Problem Definition

The mere formulation of a problem is far more often essential than its solution, which may be merely a matter of mathematical or experimental skill.

To raise new questions, new possibilities, to regard old problems from a new angle requires creative imagination and marks real advances in science.

The First Four Steps

1. Collect and analyze information and data
2. Talk with people familiar with the problem
3. If at all possible, view the problem first hand
4. Confirm all findings

Step 1. Collect and analyze information and data

- Learn as much as you can
- Determine what information is missing and what information is extraneous
- The information should be properly organized, analyzed, and presented
- Communicate using drawings, sketches, and graphs
- Display numerical or quantitative data graphically

Problem Definition Techniques

- The Case of the Dead Fish

Consider the case of a chemical plant that discharges waste into a stream that flows into a relatively wide river.

Biologists monitored the river as an ecosystem and reported the following data of the number of dead fish in the river and the river level:

- Graphs of the type shown above are called time plots and control charts.
- The acceptable level of dead fish was exceeded on August 1 and 15.
- We discover that on July 29 there was a large amount of chemical waste discharged into the river. Discharges of this size had not caused any problems in the past.
- There has been little rain and the water level in the river was low on August 1.
Step 2. Talk with people familiar with the problem

- Looking past the obvious
- Challenging the basic premise
- Asking for clarification when you do not understand something
- Ask insightful questions

Step 3. If at all possible, view the problem first hand

- You can see a lot by looking - Yogi Berra
- You should not rely on other people’s interpretations of the situation or problem
- Go inspect the problem yourself

Step 4. Confirm all findings

- Cross check and cross reference data, facts, and figures
- Challenge assumptions and assertions

Seeking Advice

Here is a problem encountered by a major hotel a number of years ago: this hotel had become very popular, the elevators were very busy, and frequently caused backups in the lobby area.

- Adding additional elevator shafts would require removal of a number of rooms and a significant loss of income.
- The doorman, overhearing their conversation, casually mentioned that it was too bad they couldn’t just add an elevator on the outside of the building.

A great idea!

It occurred to the doorman because he was outside the building much of the time, and that was his frame of reference.

Viewing the Problem Firsthand

In the mid 1970s a company completed a plant to produce a plastic product (PVC). The main piece of equipment was a large reactor with a cooling jacket through which water passed to keep the reactor cool.

- When the plant was started up, the plastic was dark, nonuniform, and way off design specifications.

The engineers in charge reviewed their design and refined their model and calculations. However, the problem did not change.

Finally after many days, one of the engineers decided to look into the reactor. He found that a valve had been carelessly switched to the wrong position.
Step 4. Confirm all findings

- Boxright had installed a new process for recovering and recycling their "cooking" chemicals used in the paper making process.
- After two years, the process had yet to operate correctly.
- Courtland Construction was the supplier of the recycling equipment.

Courtland presented data and information from an article in the engineering literature that they claimed proved Boxright was not operating the process correctly.

When Boxright analyzed this information in detail, it was stated that the data would not be expected to apply to industrial-size equipment or processes.

Problem Definition Techniques

- Finding out where the problem came from
- Exploring the problem
- Present state desired state & Duncker diagram
- K.T. Problem Analysis
- Problem Definition Techniques
- Statement Restatement

Find out where the problem statement came from

- Never assume the problem statement is correct
- Where did the problem originate?
- Who posed the problem statement in the first place?
- Can that person explain the reasoning as to how they arrived at that particular problem statement?
- Are the reasoning and assumptions valid?
- Has that person considered the situation from a number of different viewpoints?
- Have you used the first four steps to gather information about the problem?

The Case of the Dead Fish

- The Situation: “Design a new waste treatment plant to reduce the toxic waste from the chemical plant”
- Who Posed the Problem? (company upper management’s)
- Can reasons for arriving at the problem statement be explained? (company wants to deflect negative press)
- Are the assumptions valid? (company has decided to treat the symptoms)
- Has sufficient data been collected? (our engineer initiates his own investigation)
Exploring the Problem

1. Identify all available information
2. Recall or learn pertinent theories and fundamentals
3. Collect missing information
4. Solve a simplified version of the problem to obtain a "ballpark" answer
5. Hypothesize and visualize what could be wrong with the current situation

The Case of the Dead Fish

Our engineer initiates his own investigation

- Identify Available Information - toxic discharge, river level low, large number of dead fish
- Learn Fundamentals - call biologist about what could kill fish
- Missing Information - a fungus in nearby lakes could kill fish, temperature was quite high, fish dead up and down the river
- Hypothesis - Fish dying because of fungus not discharge
- More Information - an examination of the fish concluded that they did die of a fungus not the discharge
- Define the Problem - Identify ways to cure infected fish and prevent healthy fish from being infected

Present State/Desired State

“You can’t get there from here”

- Present State/Desired State - help us verbalize where we are and where we want to go.
- Present State statement should match the Desired State statement
- The Desired State should not contain solutions to problems that are not in the Present State
Hitting ‘Em Where They

The Situation: “During WWII, a number of aircraft were shot down over Germany. Many of the planes that made it back safely to base were riddled with bullet and projectile holes.”

Instructions: “Reinforce these damaged areas with thicker armor plating”

The Duncker Diagram

- The Duncker Diagram points out ways to solve the problem by making it OK not to reach the desired state.
- There are two General Solutions:
  - Solutions that move from the present state to the desired state
  - Solutions that modify the desired state until it conforms to the present state
- Functions Solutions are possible paths to the desired state
- Specific Solutions implement the functional solutions

Kindergarten Cop

- The real problem was how to lower her stress at her workplace
To Market, To Market

Problem Definition Example

A possible Duncker Diagram might look like the following:

Statement–Restatement

Problem Statement Triggers
1. Vary the stress pattern—try placing emphasis on different words and phrases.
2. Choose a term that has an explicit definition and substitute the explicit definition in each place that the term appears.
3. Make an opposite statement, change positives to negatives, and vice versa.
4. Change “every” to “some,” “always” to “sometimes,” “sometimes” to “never,” and vice versa.
5. Replace “persuasive words” in the problem statement such as “obviously,” “clearly,” and “certainly” with the argument it is supposed to be replacing.
6. Express words in the form of an equation or picture, and vice versa.

Problem Definition Techniques

Finding out where the problem came from

Exploring the problem

Present state

Desired state & Duncker diagram

Statement Restatement

Trigger 1 – Vary the stress pattern—try placing emphasis on different words and phrases.

Cereal not getting to market fast enough to maintain freshness.

Cereal not getting to market fast enough to maintain freshness. (Can we make the distance/time shorter?)

Cereal not getting to market fast enough to maintain freshness. (Can we distribute from a centralized location?)

Cereal not getting to market fast enough to maintain freshness. (How can we keep cereal fresher, longer?)
**Statement–Restatement**

**Trigger 2** - Choose a term that has an explicit definition and substitute the explicit definition in each place that the term appears.

- Breakfast food that comes in a box is not getting to the place where it is sold fast enough to keep it from getting stale.

  (Makes us think about the box and staleness... what changes might we make to the box to prevent staleness?)

**Statement–Restatement**

**Trigger 3** - Make an opposite statement, change positives to negatives, and vice versa.

- How can we find a way to get the cereal to market so slowly that it will never be fresh?

  (Makes us think about how long we have to maintain freshness and what controls it?)

**Statement–Restatement**

**Trigger 4** - Change “every” to “some,” “always” to “sometimes,” “sometimes” to “never,” and vice versa.

- Cereal is not getting to market fast enough to always maintain freshness.

  (This change opens new avenues of thought. Why isn’t our cereal always fresh?)

**Statement–Restatement**

**Trigger 5** - Replace “persuasive words” in the problem statement such as “obviously,” “clearly,” and “certainly” with the argument it is supposed to be replacing.

- The problem statement implies that we obviously want to get the cereal to market faster to maintain freshness.

  Thus, if we could speed up delivery freshness would be maintained. Maybe not! Maybe the store holds it too long. Maybe it’s stale before it gets to the store.

  (This trigger helps us challenge implicit assumptions made in the problem statement.)

**Statement–Restatement**

**Trigger 6** - Express words in the form of an equation or picture, and vice versa.

- Freshness is inversely proportional to the time since the cereal was baked.

  \[ \text{Freshness} = \frac{k}{\text{Time Since Baked}} \]

  Makes us think of other ways to attack the freshness problem. For example, what does the proportionality constant, \( k \), depend upon?

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**Problem Definition Techniques**

We will discuss this in Chapter 5.
Problem Solving

End of Chapter 3