General concepts and pitfalls in problem solving

Real-life quality problems, just like people, are simultaneously different and the same. It is impossible to get a tough problem solved by just applying a pre-defined ‘cook book recipe’. Recognizing the distinctive characteristics of a problem is critical since the devil can lie in the detail. Applying the right tactics, analysis tools and techniques in the right context is key. However, too often the tools become substitutes for thought and tactics, driving out what they were supposed to support.

Problem solving is very much a human activity and reasoning has a prominent role in it. Just recall any of your discussions during a problem solving project meeting: participants make claims about the problem’s nature, the causes, and solutions, supporting their claims with more or less reasoned arguments. Erroneous beliefs and faulty reasoning can doom problem solving to failure. Many people turn out to be fundamentally irrational, by cutting corners and by using quick-and-dirty methods.

Lack of structure is another hurdle that can complicate problem solving activities. The circumstances in which tough problems have to be analyzed and solved is often not clear from the start: the team has to work under stressful conditions, the situation is very likely rather fuzzy and complex. The problem solver should focus on what is really important, prevent the team from being biased or defensive by making sure there will be no blame for their department, company, or for the person, prevent the team from spending time and energy on irrelevant discussions, and be able to structure the team’s way of reasoning. An effective approach takes all these aspects into account!

A major reason why certain problems are ultimately not solved is related to the fact that the approach that engineers use is not effective in all cases. Their approach is oftentimes based on a set of tools and techniques that is less effective for solving tough, chronic quality problems. By definition, chronic problems are those kinds of problems for which it is difficult, if not almost impossible, to conceptualize or brainstorm the possible causes (the Xs). A first attempt to solve a problem is usually to think with experts about the most plausible causes (=brainstorm). Engineers select the most likely Xs and run an experiment to verify if they were right. Many easy real-life problems can be solved in this manner. However, for tough, chronic quality problems, this approach often times doesn't work. The reason is that the actual cause is not in their brainstorm list; it is something that is yet unknown.

That's why we prefer a methodology that doesn't start with listing of possible causes (the Xs). We prefer to start with contrasting extremely good and extremely bad products. So it embarks from studying the behavior of the effect, the Y first, and asking the question: “what makes the difference between an extremely good and extremely bad product?”, the BOB (Best-of-the-Best) and the WOW (Worst-of-the-Worst) in the Shainin jargon.

Shainin-based techniques for quality problem solving

Problem solvers should not neglect the fact that usually the majority of the products performs well and just a certain percentage of the products fails. It is best to first find the cause of the problem in the existing design, and then decide what to do to fix the problem.

Statistical engineers, following the discipline developed by Shainin, solve problems by finding “what is different?” They combine statistical thinking with engineering insight to converge on the cause–effect relationship that is driving most of the difference between the extremes of a population. Once this cause–effect relationship is thoroughly understood, statistical engineers will consider alternative solutions that will control the relationship and reduce variation. Their fundamental perspective is that $\sigma_Y^2=f(\sigma_X^2)$ rather than $Y=f(X)$. The key to solving variation problems is to find the Red X by “talking to the parts”. They think $Y \rightarrow X$ and never speculate about possible sources of variation.
The Shainin based approach is a rigorous discipline for performance improvement in manufacturing and engineering. The roots go back to the 1940s when Dorian Shainin and Joseph Juran recognized that Juran’s Pareto principle also applied to the causes of variation.

This “typical SE problems” can be characterized as being chronic (not being able to tackle the problem effectively), there is variation (most products or systems are OK, and some are not), and the fact that the root cause is not obvious (one cannot find the cause of the problem by applying conventional problem solving tools like brainstorming, Fishbone diagrams, 5 Times Why and the like).

The basic starting points are straight forward:
1. Pareto principle (the 80/20 rule);
2. Fact based decision making;
3. Convergent strategies.

Dorian Shainin was telling his clients that their problems were not caused by a little bit of each of many X’s; no, they were caused by one dominant X, the first bar in the Pareto graph, or the Red X. The problem can be solved by finding the Red X. Fact based decision making means making decisions based on observed facts, not opinions. Some popular problem solving methods begin with brainstorming or drawing fishbone (cause and effect) diagrams. These are based on opinions! To observe the real facts you must look & measure very carefully what is actually happening. This is harder than it seems. We like to use the language “talk to the parts”; meaning use the actual failures to perform careful observation.

It is often easy to think of how to test a single idea. But what if that idea is wrong? You will have wasted all the time and money required for the test only to show that your ‘good idea’ was wrong. It is much more difficult to design a test that splits all the possible answers in half. If the test turns out one way you know the answer is in one half of the possibilities. If it turns out the other way you know it is in the other half. Either way you win with the answer. You have cut down the number of possibilities so your strategy is “convergent.”

The Shainin methodology is based on parsing variation into its sources. Variation comes from many places (sources) and each source contributes to the total observed variation in the Y (the effect). A systematic method of dividing this variation into ever smaller ‘families of variation’ leads to rapid convergence towards key variables (the important or relevant Xs). In order to do this, the methodology gives a collection of simple but powerful techniques. In all cases we will work from (contrasts in the) Y or effect backwards to causes (Xs).

<table>
<thead>
<tr>
<th>‘Conventional’ Q&amp;R Problem Solving</th>
<th>Shainin-based Q&amp;R Problem Solving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start with brainstorming possible causes (Xs)</td>
<td>Start with studying the effect (Y) in detail</td>
</tr>
<tr>
<td>Cause to effect reasoning</td>
<td>Effect to cause reasoning</td>
</tr>
<tr>
<td>(Initially) Divergent strategy</td>
<td>Convergent strategy from beginning</td>
</tr>
<tr>
<td>Strong focus on data analysis</td>
<td>Strong focus on investigation strategy</td>
</tr>
<tr>
<td>Advanced statistical tools (often MiniTab based)</td>
<td>Simple analysis tools (Excel based templates)</td>
</tr>
<tr>
<td>Need for changing suspect process parameters (Xs) to study Cause to effect relation with DoE</td>
<td>No interference with (production) process to study Cause to effect relation</td>
</tr>
<tr>
<td>Typical tools for root cause finding: brainstorm, fishbone diagram, (frac.) factorial DoE, ANOVA, regression / correlation analysis, t-test, etc</td>
<td>Typical tools for root cause finding: decision trees, Multi Vari. Component Search, Paired Comparisons, Clue List, BV C-testing, etc.</td>
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<tr>
<td>Appealing to quality experts</td>
<td>Appealing to engineers</td>
</tr>
</tbody>
</table>

Table: Comparison of conventional and Shainin based method
The example below illustrates the approach for an imaginary case

The problem is related to the noise level of assembled fridges. Suppose that this noise level is measured at an end-of-line test. The baseline of the problem is preferably plotted as a graph, showing the variation in the noise level over a number of manufactured fridges.

One needs to verify if the variation you see in the graph is related to the variation in the fridges or if it is caused by the measurement itself. Suppose that the measurement system is OK, so the variation in the graph reflects good and bad fridges (i.e. silent and too noisy appliances).

By selecting an extremely good (that is a silent) and an extremely bad (that is a noisy) system we can check whether the problem is related to a) the modules and parts that are used or b) to our assembly process. The tool that is used for this is called Component Search. When, after disassembling and re-assembling the extremely good and bad fridges keep on behaving the same, one can conclude that the problem is related to the parts inside and not to the assembly process.

In the next stage this problem-causing part has to be identified, that’s done by swapping parts from the good to the bad system and v.v. When the experiment shows that a certain part can switch a good system into a bad, and simultaneously a bad into a good system, you identified the part that is causing the problem.

Now we know the culprit part, we finally have to identify the feature, the characteristic of the part that is causing the problem. We have some tools in our Shainin toolbox to do this. Paired Comparisons.

The problem is caused by the out-of-roundness of a shaft inside the pump.

My experience is that the cause of a chronic problem, very often is related to something that nobody thought about upfront and/or something that was not specified.

In this case the initial fix could be to sort out all bad shafts, but ultimately the supplier of the shafts has to optimize his manufacturing process and only make and deliver good parts.

This example demonstrates that the X, the cause of the problem for one organization is the Y, the effect of the supplier organization.

Further reading:

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