999; Savransky, 2000) and are also are the original basis for much of the commercially available TRIZ software.

Lines and patterns of evolution

The study of the patent literature also reveals that there are reproducible patterns of technological evolution for technical systems. The original eight lines of evolution have been extended and dissected in a number of ways by both consultants and software providers. These lines have also been extended and modified for non-technical systems.

'Reverse TRIZ'

This is a process wherein the basic TRIZ algorithm is inverted and used for failure analysis and prediction. For example, we have a system or product failing for unknown reasons. We invert this problem statement and state what we wish to have this problem. Next we exaggerate the inverted problem (we want this failure, etc.) to occur *all* the time. We then ask: how could this be accomplished? Do we have the resources, etc? This technique is used as an alternative to such tools as FMEA and HAZOP when these standard industry analytical tools have failed to identify failure or potential failure mechanisms and routes. An outline of the basic TRIZ process is shown in Figure 1.

Details on all these different aspects of TRIZ are beyond the scope of this paper, but suffice it to say that TRIZ is a structured ('left-brained') approach to inventiveness and problem solving, whose basis is that most problems we encounter have already been solved in a generic sense. Thus the focus of TRIZ problem solving is to model a problem in a basic, fundamental way and then to use the previously described principles (which apply to all inventive solutions) to solve it. ARIZ ('Algorithm for Solving Inventive Problems') is a sophisticated model for combining all of the previous tools, and again, it is the basis for much of the commercial TRIZ software. It will not be discussed here.

There are many ways that the elements of this toolkit are used or combined in a typical TRIZ problem-solving effort. These include remote consulting by a consultant knowledgeable about the various tools and the problem of concern and providing solutions directly to a client, to on-site group problem-solving session (varying in length) using the aspects of the toolkit and/or software as desired. Combinations of these two extremes are also used commercially. The structure of any of these efforts or work sessions usually follows the following structure:

1. Define system ideality or ideal final result.
2. Evaluate resources that are available to achieve the ideal state.
3. Define contradictions that prevent the achievement of the ideal final result.
4. Use the resources and suggested problem-solving principles (from standard solutions,

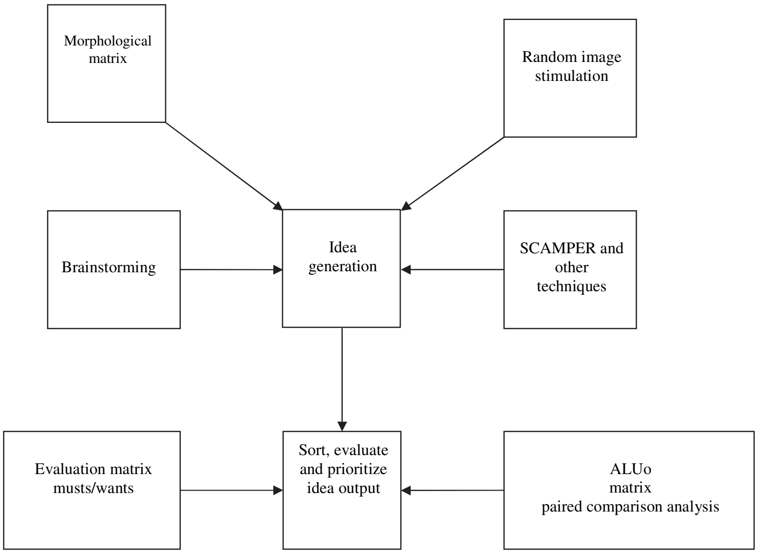

Figure 2. The Basic CPS Process

contradiction table) to generate breakthrough ideas to resolve contradictions.
5. Evaluate the problem and solution against the TRIZ lines and patterns of evolution to provide additional idea and longer-term ideas.
6. Uses 'reverse' TRIZ to analyse for potential failure routes and mechanisms.

Time for an initial on-site TRIZ problem solving session can vary from 2–5 days depending upon quantity of solutions desired, and the nature of the complexity of the problem. Longer-term consulting with TRIZ on strategic new business or product development can be done over a period of months and years, no differently than other type of intensive problem-solving consulting.

There is no one standard way of using the TRIZ problem-solving toolkit described above, and the tools and the exact process will vary with the type and nature of problem, the problem owner, the organizational situation and environment, and the expertise and preferences of the external consultant (if used). The process can be used to generate a large quantity of ideas for further evaluation or to generate a few focused ideas for immediate use. TRIZ software can be used successfully, but only after the group understands the basic thinking fundamentals of the process.

Creative problem solving (CPS)

Creative problem solving (CPS), first developed in the 1950s by Alex Osborne, was an attempt to improve the simple process of brainstorming. An overview of this process is shown in Figure 2. Summaries of the process and the various tools in its toolkit are available (Isaksen, Dorval & Treffinger, 1998; MBTI 1998). The major improvement made in this process, compared to previous ideation techniques, was to separate the idea generation phase of the process from the idea evaluation process in order to ensure the maximum volume of idea generation. The number of ideas generated in a CPS session is a primary success measurement used by most CPS facilitators. The assumption here is that the more ideas generated, the more likely it is to generate sufficient ideas of further interest that could solve the problem of concern. The separation between idea generation (the divergent phase) and idea combination, critique and evaluation (the convergent phase) allows the generation of ideas without fear of criticism or preliminary evaluation from other participants. This process, over time, has also developed a number of idea-generation tools to improve the quality of the ideas produced during the divergent phase. This process and its tools are widely used within group problem-solving sessions, and are the focus of several conferences. A consulting industry has also built up around the process, its concepts and improving its use and application. One of the fundamental differences between CPS and TRIZ is that TRIZ does not make the linkage between the need to generate a large quantity of ideas to generate the optimum solution. TRIZ has the capability to produce an optimum solution without the need to analyse many alternatives.

One of the commonly used CPS models would look as follows, dividing into (i) the divergent phase and (ii) the convergence phase:

Divergent phase

In the idea generation using brainstorming (assisted with Post-It™ notes if desired), brain writing, image stimulation, the SCAMPER idea generation (Substitute, Combine, Adapt, Modify, Eliminate, Put to other Uses, Reverse) tool. A morphological matrix, where a few basic properties of a system or product are varied deliberately, can also be used to stimulate ideas. Each major attribute of the system under consideration and the group lists possible parameters or characteristics of each parameter. Randomly combining each of the entries of the matrix can generate hundreds or thousands of possible ideas.

Convergence phase

Once a list of ideas has been generated by the divergent phase of the CPS process, these ideas are narrowed and focused by a number of different tools, regarding focusing, screening, and selection and use of an evaluation matrix, comparison against criteria, highlighting and grouping, prioritization against absolute needs, and comparison of ideas with each other.

ALUo

This focusing tools asks the participants to analyse each idea in terms of its Advantages, Limitations, Unique qualities, and overcome limitations to assist in idea optimization, prioritization and selection.

Evaluation matrix

This tool lists the ideas selected for final evaluation against evaluation criteria established by the problem-solving group or its organization. In a simple table, the ideas are listed vertically and the criteria listed horizontally. At each intersection, a rating or relative ranking is made, assisting in the final decision-making of the group.

Other techniques for focusing and choosing include distinguishing between musts and wants, and deliberate paired compared analysis of ideas against each other.

Using CPS as an umbrella for the use of TRIZ

CPS can be used as an 'umbrella' under which to incorporate many of the simple TRIZ problem analysis and problem solving tools (Figure 3). The details of this overall diagram and structure will now be discussed.

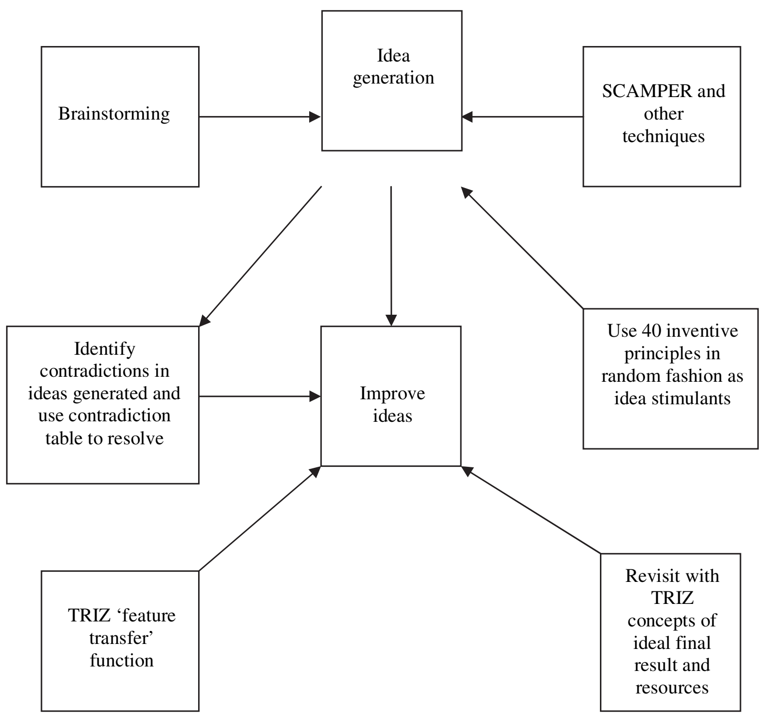

Figure 3. A CPS umbrella for TRIZ

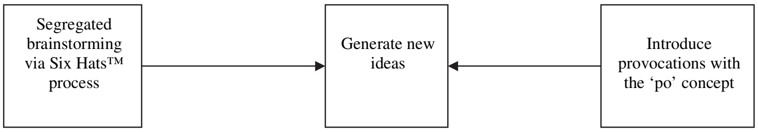

Figure 4. Overview of Lateral Thinking™ and Six Hats™ Use

There is complete agreement between TRIZ and CPS with regard to the concept of separating the idea generation from the idea evaluation phase of an innovation process. In fact, TRIZ consultants frequently make a point of noting individual statements made during a problem-solving session, such as 'that won't work because . . .', to illustrate and take note of a contradiction for later consideration. TRIZ adds more emphasis on the problem-definition aspect. In the idea generation phase of CPS, the emphasis is on quantity of ideas on the assumption that the ratio of ideas generated to potentially valuable ideas is a constant. TRIZ argues that a well-defined problem eliminates the need for a high ratio, but if this is the desired goal, this is how TRIZ principles can be used to improve the CPS process, assuming that it is the overriding general process to be used.

TRIZ tools for the CPS idea generation phase

The simplest way to introduce a small part of the TRIZ toolkit into CPS is simply to use the original 40 principles as part of the general idea generation phase. Suggest one of the principles at any time. Continue to do this with all 40 principles. An interesting exercise at the end of such a session would be to compare the 'roots' of the various ideas selected and compare the efficiency of the 40 principles with other techniques used. A second way is to write each of the 40 principles on a Post-It™ note and distribute them among the group and ask for ideas via that stimulus as part of a brain-writing exercise. A third way, connecting with the visual CPS image stimulation tool, is to use a simplified diagram of a particularly inventive patent, illustrating an inventive principle, which may not necessarily have any direct connection to the problem at hand.

The SCAMPER idea generation tool mentioned previously has some strong overlaps with parts of the TRIZ toolkit. For example, asking the 'E' question 'eliminate?', that is, 'can we leave it out? Have fewer parts? Make it lighter, shorter' and so on, are all examples of questions that would be asked by a TRIZ facilitator while focusing on the question of 'resources'. Since the TRIZ definition of resources (see previous list) is far more comprehensive, additional ideas would be expected. Similarly, the SCAMPER 'A' question relating to 'adapting' (What could I copy? Does the past offer a parallel?) would allow a knowledgeable TRIZ participant to suggest a more formal review of parallel industries that might have similar problems or the use of TRIZ software products that contain or have access to this kind of information immediately. The 'R' question is a restatement of one of the basic TRIZ principles, 'do it in reverse'.

TRIZ tools for the CPS convergent phase

The ALUo analysis described above will generate a list of limitations to which the TRIZ contradiction table, 40 principles and separation principles can all be applied, as opposed to simply brainstorming solutions to the problems identified. The CPS evaluation matrix is an excellent tool for graphically displaying contradictions. The TRIZ tools used for contradiction resolution, 40 principles and separation principles can be used to solve these contradictions. Paired comparison analysis is similar to a TRIZ technique (not mentioned previously) called 'feature transfer' where we ask what good features of a known good idea (or one good aspect of an overall poor idea) can be transferred to another idea to make an overall better idea.

The CPS evaluation matrix, identifying why a particular idea does not meet the criteria, can be supplemented with TRIZ problem-solving tools to improve the suggested ideas. TRIZ can be used to expand the utility of paired comparison analysis by using this tool, not as one solely to compare and prioritize ideas, but as a list of ideas whose features can be transferred to other ideas.

Six Hats™ and Lateral Thinking™

These tools and processes, developed by Edward DeBono and the subject of numerous books and publications, take the separation in idea generation and evaluation used in the CPS process to a higher level. Excellent summaries are available (DeBono, 1999, 1985, 1973). In the following, Six Hats™ and Lateral Thinking™ are introduced.

Six Hats™

Six Hats™ is a problem-solving process, during this participants are asked to wear different 'hats', allowing only a certain type of thinking and sharing. This is a more focused way of eliminating the immediate criticism of ideas that typically occurs during idea generation. These hats have colour codes as follows:

- blue – discussion of the meeting and idea generation process itself;
- green – idea generation;
- white – discussion of information needed to define the problem or to evaluate proposed ideas and solutions;
- yellow – discussion of positive aspects of an idea or ways to improve it;
- black – discussion of negative aspects of ideas or their implementation;
- red – discussion of emotional or 'gut feel' about an idea, regardless of facts or information. This 'gut' or emotional feeling could be positive or negative.

These hats can also be used in varying sequences depending upon the nature of the problem. Six Hats™ facilitation can also involve the wearing of 'hats' of these various colours to accentuate the differentiated thinking as a function of time. The major point is that all participants in the session wear the same 'hat' and think along the same lines at the same time.

Lateral Thinking™

Lateral Thinking™ is a formal technique used to generate provocations, and if used in conjunction with Six Hats, would typically be used under the green hat. It provides a specific technique known as 'po' ('provocative operation') to purposely reverse the problem or another orthogonal way of looking at the problem. Lateral Thinking™ contains specific suggested 'po's' to use in various situations.

Using the Six Hats™ and Lateral Thinking™ processes as an umbrella for use of TRIZ tools

These processes, as was the case with CPS, are inherently limited by the knowledge of the individuals in the problem-solving group. TRIZ adds the knowledge of patterns of invention from the global patent literature and well as knowledge from outside the room to both tools. As with CPS, there is a tendency within an organization, evaluating a competitive process, to focus on the differences instead of the possibilities of combining TRIZ within an existing problem-solving structure.

TRIZ tools can be used under the umbrella of the 'hats' and integrated into this process (transparently if necessary!) as follows.

Blue

This 'hat' is used to discuss the structure of the problem solving and meeting process itself. It is typically used at the onset of the group session, but can be revisited at times during the problem solving session as deemed necessary by the group or its facilitator. Under this hat, the high-level TRIZ algorithm is used to check the logic of the meeting process itself. For example, has the problem been adequately defined? Has an ideal state been clearly defined? Are the problem owners in the room? Have the consequences of both success and failure been thought through adequately?

White

This 'hat', used in clarifying and asking about informational aspects of a problem, can be supplemented in its effectiveness by various pieces of the TRIZ toolkit. What information is a system generating but is not being collected? Is there enough information to clearly identify the conflict in a problem? Are there parallel industries or technologies that can be searched and studied?

Green

When generating ideas under this 'creative' hat, the 40 principles can be used for general stimulus, and if, under the blue or white hats, a contradiction has been identified, the TRIZ contradiction table can be used to resolve these identified contradictions, resulting in new ideas.

Red

Even though this hat is typically used for only a short period of time, the feelings and expressions may be indications of past knowledge and experience, which if captured properly, can add value. For example, an expression of 'that won't work' may in fact be rooted in an experience with an inherent contradiction that TRIZ may be able to solve. Encouraging a participant to express this concern as a contradiction (rather than some general statement of dislike) sharpens and clarifies the issue and

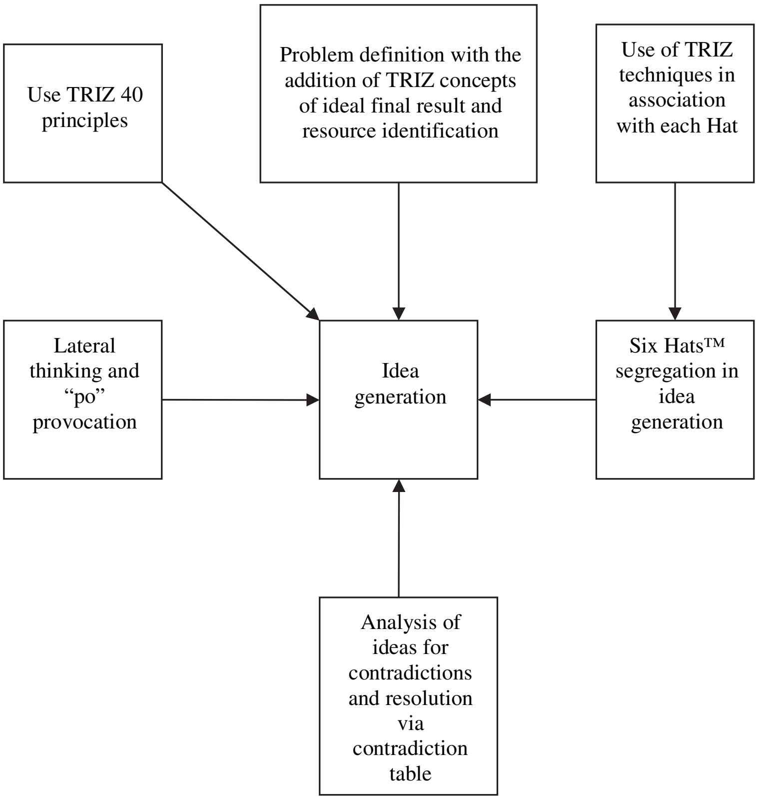

Figure 5. A Six Hats™ and Lateral Thinking™ Umbrella Structure for the Use of TRIZ

allows the use of contradiction-resolution tools.

Yellow

While asking and considering what is good about a particular idea or concept, the TRIZ concept of IFR can be used aggressively for each idea already expressed. The question of how to make an idea even better will also elicit expressions of limitations, which in turn can be translated into contradictions, again allowing several TRIZ contradiction tools to be used.

Black

In the group's discussion of negative attributes of an idea or concept, it is best to express these concerns in the form of a contradiction, allowing the use of TRIZ contradiction-resolution tools. Using 'reverse' TRIZ to ask how we might intentionally cause this idea to fail commercially or technically can also develop solutions to problems whose root cause has been identified.

A summary of a proposed combination of the Six Hats™ process with TRIZ tools is shown in Figure 5.

Using individual psychological assessment tools in conjunction with TRIZ problem solving

As with problem-solving tools and processes, most organizations use various psychological assessment tools to assist employees in self-development, provide input that allows employees to improve their interactions with other employees, or for career planning. These tools include the Myers Briggs Type Indicator™ (MBTI, 1998) and alternatives such as the Herman Brain Dominance (HBDI™) model and the KEYS™ (Keirsey, 1998) assessment tools. Many large consulting firms also have developed their own proprietary audit and assessment tools. The degree of psychological validation of the various assessments should be considered prior to using in a broad-based, organizational way. Assessments focusing more on an individual's problem-solving style and their preferred behaviour in problem-solving team situations (Kirton KAI™, BCPI™/FourSights™) are also used. The objective of this paper not to compare or explain all these different assessment instruments, nor to cover all the possible connections and comparisons between them. The reader is referred to the appropriate references for detailed information on any one particular assessment instrument. In this paper, we will review two examples of TRIZ use with two of these assessment tools that are widely used. These assessment tools are (i) the Myers Briggs Type Indicator™ and (ii) the Kirton KAI™.

The Myers Briggs Indicator

The Myers Briggs Indicator, commonly referred to as MBTI™, is one of the most widely used psychological assessment tools. In addition to the MBTI™, there are competitive assessments such as 16Types™ and Insights™, generating the same type of analysis. However, all of them analyse the same aspects of social behaviour, all have been validated, and the comments following apply to all similar instruments. Basically, these assessments measure an individual's style of social interaction in the following categories:

- Extroverted/Introverted (E/I): is someone basically inward or outward focused in their interactions with others? In a problem-solving session, this characteristic may indicate a person's willingness to express his/her opinion or the desire to enter into a discussion or argument about the quality or validity of an idea.
- Sensing/Intuitive (S/iN): Is someone's perception process based on the senses of sight, touch, smell, hearing, taste? Is hard data of primary concern? Or is it more intuitive and based on meanings, relationships, and insights? In a problem-solving session, this difference may manifest itself in how someone reacts to an idea and how interested he/she may be in evaluating or implementing it.
- Thinking/Feeling (T/F): what is the nature of an individual's decision making process? Is it based upon impersonal logic, objectivity, and fact or upon feelings and personal values and standards? In a problem-solving session, this difference will show itself in the manner in which someone reacts to an idea, for example, gut feeling or asking for facts and data.
- Judging/Perceiving (J/P): what is a person's drive toward closure, organization, plans and schedules? A person having an open-minded perceiving attitude versus a judgemental, closure one.

An individual profile is a four-letter summary, covering each aspect of the evaluation. An example of a profile determined by such an instrument would be INTP (**I**ntroverted, **iN**tuitive, **T**hinking, **P**erceiving). There are 16 possible combinations, and thus a wide diversity in any group's participants. This type of assessment instrument is widely used within organizations, but very seldom within the context of TRIZ problem solving. Participants may be aware of their individual profiles or of the behavioural patterns that are normal for them, but have seldom proactively used it personally, let alone in a group problem-solving situation.

There are 16 possible combinations of profiles and not equally distributed by gender, race, occupation, level in an organization. As two examples, 75 per cent of the general population are 'E's' or extroverts and 75 per cent of the population are 'S's' (MBTI, 1998). Two-thirds of men are 'T's' and two-thirds of women are 'F's' (MBTI, 1998). There is no reason to expect any particular distribution in a problem-solving group.

How can this knowledge be used to improve a TRIZ session? First of all, the knowledge of 'E' versus 'I' profiles can assist a session leader in soliciting input from individuals less likely to actively participate. Second, the level of problem definition and attack can be segregated and matched with the 'T' versus 'F' component of the MBTI™. A less-defined, longer range, more ideal vision of a problem solution can be done by one group, while another sub-group can look at more practical, shorter-term aspects. In all problem-solving sessions, closure is desired on post-session action items. A combination of 'S' and 'T' people might be used to structure and plan immediate activities; while a group of 'P' individuals might be asked to look at longer-term options requiring additional research or exploratory efforts. Individuals with a strong 'F' preference would be outstanding at evaluating the people impact of new ideas generated from a TRIZ session. These suggestions are not meant to be all-inclusive, but starting points in thinking about how to use, from a TRIZ perspective, the resources already present within the group. The reader can think of other examples of proactive use of this information in combination with TRIZ problem solving. The extent to which this might be useful will be a function of the degree of permanence of the problem solving team, time the team is going to be together as a team, how much of the discussion is done remotely and so on.

Kirton KAI™

A further very useful assessment tool is the Kirton KAI™ assessment tool, which measures an individual's problem-solving style (not capability). One can think of this instrument, in a very general sense, as assessing one's relationship to problem solving in the same sense as the MBTI™ measures one's relationship to other people. The KAI™ instrument contains 32 questions, which can be completed in 15–20 minutes. Examples of the types of questions would include: how easy or difficult is it for you to present yourself, long term and consistently, as someone who conforms, enjoys detailed work, is stimulating, is predictable? Another similar instrument, whose output is in the form of bar graphs and is available online, is the Buffalo Creative Process Inventory (BCPI™) – now referred to as FoursSights™ (Puccio, 2002). For the purposes of this paper, we will use the KAI™ as the instrument for the discussion focal point.

The output of the KAI™ is an output number ranging from 32–160 with the 'norm' around 90 and a two-sigma deviation from 70–120. This varies a slight amount by gender and national origin, but not significantly. Sub-scores, which can vary significantly, highlight particular areas such as originality, rule/group conformity and efficiency. These sub-scores sum to give the total KAI™ assessment number mentioned earlier. These sub-score areas are as follows:

- originality (total from 13–65). This can be looked upon as a measure of an individual's raw capacity to generate ideas. A person with high originality sub-score will tend to generate a large quantity of unfiltered ideas. A person with a lower sub-score will tend to filter ideas prior to expressing them. This filtering could be as a result of a sense of impracticality or fear of being ridiculed. Note that this is a different aspect than extroversion and introversion as mentioned previously during the MBTI™ discussion;
- efficiency (total from 7–35). This is a measure of how structured and visible an individual's problem-solving process is to others. For example, if someone is talking and discussing an idea concept and the methodology and thinking process are readily visible to everyone, this individual probably has adoptive efficiency sub-score. However, if an individual always appears to others as 'coming out of the blue' and their thinking and analysis process is not externally visible, they likely have innovative efficiency sub-score.
- rule and group conformity (total 12–60). This is a measure of an individual's tendency toward needing group processes, norms, and structures during problem solving. A strongly adaptive rule-and-group-conformity person will be very concerned with group consensus around an idea and respect rules and procedures that may be in place for idea evaluation, implantation and so on. A strongly innovative person on this sub-scale will be more challenging to norms and procedures, permissions required and group consensus prior to proceeding.

How can this information be used to improve the quality of output of a TRIZ session? A TRIZ problem-solving session, as indicated earlier, has a strong problem definition aspect to it, even more so than other creativity and problem-solving processes. The structure of typical TRIZ problem solving effort helps both sides of the KAI™ problem-solving spectrum – a very unusual and positive aspect of TRIZ. It provides stimulus, via its basic concepts (IFR, use and recognition of resources, identification and resolution of contradictions) that assist in problem definition. The stimulus of previous patent examples and strict cause-and-effect modelling for provided by TRIZ software products positively impacts both ends of the KAI™ spectrum. Prior to a TRIZ session, the KAI™ instrument can be completed by participants and then feedback provided as part of the TRIZ session. It is sometimes productive and educational to segregate the group, via scores known only to the instructor, to illustrate how different people approach problem-definition and solution ideas.

In one actual industrial case study (Hipple, 2003), KAI™ assessments were made prior to a TRIZ problem-solving session with a Fortune 100 US chemical company. The KAI™ scores were segregated very strongly into adaptive (scores 80–85) and innovative (110–130) problem-solving styles, with no representation of mid-range problem solving. Each group was asked to separately diagram the problem they were addressing using a commercial TRIZ software product. Figure 6 shows the cause and effect diagram created by the more adaptive segment of the group. One can see the structure and organization apparent in the diagram and problem definition. Figure 7 shows the same basic problem diagrammed by the higher KAI™ (more innovative) segment of the group, demonstrating the lack of need for structure and organization for this group. There were also differences in the number of contradictions identified, but this cannot be tied directly to the KAI™ scores as this is seen frequently in TRIZ sessions. Links between exact problem definition and the KAI™ needs further research.

The discussion which occurred after the diagrams and their associated idea output were presented consisted of the following types of questions:

- Why do you see the problem that way?

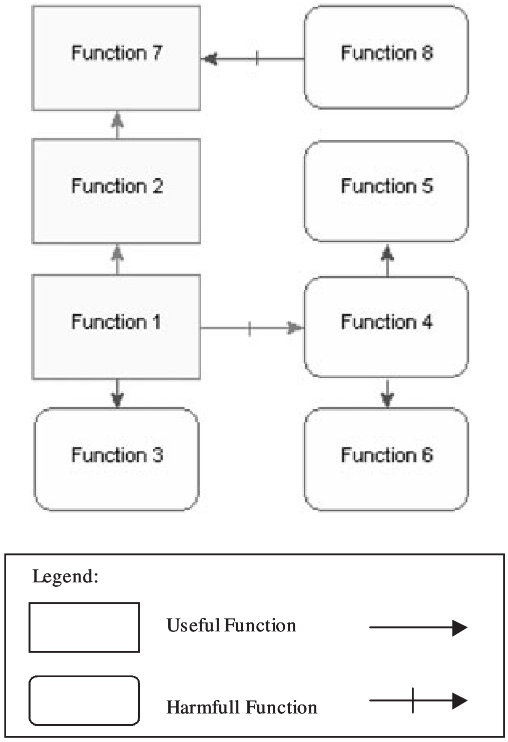

Figure 6. TRIZ Cause and Effect Diagrams Drawn by KAI™ Adopters
Source: modelled by Ideation WorkBench

- How can you possibly make any sense of your diagram?
- Why did you choose those particular ideas to pursue?

This difference in KAI™ perspective was also used in a proactive way to separate short- and long- term action items resulting from the session.

Summary and conclusions

TRIZ uses a fundamentally different process and framework to the problem-solving environment, which is difficult for many individuals and organizations to understand and accept. It is frequently introduced into organizations with existing problem-solving processes (two of the major ones having been discussed in this paper). This paper has presented overviews of other tools and how they can be integrated in a preliminary manner with the TRIZ toolkit in order for an objective analysis to be done without having to make a discrete choice between one or the other being 'better'. Though this author believes TRIZ to be a superior problem-solving tool, it is far better to have part of the methodology tried and used within an existing problem-solving structure such as Six Hats™/Lateral Thinking™ or

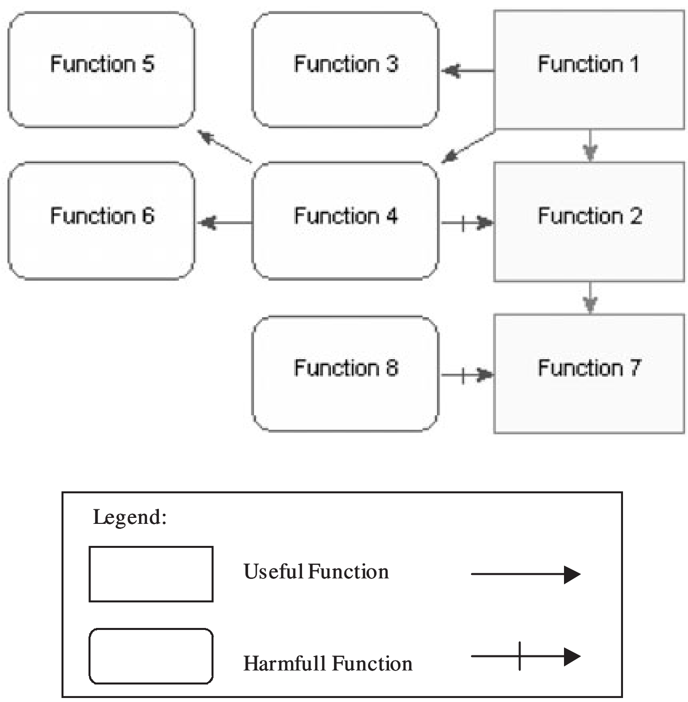

Figure 7. Cause and Effect Diagram Drawn by KAI™ Innovators
Source: modelled by Ideation WorkBench

CPS than not to be used at all. Once the various tools have been validated, curiosity will occur about the nature and origin of these tools, leading to additional learning and use of the complete TRIZ process.

The fundamental limitation of these processes and tools is their reliance on psychological stimulation or organization of the session and session participants. The processes and tools, on their own, bring no additional problem-solving or technical knowledge beyond that which already exists within the group of problem-solvers. One of the major strengths of TRIZ problem solving is not only its ability to provide structure (beyond that provided by CPS or Six Hats™) to a problem-solving situation, but its capability, through both its problem-definition and problem-solving principles, to inject new knowledge that did not exist in the group originally. In summary, it is not necessary to 'replace' processes such as CPS or Six Hats™ in totality to have TRIZ problem-solving concepts demonstrated and evaluated. Many TRIZ tools can be used under the umbrella of these and other processes to demonstrate their value, and produce interest about the entire TRIZ process and toolkit.

It is also possible to use known, or easily obtainable, psychological-profile information, to make a TRIZ implementation and problem-solving session more productive and rewarding, not only for the problem owners, but also the problem-solving participants themselves. Assessment tools such as MBTI™ and KAI™, usually used solely to assist individuals in career planning or in work environment situations can be used proactively within TRIZ problem-solving sessions to maximize their productivity.

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Jack Hipple is Principal in the consulting firm, Innovation-TRIZ. In addition to his formal training in chemical engineering (BS ChE, Carnegie Mellon University, 1967) and a 30-year career in the chemical industry, he is certified and trained in most major creativity, innovation, and organizational assessment techniques. For the past six years, he has focused on TRIZ training and problem solving and teaches TRIZ for the American Institute of Chemical Engineers and the Society of Mechanical Engineers. He also runs TRIZ training workshops for the Institute of International Research, the Innovation Network and the World Future Society.