



# Problem-Solving Strategies:

## Methods for Team-based Competitions

The following resource is an excerpt from "**Total Quality Learning® (TQL®): A Team Development Workbook for Thinking Skills Sports.**"

For the TSA TEAMS competition, following the formal Problem-Solving process—at least until the entire team is comfortable and familiar with it and is able to effectively follow the steps—increases the team's chance for success.

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### The Scientific and Engineering Methods

Most schools teach the scientific method; however, few teach the difference between the scientific method and the engineering method. While there are similarities, the two methods have different purposes and outcomes.

The **scientific method** takes a problem and seeks information through research, for the purpose of seeking new knowledge. This new knowledge may or may not be applied to the development of a new product. A new product that may be developed by using the scientific method is not the primary motivation for using the scientific method.

For example, the scientist may discover that a particular combination of chemicals produces a new molecular structure that is non-polluting and appears compatible with gasoline under certain conditions, but at this time there is no proven use for this new structure. The finding is interesting and potentially useful.

The **engineering method** is not used for the primary purpose of gaining new knowledge, rather it applies knowledge to a problem and produces a new solution or product. The result of the engineering method is usually a new product or process. Knowledge gained during the engineering method is not the primary purpose for using the method.

Using the same molecular structure discovery, the engineer would seek ways to enhance the performance of gasoline, to manufacture the structure, and to ensure its continued effectiveness over a long period. Engineers would also ensure that it is environmentally sound and cost-efficient. The structure, and the knowledge gained from its discovery, can now be used to benefit humankind.

### The Problem-Solving Process

TEAMS has defined seven major areas of focus for problem-solving, each with additional sub-steps, which enable you and your team to see the flow of the total process. Some sub-steps may be eliminated by your team or not consciously worked through.

For example, in the TEAMS competition, the key element of success is for the team to correctly solve as many questions as possible in the specified amount of time (i.e., 90 minutes). Obviously, many of the steps in the detailed engineer's Problem-Solving sub-

steps listed below would not be used during the competition, but the team may practice all of the steps of the strategy when preparing. At the competition, the entire process, if properly practiced beforehand, will be condensed into an organized and efficient one that enables each question to be answered more efficiently.

## **Major Areas of Focus and Sub-steps**

### **1) Determine Why Acting is Necessary:**

- Determine that there is a need to act
- Verify the need by gathering facts

### **2) Define the Exact Problem:**

- Define the problem
- Analyze the problem
- Determine the problem's scope and limits
- Gather resources that may help enhance understanding of the problem

### **3) Decide How to Approach the Problem:**

- Generate a wide range of ideas about how to go about solving the problem
- Plan and select an approach for initiating a formal Problem-Solving process
- Generate alternatives and elaborate on proposed solutions

### **4) Focus On an Appropriate Solution:**

- Focus
- Intensify data and resource search and analysis
- Evaluate and select the best alternative

### **5) Implement the Solution:**

- Design, build or implement the best solution

### **6) Test the Solution:**

- Test the implementation
- Refine and optimize the solution

### **7) Evaluate and Refine the Solution:**

- Evaluate performance and track effectiveness
- Maintain and sustain improvement
- Repeat the process to improve the new solution

## **Sub-steps Expanded**

### **Determine that there is a need to act.**

The ultimate goal of engineers—and the profession—is to fulfill the needs of humankind. Action for no defined purpose is wasted energy; a problem or challenge must exist in order to act. Start by asking yourself:

- Why do the work?
- Who has determined that a need exists and by what criteria?
- Are the needs purely physical or economic, or is there a social dimension?

Is there a need for a new or improved product? Under the current or likely future conditions, will the prior product perform adequately? This is NOT to say "If it ain't broke, don't fix it!" Rather, can it be improved to serve a better function? For example, propeller aircraft work very well and the concept was never "broke." However, someone determined that the field of aerospace needed to provide better and faster services and this could be done by applying jet principles to commercial aircraft.

### **Verify the need to act by gathering facts.**

The concerns of one person or a small group, while important, should not dictate a team's perception of the need to address a problem. Consider the following:

- Is the problem important enough to justify action based on various constraints?
- Does the problem impact a large percent of humankind?
- What are the facts? Do the facts justify proceeding at all or only in a specific direction?

Entrepreneurs sometimes make the mistake of thinking that the whole world needs, and wants, their better gadget. Based on this often false assumption, considerable time, effort and money is spent to develop a new product that may only benefit a small amount of people. In some cases, this is caused by a lack of preliminary market research or just a failure to look honestly at the situation.

### **Define the problem.**

State what need is to be developed or accomplished and what customer needs will be satisfied by solving the problem. It is important that all team members agree on and are comfortable with the definition of the problem. An unclear definition of the problem is likely to cause the solution to be rejected.

- Is the problem clear?
- Does the definition of the problem set a clear objective? If not, and the problem can't be redefined by the team, can the team agree on how they will define the outcome or objective?
- Are any potential solutions ruled out by the parameters of the definition?
- Are sub-problems included and can they be addressed separately?
- Does the problem define the population to which the solution will be applied?

At this stage the team is refining its thoughts on exactly what the team members must do and what they can or cannot do. For example, if the problem is:

*"Design a robot which will move 10 feet, remove three ping-pong balls from a box, put the balls in a bag, return to the starting place with the bag of balls and signal when it is done."*

The team must determine the exact parameters of the problem statement and may ask:

- Must the robot walk? (No)
- Must the robot pick up the balls? (No)
- Must the robot hold the bag? (No)
- Must the robot talk? (No)

### **Analyze the problem.**

Problems normally have underlying causes or factors that may or may not be obvious. Determining what these factors or causes are is essential to addressing the problem properly.

For example, if, in an industrial setting, a company decides to increase the use of robots the decision may be made for various reasons. The factory may be in a location where there are insufficient numbers of workers (a personnel problem); the Federal Government may have implemented new safety standards and the only way to meet them is to have robots replace humans (both a personnel and regulatory problem); or profits are decreasing and the company must increase its production output to retain profitability (a financial problem) and the only way to do this is to supplement workers with robots. Each underlying reason could have a different impact on the type and number of robots that are designed for this business.

### **Determine the problem's scope and limits.**

Identify sub-problems that may exist or that must be solved, and clarify restrictions and the realm of allowable solutions.

- What, if any, sub-problems exist?
- Can we break the problem down into a sequence of sub-problems?
- In what priority should the sub-problems be addressed?
- What bounds are established by time, cost, space, safety, production capabilities and processes, aesthetics, energy costs, ecology, or the need to recycle?
- Are bounding conditions independent? Are they absolute or can there be trade-offs and adjustments?
- What limits are imposed by standards or codes?

### **Gather resources that may help enhance understanding of the problem.**

Proposing solutions without a somewhat broader understanding of the problem can often lead to "wheel spinning." Your team may decide to approach an engineer or others and ask them how they "read" or interpret a problem and its underlying assumptions or causes.

- Have others tried to solve this problem before? Who, when, how and where?
- What problems did others find in trying to solve this problem?
- What do we have to find out to solve this?
- Is there a single resource or place where this type of information might be located? If so, might it save us a lot of time?

### **Generate a wide range of ideas about how to go about solving the problem.**

At this point, a brainstorming session might be helpful. The purpose here is to get team members thinking "outside of the box" while keeping in mind the problem itself and potential methods of solution. The purpose here is not to propose detailed solutions, but to expand the team's thinking about possibilities.

For example, the team members might list ways in which they could go about solving the problem. These might include designing a new device, searching catalogs to buy a somewhat similar device and modifying it, or even taking the chance to redefine the problem to fit their vision of the device's purpose.

### **Plan and select an approach for initiating a formal Problem-Solving process.**

Determine what activities the team must go through to solve the problem and in what order they should be approached. Now that the team has defined the problem, has some ideas and knowledge of available resources, and may even have some unique possible solutions, the next step is to figure out how to bring this information together and accomplish a task or set of tasks that will develop a quality solution to the problem.

The problem may need to be approached in a "parallel" fashion rather than by using a "serial" approach. **Parallel processing** is when team members, sub-teams or the full team addresses multiple problems and activities at the same time by organizing time and resources into a matrix of opportunities. A **serial approach** is when every step is dependent on the completion of the preceding step and multiple steps cannot be accomplished simultaneously. Consider the following:

- How can we identify and distribute TEAMS questions quickly and efficiently so that our pre-defined sub-teams can have the most time to work together and also potentially have remaining time to assist other sub-teams?

### **Generate alternatives and elaborate on proposed solutions.**

The team may determine that a question or set of questions can be deduced intuitively and without calculation. This could result from a known mathematical or scientific principle that virtually eliminates most of the answer choices given.

#### **Focus.**

Having used the techniques presented in the previous step, the students can now determine the one or two solutions that have the greatest potential for success.

TEAMS students often skip quickly to this step. Since they have practiced solving questions and know where specific important data can be found. They can now focus their efforts on deciding which of the remaining answers is best.

### **Intensify data and resource search and analysis.**

At this point, teams should be dealing with no more than two reasonable answers or approaches to a solution. The team should do a relatively quick but rigorous search of resources to help them decide on the final choice. Questions to consider include:

- If data is known, where do we find it?
- If data is unknown, what research do we have to perform and should we perform it?
- What guesses or estimates do we have to make, and do we feel comfortable with those?
- What is the validity of the information used?

### **Evaluate and select the best alternative.**

The results of the team's search should be discussed and used as supporting information to help define criteria. The group may elect to use a Rule of Reduction, Multi-Voting, or Matrix approach to make the final decision on which option to pursue or which way to proceed. The basic decision is to determine which idea or approach will actually best solve the problem.

- What criteria are the most important?
- If validation tests are required, which test do we select?

### **Design, build or implement the best solution.**

Using all the prior data, the team should have a broad understanding of what is needed to make the final answer choice on a TEAMS question. Remember, in TEAMS getting to this step may have taken only 30 seconds to as long as a few minutes. In some industries that make billion-dollar decisions, this process may continue for a decade.

### **Test the implementation.**

In some ways, the analysis of this step is obvious. Your main objectives should be to learn if the solution worked or to what degree did it work? Other considerations include:

- Does the product or solution work as anticipated?
- Does it solve the problem?
- To what extent is the final real object, process or system different from the concept?
- What are the "errors of translation?"
- What is the effect of every part on the whole?
- Was the answer right?
- Was our thinking process flawed?

### **Refine and optimize the solution.**

Some people refer to this step as "tweaking," or informally searching for ways to improve the solution quickly. Ask these questions when refining the solution:

- Is the solution performing adequately?
- Are there parts of the solution that can be improved without major changes or costs?
- Can the solution be easily made to perform better?

### **Evaluate performance and track effectiveness.**

This is the stage where the team will formally test the design when subjected to the environment of actual service. This could be a field test or pilot test.

This stage is not only the engineering test, but also a marketing test. The design may be excellent and flawless, but unless the product solves the problem and unless people determine that your solution meets their needs or those defined by the problem, the product or solution cannot be considered as effective as it could be. To begin evaluating and tracking effectiveness, consider:

- To what degree does the product satisfy the original design requirements?
- Can the product still be improved?
- Did the design process anticipate the nature or effect of the service environment?
- How many unanticipated problems came up?
- Did the product sell as expected?

### **Maintain and sustain improvement.**

Change or improvement is measured by degree and duration. Solutions that only work for a short period of time, or those that narrowly address the issue, are not usually as valuable as those that can be sustained and have a broader impact on the target population.

To sustain the impact, standardization must ensue. The improvement becomes the new minimum standard of success. The improvement is now looked at as the new foundation on which to repeat the process.

### **Repeat the process to improve the new solution.**