FEATURE

by Ed Sickafus

Structured Inventive Thinking:

A conceptual approach to real-world problems

This methodology organizes scientists and engineers into more efficient problem-solving teams

About 50 years ago, Henry Altshuller of the former Soviet Union invented a problem-solving technique called TRIZ (pronounced "trees"), which is a Russian acronym for the theory of inventive problem solving (sometimes referred to as TIPS). Four decades later, instructors at the Open University of Israel modified and simplified Altshuller's technique to produce a problem-solving method called Systematic Inventive Thinking. More than 3,000 engineers have been trained in the Israeli method, and training is being expanded beyond the courses offered at the Open University and by their consultants. Today, there are several Israeli corporations that run in-house training programs in this method.

In Spring 1995, Ford Motor Company began experimenting with structured inventive thinking (SIT)—a streamlined version of the Open University's problem-solving technique. Our SIT program is easier to learn and more readily applied—a necessity for corporate engineers who have little time for supplemental training. At Ford, two physicists (I and my colleague Craig Stephan) teach a basic SIT course every three weeks. A course consists of six half-day classes over a two-week period, for a total of 24 contact hours. Naturally, our students do not emerge as SIT practitioners after a basic course. In the former Soviet Union, learning TRIZ required at least 120 contact hours. So we supplement our basic course by inviting graduates to 90-minute weekly user-group meetings. Employees attend all the programs voluntarily, which is an important indicator of committed participation.

How it works

Problem-solving teams are brought together to learn and apply SIT methodology to corporate problems. In the SIT process, these teams concentrate on conceptual problems and seek conceptual solutions to them. That is, the SIT process helps investigators strip a problem to its fundamental characteristics and then develop a general solution. When faced with a real-world problem such as "wetting microscopic cobalt particles with viscous linseed oil," for instance, a SIT team might convert it to a conceptual problem, such as: "wetting particles with a fluid." A resulting conceptual solution might begin: "Coat the particles with molecules." Later, the solution's specific engineering details could be developed from conventional engineering procedures. Through this approach, SIT emphasizes inventiveness and stresses to participants a thorough search for all possible solutions.

Needless to say, SIT does not lead a problem solver to solutions that could not be found by other means. It simply leads to solutions more quickly and efficiently. Moreover, SIT does not hand over a solution; rather, it helps a problem solver discover inventive solutions.

This article provides an interim report on Ford's SIT experiment—an effort to leverage in-house expertise for solving technological problems. The experiment consists of training volunteers in SIT methodology through a basic course and then engaging them in regular SIT user-group meetings, where corporate engineers (usually SIT graduates) can present their own technological problems. The SIT user-group meetings provide continued "on-a-problem" training, which improves a new SIT graduate's competence and confidence in applying the technique. We believe that this structured problem-solving methodology serves two purposes: It makes scientists and engineers more efficient problem solvers, and it engages practitioners from various disciplines of science and engineering in a natural, productive team effort based on a common language.

Although we have only anecdotal information on this ongoing experiment, two key factors argue for this preliminary report. For one thing, SIT remains largely unknown in the United States, and this article will inform potential users about the process and its history. In addition, sufficient success has been achieved to encourage wider use of the methodology, which could further enhance its growth and maturation.

Streamlining steps

With any industrial problem, defining it is usually one of the most difficult parts of solving it. To truly define a problem, we must sweep away the extraneous information and focus on the essential information that characterizes the problem. SIT expedites this stage by encouraging problem solvers to set aside what we call engineering filters, such as cost, timing, dimensions, and material specifications (assuming that none of these is essential to the problem). Setting aside these constraining filters allows problem solvers to explore as many potential solutions as possible. Later, engineering filters can be reapplied to select one or more solutions of choice.

Encouraging inventive solutions—one of SIT's fundamental goals—can also be improved by removing psychological barriers to the thinking process. For example, such barriers crop up in the form of technical words in the statement of a problem. Although technical words are crucial to clear communication in science and engineering, such words can block inventive thinking. So in the SIT process, problem solvers change technical terms into generic ones. For instance, SIT might modify a problem's definition by replacing the word "screws" with "fasteners."

Removing the technical terms transforms a real-world problem into a conceptualized one—a problem that has been simplified, stripped of technical terms, and essentially lifted to the level of a puzzle, or a problem that lacks detailed specifications. In the next stage, SIT defines the given problem in terms of a limited set of so-called objects.

Butter patties

In order to understand how SIT uses these objects, let's discuss an example problem. In this case, an Israeli company faced a challenge in its process for manufacturing butter patties. The process produced many out-of-specification patties, which were recycled by placing them in a jacketed metal vat that had steam flowing through its annular region (see Figure 2a). The recycling process was slow and a greater throughput was desired. How could this be achieved?

Before reading on, stop a minute and consider how you might solve this problem. What would you do? What possible concepts come to mind for increasing the rate of melting and recycling the butter patties?

As mentioned, SIT quickly focuses attention on a conceptual problem's fundamental factors by defining the set of objects. In this example, the objects are patties, vat, and steam. Next, the objects are arranged hierarchically in a closed-world diagram (see Figure 2b), which produces a new view of the system based on the function of the objects. The structure of a closed-world diagram arises from the functional, not structural, relationships between the objects, and the hierarchical organization reveals the order of importance of the selected objects. The SIT system includes precise rules for selecting objects and building a closed-world diagram. We confine a conceptual problem to its closed-world diagram to assure that all solutions comply with the basic function of the original system. This is a typical constraint that is common in many engineering problems.

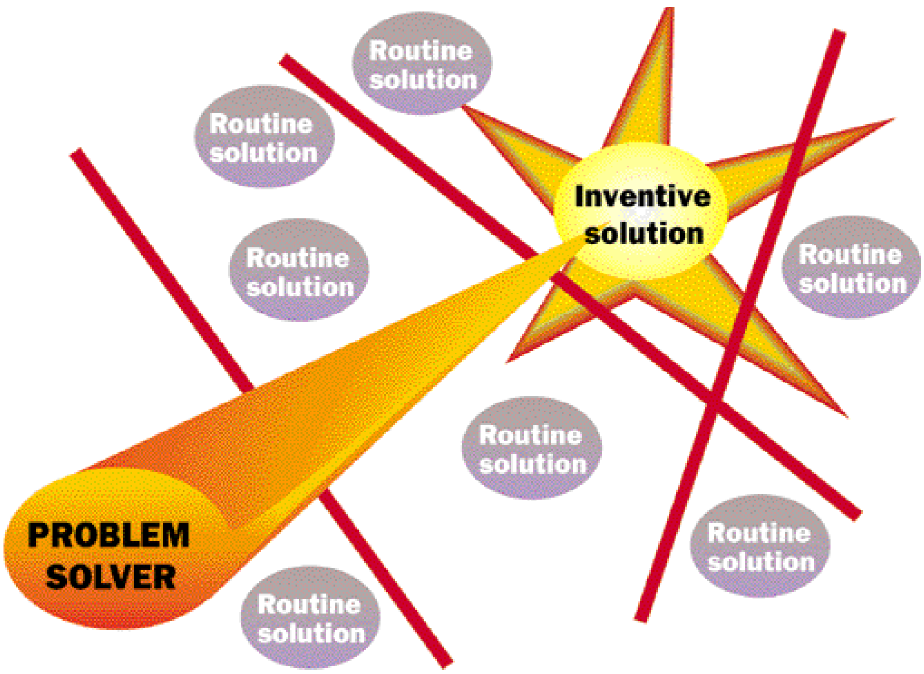

Figure 1. Structured inventive thinking allows us to penetrate the psychological barriers that often shield truly inventive solutions

Innovation

Once the problem has been set up, several solution techniques can be applied. As mentioned, a problem solver seeks conceptual solutions, each of which may provide an opportunity for developing a specific solution or a stepping-stone to another concept—good reason to avoid engineering filters early in the process.

In the butter-patty problem, the closed-world diagram shows that although steam contacts the vat, the steam's main purpose is delivering heat to melt the butter. Therefore, an immediate solution becomes evident by recognizing that heating the vat wastes time. The conceptual solution reveals that the melting process could be shortened by bringing heat directly to the patties, rather than into the vat's annular region. In generic words, bring the heat-conveying medium directly in contact with the object to be melted.

Directing steam into the vat, however, would generate a new problem: separating condensed water from the melted butter. At that point in the SIT process, though, an engineer from the dairy plant recognized that another heat-conveying medium—hot milk—was readily available. Moreover, the plant already had a process for separating butter from milk. So the final engineered solution proved straightforward, economical (no significant cost), and inventive.

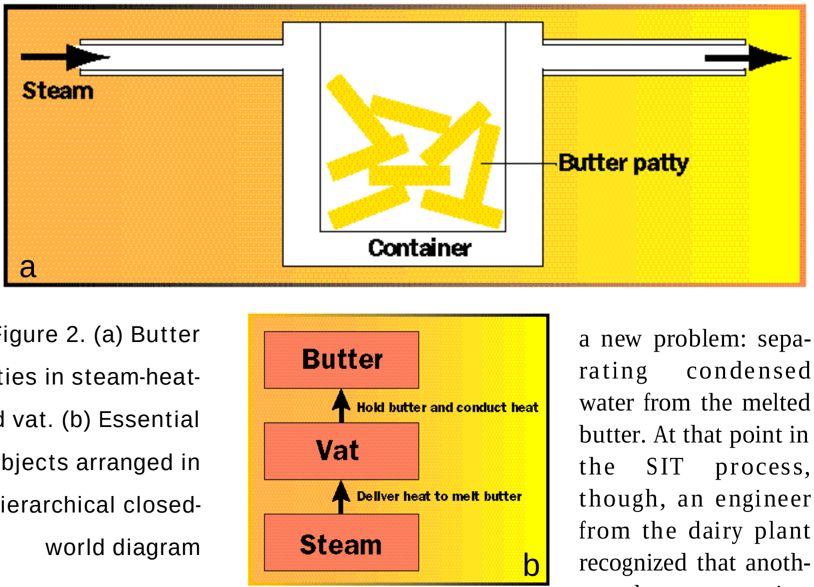

Figure 2. (a) Butter patties in steam-heated vat. (b) Essential objects arranged in hierarchical closed-world diagram

Posing problems

Our SIT classes start with discussing principles, along with examples of how certain features of the algorithms and solution techniques work. After discussion, we divide the class into three-person teams to test their understanding of the principles just taught. The teams take 30 minutes to set up SIT problems, then they present their results to the class for correction and improvement. These classroom exercises are primarily a forum for learning how to set up problems in the SIT methodology, but this early stage of learning also occasionally generates a real solution to a real problem. Moreover, the amount of problem solving that can be accomplished in just half an hour also impresses students with the power of the SIT process.

Although students are welcome to bring any kind of problem to class, finding problems to work on is relatively difficult. One possible explanation for this difficulty is that students may be unable to identify what they are comfortable in bringing. Another is that students may be reluctant to expose their own problems, preferring instead to listen to their colleagues' problems being analyzed. Sometimes students fall back on problems that have already been solved satisfactorily; they want to see if SIT will generate the "known" solutions. The danger is that if a problem-solving team selects such a solved problem, then one team member has a specific solution in mind, which may bias the entire SIT process.

Nevertheless, many students stimulate these classes by bringing a broad spectrum of good engineering problems: mechanical engineering problems, process problems, manufacturing issues, and many others. And as mentioned above, students in our SIT classes have even solved some of their workplace problems. Examples include: making a reproducible assembly-line measurement of an opening in a compressor piston; developing a shipping method that eliminated a protective plastic cap and still prevented bending of the pins on an electronics-component connector; using embossments to improve the heat transfer from an air conditioner's cooling fins; changing a process so that left-hand and right-hand leather stampings do not end up in incorrectly labeled boxes; and testing for very slow leakage from a sealed microvolume enclosed between two wafers of dissimilar materials. So we have solved a wide variety of real problems in our SIT classes.

Early indicators

Although this experiment continues, students have provided positive feedback, especially about the efficiency of the SIT process. In one case, a student challenged a SIT class with a problem of how to ship gauges without leaking damping fluid, and the class generated half a dozen solutions in 15 minutes of teamwork. When the student was asked whether these were new solutions, he replied, "No, none of them are new. However, what was accomplished in class in a brief period took six months to achieve by conventional means."

At the beginning of each basic SIT class, we pass out invention-disclosure forms, which represent the first step in the corporate patent process. We do this for several reasons: to impress our students with the technique's potential for rapid turnaround time in invention; to encourage their commitment to learning the technique; and to show them our seriousness in this program. In fact, at least two of our students submitted new invention disclosures before their classes ended.

Despite these early indicators of success, an objective assessment of SIT's actual achievement will not be easy. I believe the basic question is: How can problem solvers know what specific technique actually led to their inventive solutions? Answering that question may require studies by cognitive psychologists, but I know of no such projects at this time. In fact, I know of no other companies in the United States that use SIT. While we eagerly await the results of future definitive experiments, engineers and scientists at Ford will continue to learn SIT's quicker, more thorough, and more enjoyable paths to inventive problem solving.

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