

Collecting data related to factory on river:

Fish kills below acceptable levels through July.

Fish kills above acceptable levels August 1, 15.

Toxins released on July 29 (but this level had not caused trouble before).

Water levels normal in July.

Water levels low in August.

Hotel needs new elevators:

New shafts would cut rooms, etc.

Doorman suggested adding elevator to outside of building.

New factory generated defective plastic.

Extensive analysis of design and materials detected no flaw.

Eventually an engineer decided to look at the plant.

A valve was set wrong, and no coolant reached the equipment.

During collection stage, need to talk to the people familiar with the situation.

Example: Equipment operators.

Inspect the physical location if possible/appropriate.

Most successful organizations have a person who both knows the facts on the ground and is a good “systems analyst”, and so can correlate the facts.

Electrical company installed an electrical cabinet at a customer's factory. The next day, the cabinet was energized, and exploded shortly after.

The supervising engineer from the contractor went to inspect the site. He noticed that an unusual handle had been installed in the door of the cabinet.

The factory maintenance staff had added the handle to allow access from their key.

The handle had a metal rod protruding into the back. This metal rod caused a short circuit in the equipment.

Check problem statement with Socratic questioning (Critical Thinking Algorithm):

Where did the problem originate?

Who posed the problem statement? Your boss? Their boss? Colleague? Client?

Can that person explain their reasoning?

Are the reasoning and assumptions valid?

Has that person considered different viewpoints?

What are implications and consequences of assumptions?

The goal of Socratic Questioning is to direct thinking towards a solution, often by jogging the solver out of a run.

Engineer asked to redesign plant with $1/10^{\text{th}}$ the emissions.

Why? Bad publicity from dead fish.

Who? Upper management.

Reliable assumption? Fish kills are correlated with low water. Toxins discharges are more concentrated then.

Was enough toxin in the water? Not measured.

Are there alternatives? Ask an expert. Fungi associated with heat and low water is suggested.

Are fish dying elsewhere? Ask an expert (DNR), who says yes.

Does the alternative pan out? Test the fish for fungi. Yes, it does.

Conclusion: refitting the factory won't help.

Define the present state.

Define the desired state.

Make sure both are precise.

Make sure they match.

Situation: Too many bombers in WWII shot down. Many come back with bullet holes in similar spots.

Perceived problem:

Many bullets penetrating aircraft.

Solution: reinforce damaged areas with thicker armor.

Mismatch:

Present state: many bullets penetrating aircraft.

Desired state: fewer planes being shot down.

Not a match because surviving planes have bullet holes.

New statements:

Present state: many bullets penetrating critical and noncritical areas.

Desired state: fewer bullets penetrating critical areas.

These statements match.

This focuses on the real problem.

The original solution “fixed” something that wasn’t causing the real problem:

Planes with holes in noncritical areas were not the ones shot down, so don’t reinforce noncritical areas.

Example: Bomber Survival

Defining the Problem 12



Trees in two dimensions

1. Steps:
 - Goal
 - What to do
 - How to do it
2. Desired state vs. make present state OK

Example: Find a better job.

1. Find a better job.
2. Make present job OK.

Problem: kindergarten teacher burned out from 25 years of teaching.

Quit teaching:

1. Find a new job:
 1. Office manager.
 2. Sales person.
2. Retire.

Make it OK not to quit:

1. More leisure time:
 1. teach alternate terms,
 2. teach half days.
2. Lower stress level:
 1. teach different grade,
 2. get more control over content.