

Introduction

The four types of problems are:

Type 1: Troubleshooting: Reactive problem solving that hinges upon quick response and dealing with immediate symptoms of a perceived problem. It provides some immediate relief and problem mitigation but generally fails to get at the actual root cause of a problem and can lead to prolonged cycles of firefighting.

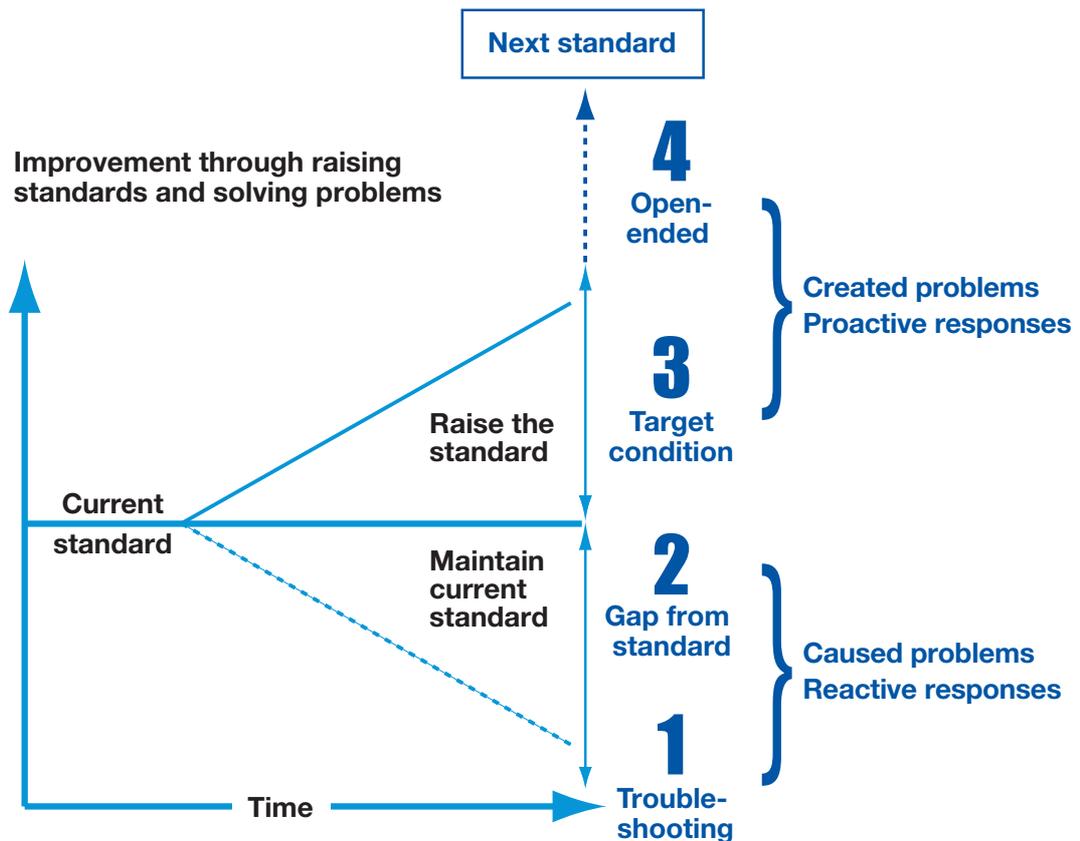
Type 2: Gap from Standard: Structured problem solving that focuses on specific problem definition, setting goals, root cause analysis, establishment of counter-measures, checks, standards, and follow-up activities. The aim is to prevent the problem from recurring by eliminating its underlying causes.

Type 3: Target Condition: Continuous improvement (kaizen) that goes beyond existing levels or standards of performance. It seeks to eliminate waste, overburden, unevenness, or other specific concerns systemically. It may utilize existing methods in new creative ways to deliver superior value or performance toward a new target state of improvement.

Type 4: Open-ended: Innovative problem solving based on creativity, synthesis, and recognition of opportunity. It is open-ended and identifies new problems, solution spaces, or opportunities in ways not previously recognized. It establishes new norms that often entail radical improvements and unexpected products, processes, systems, or value for the customer well beyond current levels.

The problems that confront organizations can be effectively understood through these four types. Some essential elements are common to any problem-solving activity, i.e., grasping facts, identifying desired direction, seeking to understand causality, taking purposeful action that may entail applying a known counter-measure, or experimenting to learn. Capability in all four approaches enables an organization to attain stability, improve and sustain gains, and advance steadily toward its goals and visions. The use of each type is based upon situational logic and specific need.

The best technique and best approach depend upon the problem situation. For example, a maximum of 14 clubs are allowed in a professional golfer's bag. A golfer needs to learn not only how to use all 14 clubs, but also how to hit each one well in different situations. Some situations favor a right-to-left trajectory, others a left-to-right. Some shots require a higher ball flight, others a lower one. Some days are sunny, others windy, rainy, etc. An expert golfer has to know how to play different shots with different clubs in different situations in order to succeed. The same is true of problem solving.



A problem is any outcome other than the desired performance at any given time.

Many organizations distinguish between two basic types of problems: caused problems/reactive responses vs. created problems/proactive responses. The Four Types breaks these down further to make clear the kind of capabilities and systems required to effectively deal with any problem situation.

The Four Types Illustrated through Ohno's Famous *Five Whys* Story

We are breaking up the four types of problems to consider them as separate capabilities. However, the four types are merely lenses through which to view any problem. Timing, resources, urgency, necessity, and priorities often dictate the proper response. With some problems it is sufficient to apply troubleshooting methods and then return to larger issues that require more attention. Others will require the application of the other types. And certain problems will, over time, require all four types of problem solving. An organization with deep capability in all four will have the adaptive and competitive advantage no matter the situation.

Background and Original Problem

To illustrate this point, let's look at Taiichi Ohno's famous example of the *Five Whys* and the personal experiences of Tomoo "Tom" Harada, an engineer who worked for Ohno in Toyota's Kamigo engine plant. This example is often used to illustrate root-cause thinking to solve a problem.

In its original form, a machine tool in an engine plant has stopped working and halted a production line. The basic concept is that when something abnormal occurs, it is important to pursue the causes in depth to get to a level where you can prevent it from happening again. This style of thinking requires persistent investigation and thinking.

Situation: A machine tool has stopped working, halting production

1. *Why did the machine stop working?*
Because the machine overloaded blowing the fuse in the control panel.
2. *Why did the overload condition result?*
Because there was insufficient lubrication to the spindle bearing.
3. *Why was there insufficient spindle bearing lubrication?*
Because there was insufficient lubrication drawn up by the pump.
4. *Why was there insufficient lubrication draw from the pump?*
Because the pump shaft was worn and rattling.
5. *Why was the pump shaft worn?*
Because there was no strainer on the lubrication device inlet port, and small metal cutting chips entered the system causing damage.

Countermeasure

In order to prevent recurrence of the problem, the simple act of adding a strainer to the inlet port of the lubrication device will, with a high degree of certainty, stop this particular problem from recurring. This *Five Whys* story presents a good example of causal analysis in Type 2 gap-from-standard problem solving. Now let's consider this example in the greater context of the four types of problem solving. In reality, Toyota solved this cutting chip buildup problem in a number of different ways over the years.

Type 1: Troubleshooting

The buildup of cutting chips is a natural part of any typical machining process. A cutting tool cuts into the metal of the workpiece and physically creates a “chip” that must then be properly evacuated from the part and the machine. Failure to do so is a recipe for a variety of issues, such as safety, machine downtime, and dimensional quality issues.

In the early days of Toyota, cutting chip buildup (literally, a pile of small metal chips) in machining operations was a big problem. So big that it was continually listed on hourly production charts for plan vs. actual production. This represents an historical example of a common Type 1 problem inside Ohno's machine shops. Hourly production totals were often off by a few parts per hour, and the cause was frequently listed as “cutting-chip buildup,” which necessitated unplanned cleaning work and machine downtime.

The countermeasure in many cases was to clean the machines at the start, middle, and end of a shift using a variety of mechanisms, e.g., brushes, small rakes, manual air blow, and additional coolant flushes. Standardized work and job instruction training was emphasized as well but had only a limited effect on the problem. Cleaning procedures worked for immediate needs, but they did not prevent the problem from recurring; a better approach was needed to get at the real set of underlying issues and inherent waste.



Troubleshooting

Reactive problem solving based upon quick responses to immediate symptoms. Provides relief and immediate problem mitigation. But may fail to get at the real cause, which can lead to prolonged cycles of firefighting.

Type 2: Gap from standard

As the problem of cutting-chip buildup and contamination continued to occur, supervisors, engineers, and managers were trained to think about the problems in a different, fundamental way—Type 2 problem solving.

Leaders such as Ohno, Eiji Toyoda, and others began to require that the real root causes of the safety, downtime, and quality issues in machining be addressed more thoroughly. The emphasis on the *Five Whys* occurred in the 1960s in conjunction with structured problem-solving training and execution. Simple daily cleaning, expectation setting, communication, and training were no longer enough.

Machine-by-machine and problem-by-problem, issues were tackled by Toyota with a root-cause emphasis and goal of recurrence prevention. The root causes of downtime, quality issues, and other abnormalities were considered more thoroughly. The simple act of adding a strainer solved one specific problem, but other problems required different solutions entirely.

Type 3: Target condition

Type 1 and Type 2 problem-solving routines solved most cutting-chip issues in a narrow sense: in most cases there was no longer a gap-from-standard problem to be solved, and individual machine and production line performances were achieving their daily goals. But structured Type 2 root-cause analysis with convergent thinking patterns wasn't the only way to study the problem.

The bar for annual improvements within Toyota had moved higher, requiring better performance as well. Type 3 problem solving became both necessary and desirable. Target-condition improvement involves principles of flow; takt time;

2

Gap from standard

Structured problem solving focused on problem definition, goal setting, root cause analysis, counter-measures, checks, standards, and follow up activities. Specific aim is to prevent the problem recurring by eliminating its underlying causes.

built-in quality; safety; and reliability; and an attitude of mental challenge. For example, 100% safety, 100% quality, and 100% uptime with a shorter lead time are target-state aspirations. The act of cleaning cutting chips was viewed as wasteful in nature and also not respectful of the human operator.

Management and engineering looked at the cutting-chip issue from an “ideally how should this process work” point of view. Eliminating cutting chips is not always possible, even with today’s machining technology, but one can still consider what is the ideal size of the chip (e.g., smaller is better), how it is formed, how it flows away from the part, how the machine is guarded, and how the operator is protected.

This line of inquiry led to many trial-and-error and improvement suggestions over the years inside of Toyota machine shops. Improved control of machine feeds and speed, with an emphasis on tooling and better, smaller chip formation, led to some improvements. Improved use of coolants, nozzle pressure, nozzle location, nozzle angle, etc., contributed as well. Modifying the internal bed-plate angle and fixture portions of the machines helped cutting chips flow away more effectively, greatly reducing the need for cleaning. Hydraulic, coolant, and lubrication tanks were sealed better as well. Improved usage of machine guarding and safety switches and doors contributed to greater safety.

With Type 2 routines the initial cutting-chip problem was solved *outside* of the machine, away from the point of generation, by adding a strainer to an external tank. In subsequent decades the problem was better resolved by managing the chip *inside* the machine at the actual point of formation, which Toyota often calls “cutting-point management” or “tooling-point management.” This also included special routines for tool setting and cleaning, tool-holder cleaning, setup and confirmation, and tooling programs (i.e., standardized work for the cutting program).

3

Target condition

Continuous improvement that goes beyond existing performance of a stable process or value stream. It seeks to eliminate waste, overburden, unevenness, and other concerns systemically, rather than responding to one specific problem, to deliver superior value or performance towards a target condition.

This approach represents a narrow and deep-dive case of Type 3 target condition improvement. Looking across an entire value stream would be a broader or lateral example. The focal lens for problem consideration was directed at a *should-be condition*. This more challenging consideration did not let the cutting chip escape from the machine, instead controlling it inside at the source and at a more fundamental level. This represents a classic example of kaizen and divergent creative thinking.

Type 4: Open-ended

Normally we think of innovation with product development. However, any area of a service, business, or operations can be innovated and improved. Ohno's *Five Whys* example was used as an example of Type 2 root-cause analysis. However, the real story did not end there with the one process. Over decades Toyota used innovative thinking routines to further improve cutting-chip management in its machine shops.

The following examples—sensory technology, industrial washers, and process technology—were not invented by Toyota, but they adapted the concepts to cutting-chip management and made them work for their respective situation at the time.

Sensory technology

The famous *jidoka* concept is over 100 years old, dating back to the loom business of Toyota. However, every generation of production equipment has involved greater use of sensory technology to enhance safety, build in quality, and prevent equipment downtime. Today sensors and lasers can check dimensional accuracy of work in process, as well as cleanliness of tools and critical work surfaces. In the continuing spirit of *jidoka*, problems or abnormalities are highlighted before the machine can even cycle.



Open-ended

Innovative problem solving based upon creativity, synthesis, and opportunity. It seeks to identify new problems, solutions, and opportunities not previously recognized. It achieves radical improvement, often a new product, process, system, or value for the customer well beyond current levels.

Industrial washers

No matter how carefully you manage cutting chips, some still adhere to the part and must be removed by an industrial washer before the part can be assembled into a precision engine. Every manufacturing company faces similar problems requiring cleaning. The answer for decades at Toyota, as at most companies, was to utilize industrial-sized washing machines with pressure nozzles mounted inside the machine and moving conveyor lines (like a car going through an automated wash system). Every generation the washer became larger, more expensive, more difficult to maintain, and harder to keep clean.

One day an employee questioned the whole system design. The idea of using high-pressure nozzles outside the part to spray inward (pushing the chips farther inside) struck him as incorrect. What if the part was simply dunked in a tank via a robotic arm and swished around with an agitated motion? Wouldn't this process work better and be far simpler? Several experimental tests were conducted, and the multi-dunk tank and agitate solution was found to be far superior for cleaning parts of foreign debris. Cost, ease, operation, space, energy, flexibility, and every other dimension were considered.

Process technology

In the mid-1960s, Toyota eventually adopted transfer machine technology, which was common in the West for high-volume production lines. Instead of using hundreds of small machines in production, each with its own chip-management system (coolant flow, air blow, tanks, pumps, separation system, etc.), larger combined systems were utilized in transfer machines to great effect. This vastly reduced the number of systems to be sequenced and managed at the local level and placed the burden of work (and, in reality, waste) in a more central location where it could be better managed. It simplified the task of waste management for cutting-chip control.

Note: Toyota built its own transfer machines at affiliated companies, such as Toyoda Machine Works (a division of J-Tekt Corporation today), or internal facilities, such as Teiho Machine Tool Plant. This practice, along with thoroughly documented machine standards, allowed Toyota to retain its best practices and knowledge gained from problem solving.

Summary

Ohno's *Five Whys* story is an actual historical example of how deep you need to dig in order to get to the proverbial root cause of a problem. The important point for modern audiences is to realize that the story shows just one way to think about the problem. Over time you often need to consider a problem from many different vantage points or even consider an entirely new solution space.

- **Type 1: Daily cleaning and troubleshooting** helped immediately, and often solved the hourly or daily problem, but failed to prevent problem recurrence.
- **Type 2: Use of strainers** emphasized root causes at a more fundamental level. It strived to solve more persistent problems and prevent them from recurring. This approach relied on deliberate and convergent styles of thinking about actual cause-and-effect relationships in the current process.
- **Type 3: Cutting-point management** was a more creative way to solve the problem, led by divergent and open-ended thinking routines. The heart of the approach involved considering ideal-state scenarios to prevent or eliminate the problem from occurring at a more fundamental level involving better cutting-chip formation at the source or some other form of incrementally improving beyond the current level within the existing process.
- **Type 4: New equipment** (new processes, products, technology, or systems) built further upon the target-condition thinking of Type 3. This can involve new solution spaces that are not yet completely understood and requires a willingness to experiment with completely new ideas.

How might the four types be applied to a recurring problem that you face?

