DETERMINE ROOT CAUSES OF PROBLEMS
SYMPTOM TO CAUSE
DIAGNOSTIC JOURNEY

Quality Improvement Team must answer
the question:

"WHAT'S CAUSING THE PROBLEM?"

 Opinions

SYMPTOMS

Best Judge.

CAUSES

Data Analysis

HOW DO WE MAKE THIS JOURNEY FROM
SYMPTOM - TO - CAUSE?

PROBLEM
SOLVING
METHODOLOGY

QUALITY
TOOLS

CAUSES
SYMPTOM TO CAUSE
EXAMPLE

FOOTBALL INJURY

- Symptom: Pain
- Problem: Injury
- Root Causes: Broken Bone or Torn Ligament
- Interim Solution: Pain Killers
- Long Term Solution: ???
SYMPTOM TO CAUSE

- Detection analysis and finding the "REAL" suspect of the crime will be the focus of this module.

- It is a difficult task.
  - Usually the causes are hidden among many conflicting theories and opinions.

- Once the causes of the problem have been defined, the appropriate diagnostic tools become more apparent to the team.

- A good guideline is:
  - Know what should be happening correctly and determine what is happening incorrectly.

- There are different ways to get from SYMPTOM-TO-CAUSE:
  - Opinions
  - Best Informed Judgments
  - Data Analysis

- Stories:
  - Supervisor: "When I find data disagrees with my opinion, I throw the data out!"
  - Old Saying: "In God we trust. All others bring data."
  - These are both extreme views. We need to strike a balance.
  - Use facts, not opinions.
"Well, here's your problem, Mr. Schueler."

First understand the problem
Cause and effect
By Scott Adams

Dilbert teaches "Quality" management in Elbonia

The fishbone diagram helps identify the root cause of problems.

In your case, the root problem seems to be that you're a nation of imbeciles...

True, but you're the one who had to draw a dead fish to figure it out. You're in the club. Here's your hat.
Cause-and-effect Diagrams

A cause-and-effect diagram is a useful method for clarifying the causes of a problem. It classifies the various causes thought to affect the results of work, indicating with arrows the cause-and-effect relationship among them. Figure 12-1 shows the basic structure of a cause-and-effect diagram.

![Diagram of cause-and-effect](image)

**Figure 12-1: Structure of a Cause-and-effect Diagram**

The cause-and-effect diagram is sometimes called a "fishbone diagram," an "Ishikawa diagram" (after the late Kaoru Ishikawa, the quality expert who championed its use), or a "characteristics diagram" (referring to its use in identifying the cause of various quality characteristics, including problems).

Notice that the diagram has a "cause" side and an "effect" side. Effects are stated as particular quality characteristics or problems resulting from work. Examples
include problems involving product quality, cost, quantity of production, delivery, workplace safety, and QC circle activities.

On the "cause" side are the factors that influence the stated effects or characteristics. Difficulties involving materials, machinery and equipment, operating methods, operators, or the environment are examples of some main categories, although you can use any breakdown that is relevant to your analysis. The branches of the diagram are arrows indicating the relationship between the effect and the causal factors. The thick arrows branch off the center line like limbs branching from a tree trunk.

Cause-and-effect diagrams are valuable to any process to which they can be applied. Everyone involved with the problem should participate, offering his or her opinions to uncover the factors involved in a problem.

How to Make a Cause-and-effect Diagram

STEP 1: Clarifying the characteristics of the problem and writing a title

Make sure everyone concerned understands the problem well, decide which characteristics to examine, and write a title for your investigation on a blackboard or large sheet of paper. Process data showing bad characteristics helps uncover the factors involved in a problem. You can also do this after an improvement to determine how much the process has actually improved.

Example: Cracks on the front surface of contact lenses have increased recently to become the most common defect. Until now, this problem has been solved immediately with a manual adjustment, but the problem recurs—the basic problem has not been solved. Accordingly, a survey of the causes of cracks during grinding was carried out.
STEP 2: Writing in the effect characteristics and drawing the spine

Write the characteristics to be examined in a box on the right side (see Figure 12-2). Be specific in describing the effect characteristics. Don’t just say, “Component X is defective”; instead say, “Component X is thin” or “Component X is weak.” Next, draw a thick arrow running from left to right (to the characteristics box). This arrow is the trunk.

STEP 3: Clarify the factors affecting the characteristic

The usefulness of your cause-and-effect diagram depends on how well you do this step. Methods for defining the factors include:

1. The big branch expansion method
2. The small branch expansion method (brainstorming)
3. The small branch expansion method (affinity diagram)

The Big Branch Expansion Method:

1. Divide the factors you believe affect the characteristic into categories that contain four to six items. Draw a big branch for each category, placing the category name in a box at the end (see Figure 12-3).
2. For each big branch, draw medium, small, and tiny branches based on the suggestions of participants to get to the cause of that characteristic. See Figure 12-4. In discussions, it is essential to repeatedly ask “why” until you get to the root cause.
The Small Branch Expansion Method (Brainstorming):

1. Everyone considers the factors thought to influence the characteristic. The group brainstorms to synthesize ideas. These items are then written on the blackboard or large paper prepared earlier. See Table 12-1.

2. As the participants discuss the relationships, group the factors into small categories on the basis of their suggestions. You can further group these small categories into medium and large categories. See Table 12-2.

3. Arrange the categories in the format of a cause-and-effect diagram. The large categories become the big branches, the medium categories become medium branches, and the small categories become small branches.

<table>
<thead>
<tr>
<th>Factors responsible for “many grinding cracks”</th>
</tr>
</thead>
<tbody>
<tr>
<td>lathe cutting roughly</td>
</tr>
<tr>
<td>leftover shavings from cutting</td>
</tr>
<tr>
<td>grinding time too long</td>
</tr>
<tr>
<td>cracks caused by crack removal fluid</td>
</tr>
<tr>
<td>crack removal fluid not applied long enough</td>
</tr>
<tr>
<td>untrained operator</td>
</tr>
<tr>
<td>careless operator</td>
</tr>
<tr>
<td>grinding machine not heavy enough</td>
</tr>
<tr>
<td>machine’s rotational frequency too low</td>
</tr>
<tr>
<td>machine amplitude is too high</td>
</tr>
<tr>
<td>filter water depleted</td>
</tr>
<tr>
<td>grinding agent particles too large</td>
</tr>
<tr>
<td>P block is soft</td>
</tr>
<tr>
<td>pitch dish is hard</td>
</tr>
<tr>
<td>tired operator</td>
</tr>
<tr>
<td>nervous operator</td>
</tr>
<tr>
<td>pitch dish does not join when pressed together</td>
</tr>
<tr>
<td>pitch is filled up</td>
</tr>
<tr>
<td>contaminants enter pitch dish when it is pressed</td>
</tr>
<tr>
<td>contaminants enter during grinding</td>
</tr>
<tr>
<td>mixing ratio of grinding agent</td>
</tr>
</tbody>
</table>

Table 12-1: Factor List (Brainstorming Method)
### Categorization of factors responsible for "many grinding cracks"

<table>
<thead>
<tr>
<th>Factor</th>
<th>Specific</th>
<th>Group</th>
<th>General</th>
</tr>
</thead>
<tbody>
<tr>
<td>lathe cutting roughly</td>
<td>cutting</td>
<td>lathe</td>
<td>Machine</td>
</tr>
<tr>
<td>rotational frequency too low</td>
<td>rotational frequency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>grinder amplitude large</td>
<td>amplitude</td>
<td></td>
<td></td>
</tr>
<tr>
<td>grinder too light</td>
<td>weight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tired operator</td>
<td>tired</td>
<td></td>
<td></td>
</tr>
<tr>
<td>nervous operator</td>
<td>nervous</td>
<td></td>
<td></td>
</tr>
<tr>
<td>untrained operator</td>
<td>insufficient</td>
<td></td>
<td></td>
</tr>
<tr>
<td>careless operator</td>
<td>negligence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pitch filled up</td>
<td>pitch</td>
<td>bonding</td>
<td></td>
</tr>
<tr>
<td>shavings remain</td>
<td>shavings</td>
<td>lathe</td>
<td></td>
</tr>
<tr>
<td>pitch cup pressed but does not join</td>
<td>return</td>
<td></td>
<td></td>
</tr>
<tr>
<td>contaminants enter</td>
<td>contaminant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>long grinding time</td>
<td>time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>contaminant mixed in</td>
<td>contaminant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid cracks caused by crack removing fluid</td>
<td>liquid</td>
<td>crack removing fluid</td>
<td></td>
</tr>
<tr>
<td>time when crack removing fluid</td>
<td></td>
<td>time</td>
<td></td>
</tr>
<tr>
<td>fluid applied is short</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P block is soft</td>
<td>material</td>
<td>P block</td>
<td>Material</td>
</tr>
<tr>
<td>pitch dish is hard</td>
<td>surface</td>
<td>pitch dish</td>
<td></td>
</tr>
<tr>
<td>filter fluid depleted</td>
<td>filter water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>grinding agent particles large</td>
<td>particles</td>
<td>grinding</td>
<td></td>
</tr>
<tr>
<td>grinding material mixing ratio</td>
<td>mixing ratio</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 12-2: Factor Classification (Brainstorming Method)**

**The Small Branch Expansion Method**

**(Affinity Diagram):**

1. Distribute about 50 index cards equally among all members of the group.
2. Ask members of the group to write down factors they believe influence the characteristic.
3. Place the cards on a table and based on the opinions of the group, group related cards together. These become small branches. Next, relationships are found
among the small branch headings, which are then joined together to make a medium branch. Similarly, relationships are found among the medium branch headings, which are then joined together to make a big branch. See Table 12-3.

4. Arrange the grouped cards in cause-and-effect diagram format and place them on a large sheet of paper.

Table 12-3: Factor Classification (Affinity Diagram Method)
STEP 4: Checking for omitted factors

Once the format of the cause-and-effect diagram has been set, all the participants should make sure that no factor has been left out. If a factor has been omitted, insert it in the diagram. Figure 12-5 shows the factors written in the diagram.

"Contact Lens Grinding Cracks"

Product: contact lens  
Process: grinding  
Date created: 8/26/89

Figure 12-5: Cause-and-effect Diagram: Contact Lens Grinding Cracks
STEP 5: Identifying factors that strongly affect the characteristic

Check the workplace and the data once more and discuss them with all participants. Circle factors that strongly affect the characteristic (circle between five and eight items). See Figure 12-6.

"Contact Lens Grinding Cracks"

Product: contact lens
Process: grinding
Date created: 8/26/89
Producing group: Crystal Group

Figure 12-6: Cause-and-effect Diagram: Contact Lens Grinding Cracks
(Major Factors Circled)
STEP 6: Writing in related information

Write in the product name, process name, the work station where it was made, the group name, the names of participants, the date of creation, etc.

Ways to Use Cause-and-effect Diagrams

1. Use a cause-and-effect diagram to help guide discussion. Sometimes group discussion doesn't stay on the topic. A discussion centered on a cause-and-effect diagram can keep the discussion on the topic and focus everyone's intelligence on the problem.

2. Use a diagram as a study aid. By participating in the construction of a cause-and-effect diagram and discussing it with other members of the group, people notice new things and learn from one another.

3. Use a diagram to understand the actual situation. Using a cause-and-effect diagram will make you look carefully around the workplace and think about the cause.

4. Use a diagram for factors management. Once you have made a cause-and-effect diagram, use it for daily factors management. If a quality characteristic is bad or an accident occurs, search for the cause. Each time you find a cause factor that applies, make a check mark next to it on the diagram (see Figure 12-7). In this manner, you will manage factors daily according to their priority.

5. Use a diagram as technical material when creating and revising manufacturing standards. Someone who writes a good cause-and-effect diagram understands the work well. Detailed diagrams are technical material useful for making and revising technical standards, QC process tables, operating standards, inspection standards, equipment inspection standards, and other standard references.
"Defects Due to Filling by Neutral Dust"

![Tree Diagram]

Figure 12.7: Cause-and-effect Diagram Used for Factor Checking

**References**


4.2 How to Make Cause-and-Effect Diagrams

Making a useful cause-and-effect diagram is no easy task. It may safely be said that those who succeed in problem-solving in quality control are those who succeed in making a useful cause-and-effect diagram. There are many ways of making the diagram, but two typical methods will be described here. Prior to introducing the procedures, the structure of the cause-and-effect diagram is explained with an example.

(1) Structure of Cause-and-Effect Diagrams and Example

A cause-and-effect diagram is also called a “fishbone diagram” since it looks like the skeleton of a fish, as shown in the Figure 4.1. It is also occasionally called a “tree” or “river” diagram, but the name “fishbone” is used here. An actual example is shown as Figure 4.2.

![Figure 4.1 Structure of Cause-and-Effect Diagram](image-url)
Figure 4.2 Example of Cause-and-Effect Diagram
CAUSE-AND-EFFECT ANALYSIS

1. The main purpose of Cause-and-Effect Analysis is to help the team solve problems by the identification of a root cause so that corrective action can be taken.

2. A Cause-and-Effect Diagram is a picture composed of lines and words designed to represent a meaningful relationship between an effect and its causes. The specific tool that we will focus on is called the Fishbone or Ishikawa Diagram.
Example #1:

Mike, who is a computer analyst, has been experiencing headaches on a regular basis both at work and at home. Mike would take aspirin on a regular basis to relieve the headaches; however, they continued to return. Mike’s wife suggested he go see a doctor about his headaches. Upon visiting the doctor, Mike discovered his eyesight was weak. The doctor prescribed some glasses for Mike and the headaches disappeared.

It’s clear that Mike was treating the symptom (headache); thus his solution (aspirin) was not solving the problem. However, the real root cause (bad eyesight) was confirmed by the elimination of the headaches when he wore his glasses.

Example #2:

A power plant alarm system had been experiencing a high number (average 125 per day) of false alarms. A task team was formed to find out why the problem was occurring and to correct it. The allowed number of false alarms through the Infrared beam system that circles the plant is 25.

The team interviewed security personnel. These interviews led the team to believe that most of the alarms were due to raccoons. At this point the team decided to do some data gathering on raccoons. They designed a checksheet and counted the types of animals that were entering the plant and how often. They found that 76% of the time, it was a raccoon that was setting off the alarm. Aha, the team thought, we have the root cause.

![Diagram showing frequency of animals causing false alarms]

<table>
<thead>
<tr>
<th>Animal</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raccoon</td>
<td>76</td>
</tr>
<tr>
<td>Bird</td>
<td>18</td>
</tr>
<tr>
<td>Squirrel</td>
<td>6</td>
</tr>
</tbody>
</table>
The team decided to set raccoon traps and soon caught well over 120 raccoons. The false alarms quickly fell below 30 per day. Two weeks later though, the false alarms were again well over 100 per day.

As in example #1, the team was treating a symptom, when what they should have done is ask, “What is causing the raccoons to enter the power plant?” When they finally did this, as seen in the fishbone diagram below, they discovered a small garbage dump that was enticing the wily bandits to enter the plant. When the root cause (garbage dump) was eliminated, the false alarms went well below 30 and stayed there.

In some instances, a symptom may be apparent until trial implementation, when the problem is not eliminated or reduced, or when the problem recurs after a few weeks or months. Building the fishbone by continuing the analysis to the level of “asking why 5 times” will help to identify the most likely root cause(s).
HOW IS CED DONE?

- The problem is the effect.
- Brainstorm a list of possible and specific causes.
- Draw the diagram. Write the effect clearly and objectively in a box. Start at the right, building the major categories (bones) toward the left. Build the diagram by linking the brainstormed causes under appropriate categories. Lines should flow toward the "effect" and touch with arrowheads. Refine categories where necessary and continue asking:
  — What causes this?
  — Why does this condition exist?

Keep asking these questions and building the fishbone until the causes are specific enough to verify. A guide might be to "ask why five times." Be sure to work from the level of symptoms to cause.

- Identify the likely root causes and circle (or cloud) the last element in the chain.
- Verify the most likely root cause. This is done through additional data gathering.
CAUSE AND EFFECT DIAGRAM

Cause & Effect Analysis diagrams have a wide range of applicability, from manufacturing lines to administrative and staff organizations/functions.

- Definition: A Cause and Effect Analysis Diagram (CAED) is a tree graph representing a process
  - The root is a quality characteristic that needs improvement
  - Branches represent aspects of the process
  - Twigs represent potential causes

- Optionally, the trunk of the tree can represent stages in the process to be considered for the most useful branches.

To represent the relationship between the potential causes of a given problem and the effects resulting from it. A well-detailed cause and effect diagram will take the shape of a fishbone and hence, the alternate name Fishbone Diagram. By sorting out and relating causes, these diagrams clearly illustrate the various causes affecting a process.
Constructing a fishbone diagram:

1. Define the problem clearly and objectively.
2. Define the major categories of possible causes using generic branches (people, methods, materials, machines, environment) if helpful.
3. Brainstorm possible causes and list them under the appropriate category. (Brainstorming rules apply.)
   - NOTE: The leader must be sure to spend at least as much time writing the suggestions from the group as he/she does in discussing (analyzing) suggestions from others. Remember that the suggestions from the group are group property and each suggestion must be heard, respected and recorded. Each suggestion can and should be analyzed later after each one has been recorded.
4. For each cause identified, ask: "What caused this?"
5. During the evaluation phase, identify the likely root cause(s) and circle them.
6. Gather data to verify the most likely root cause(s). A Pareto diagram is a good way to display this data.
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CAUSE AND EFFECT DIAGRAM

- Structured Brainstorming
  — Brainstorming Phase (Brainstorming Rules Apply; Go for Quantity)
  — Analysis Phase
- Definition: A Cause and Effect Analysis Diagram (CAED) is a tree graph representing a process
  — The root is a quality characteristic that needs improvement
  — Branches represent aspects of the process
  — Twigs represent potential causes
- Optionally, the trunk of the tree can represent stages in the process to be considered for the most useful branches.
ISHIKAWA’S FIVE M’S

- Material
- Machine
- Measurement
- Man
- Method
CAUSE AND EFFECT DIAGRAM
BAD GOLF SCORE

- Skill
  - Method
  - Training
  - Practice
  - Experience

- Golfer
  - Manpower
  - Attitude
  - Night life
  - Rest
  - Health

- Environment
  - Distractions
    - Water
    - Band
    - Grass
    - Long
  - Course
  - Condition
    - Balls
    - Weather

- Material
  - Ball type

- Machine
  - Equipment

- Golf score
CAUSE AND EFFECT DIAGRAM
ADMINISTRATIVE / SERVICE EXAMPLE

EQUIPMENT
- Lack of Funds
  - Outdated "Clothes Pin" System
- Fear of Computers
  - Handwritten Instructions Poor
    - "Doctor's Disease"

POLICIES
- Antiquated
  - Unclear Menu
- Poor Set-up
- Lack of Funds
  - Hiring Policies in Dietary
- Disciplinary Policies
  - No Feedback to Person Making Mistakes
    - No System
  - Unmotivated Lack of Attention in Dietary
    - Overworked Training
  - Lack of Time
    - Lack of Staff

Wrong Meals Served to Patients on Both Shifts

PROCEDURES

PEOPLE

Version 2.0
July 18, 1989
AT&T Proprietary

Quality Improvement Methodology Workshop 6-23
CAUSE AND EFFECT DIAGRAM
POOR GAS MILEAGE IN COMPANY CAR

METHOD

MACHINES

Use wrong Gears
Poor Hearing
Radio Too Loud
Can't Hear Engine

Drive too Fast
Always Late
Impatience

Fuel Mix Too Rich
Mechanic Doesn't Have Specs.
Carburetor Adjustment
No Record of Tire Pressure
Under-inflated Tires
Difficult Air Stems

Wrong Octane Gas
Don't Know Recommended Octane

Poor Training
Poor Driving Habits

No Owner's Manual

POOR GAS MILEAGE IN COMPANY CAR

PEOPLE

MATERIAL

$ No Oil Change
Improper Lubrication
No Owner's Manual

Wrong Oil
Don't Know Right Oil

"When in Rome"

Version 2.0
July 10, 1999
AT&T Proprietary

Quality Improvement Methodology Workshop
CAUSE AND EFFECT DIAGRAM
MANUFACTURING EXAMPLE

MANPOWER
- Manual
  - Assy. Groups
  - Wave Solder Operator
- Auto

MATERIALS
- Components
  - Missing
  - Wrong

METHODS
- Auto Test Operator
  - Insertion
- Auto
- Manual
  - Hand
    - Rework
  - Solder
    - Wave
- Test
  - Procedures

MACHINERY
- Fixtures
  - Auto Tester 1
    - Programs
      - Auto
      - Insertion
    - Fixtures
      - Auto Tester 2
        - Programs

P.C. BOARD YIELD TOO LOW

Wave Solder
5 WHYS: BUSINESS EXAMPLE

· 5 WHYS

1. Why are we losing money?
   — Sales Decline
   — Incompatible products
   — High development cost
   — High overhead cost

2. Why is sales declining?
   — Late introduction & advertising
   — Marketing approach not right
   — Cost too high
   — Poor contact with customers

3. Why are we introducing & advertising the products so late?
   — Long development Interval
   — Samples not ready
   — Wrong planning

4. Why is the development interval so long?
   — Design changes
   — Times for documentation

5. Why does the design change so many times?
   — Customer needs not clearly defined
   — Inadequate specification of features
The 5 whys method is an operational definition for answering the question, "When do I know if I have reached the root causes?" To use the 5 whys we first ask, "Why do we have this symptom (or problem)?" After hearing the first layer cause of the symptom we ask, "Why do we have this first layer cause?" After we hear the answer to this question we ask, "Why do we have this second layer cause?" We continue in this vein until we have asked, "Why?" 5 times, and by so doing we've gotten 5 layers down to the root cause of the initially reported symptoms. There is an example of this for the ALPS case study.

The two examples from the Japanese IC fabs are as follows:

1. At one plant contaminants (particulates) were identified to be high at periodic times. These times were identified to be related to the times at which a cement factory in the same town was mixing cement. The point is that this was a very subtle root cause and took very long to identify, even using the five whys. Reportedly, the IC plant bought out the cement plant and leveled it to solve their problem.

2. The second example is that of another IC fab whose clean room was experiencing vibrations only at particular times. The source (root cause) of these vibrations was traced to the high speed trains which traveled through the city near the plant. Their solution was to put in a swimming pool between the train tracks and the IC plant to damp out the vibrations (and provide an employee swimming pool).
1. FIRST WHY

- Why are we detecting Particulates at these random intervals and varying sizes and counts?
  - Possibly Equipment Sources
  - Possibly Handling Sources
  - Possibly Incoming Materials (Wafers, Targets, etc.)
  - Possibly External Sources

2. SECOND WHY

- Which equipment sources are most likely?
  - Evaporators
  - Construction Work
  - Tool Wear
- What Handling Sources are possible?
- Which Incoming Materials are most likely?
- Why might external sources be contributing?
  - Inadequate or Damaged Filtration
  - High Concentrations from External Sources

3. THIRD WHY

- What external sources might be contributing?
  - Nearby Factories
  - Air Pollution - Auto Exhaust

4. FOURTH WHY - EXTERNAL SOURCES

- What nearby factories could be contributing to our particulates?
  - Cement Factory
  - Steel Mill
  - Cosmetic Factory

5. FIFTH WHY

- What particulates could these sources be emitting that would be seen in our clean rooms in the sizes and counts observed?
OK, stranger... what's the circumference of the Earth?! Who wrote "The Odyssey" and "The Iliad?!"... What's the average rainfall of the Amazon Basin?

Bart, you fool! You can't shoot first and ask questions later!

No thoughts. Do it before seeing change.
Early experiments in transportation

cause and effect
be measurable. When it is impossible to
or try to make them measurable, or find
able to action.
identified cannot be acted upon, the prob-
ms are to be effected, the
en down to the level at which they can be
identifying them will become a meaningless

**Cause-and-Effect Diagrams**

to each factor objectively on the basis of
rs on the basis of your own skill and ex-
but it is dangerous to give importance to
ceptions or impressions alone. Most
can be solved by such an approach might
ed, and consequently, most of the prob-
ed cannot be solved by this approach.
 factors objectively using data is both
re logical.
use-and-effect diagram continually while
and-effect diagram will help you see those
checked, deleted or modified, and also to
ed. You should make repeated
gram, and eventually a really useful
uld. This will be useful in solving problems,
help improve your own skill and to in-
knowledge.

**4.4 Pareto Diagrams and Cause-and-Effect Diagrams**

Various methods should be applied in combination in solving prob-
ms, and the combination of a Pareto diagram and a cause-and-
effect diagram is particularly useful. The following is a typical ex-
le of this.

**(1) Selection of Problems**

Here is an example illustrating the examination of non-conformity in
a manufacturing process by the use of a Pareto diagram. When data
on non-conformity collected over two months was classified by non-
conforming items, it was found that dimensional defectives were
largest in number, constituting 48 percent of the total non-
conformance. We therefore tried to reduce the number of non-
conformity with stress on dimensional defectives.

![Figure 4.3 Pareto Diagram of Non-conforming Items](image-url)
(2) Analysis and Countermeasures

All the shop members discussed the causes of the dimensional variation and constructed a cause-and-effect diagram (See Figure 4.4). A Pareto diagram by causes (Figure 4.5) was then made by investigating all the units with dimensional variation in order to examine to what extent these factors were affecting the non-conformance. With some items, it was impossible to clarify the causes of the non-conformance, and these were lumped together under the heading “Unclear.” We discovered from the Pareto diagram that the occurrence of the defect was greatly affected by the fitting position. Although the fitting position had been stipulated by the traditional operational standard, the standard fitting method was not shown. This led to variation in the fitting position, and resulted in the dimensional defectives. The shop members therefore designed a suitable fitting method, which was further standardized and added to the operational standards.

![Cause-and-Effect Diagram of Dimensional Defectives](image)

Figure 4.4 Cause-and-Effect Diagram of Dimensional Defectives

(3) Effects of Improvement

After the improvement Pareto diagram was made, Pareto diagrams clearly reduced.

![Comparison of](image)

Figure 4.6 Comparison of...
(3) Effects of Improvement

After the improvement was carried out, data was collected, and a Pareto diagram was made to compare the results. The following two Pareto diagrams clearly show that dimensional defectives were reduced.

![Diagram](image-url)
INTRODUCTION

As we have seen, statistical control charts are important aids in stabilizing and improving a process, and help decrease the difference between customer needs and process performance. However, other techniques can be used in conjunction with control charts to aid in process stabilization and improvement. The methods we will discuss are brainstorming, cause-and-effect diagrams, check sheets, Pareto analysis, and stratification.

BRAINSTORMING

*Brainstorming* is a way to elicit a large number of ideas from a group of people in a short period of time. The members of the group use their collective thinking power to generate ideas and unrestrained thoughts. Brainstorming is used for several purposes: to determine problems to work on; to find possible causes of a problem; to find solutions to a problem; and to find ways to implement solutions. Brainstorming was fully developed and utilized by the ancient Greeks; it was known as *heuristics*. Dr. Alex Osborn revived brainstorming in the 1940s in his work in advertising, after which the technique became very popular in industrial uses.

Effective brainstorming should take place in a structured session. The group should be small in number, between 3 and 12 as a rule of thumb; having too large a group deters participation. The composition of the group should depend on the issue being examined; and it should include a variety of people, not all of whom should be technical experts in the particular area. The group leader should be experienced in brainstorming techniques. The leader's task is to keep the group focused, prevent distractions, keep ideas flowing, and record the outputs. The brainstorming session should be a closed-door meeting with no interruptions that might
break the group's creative process or cause distractions. Seating should promote the free flow of ideas. A U-shape or circle arrangement is suggested. The leader should record the ideas so everyone can see them, preferably on a flip-chart, blackboard, or illuminated transparency.

Procedure

The following steps are recommended for a brainstorming session:

1. Select the topic or problem to be discussed.
2. Each group member makes a list of ideas on a piece of paper. This should take no longer than 10 minutes.
3. Each person reads one idea at a time from his/her list of ideas, sequentially, starting at the top of the list. As the ideas are read, they should be recorded and displayed by the group leader. The group members continue in this circular reading fashion until all the ideas on everyone's list are read.
4. If a member's next idea is a duplication, that member goes on to the subsequent idea on his/her list.
5. Members are free to pass on each go-round but should be encouraged to add something.
6. The leader then requests each group member, in turn, to think of any new ideas he/she had not thought of before. It is very likely that hearing others' ideas will result in more or related ideas. This is called piggy-backing. The leader continues asking each group member, in turn, for new ideas, until they cannot think of any more.
7. If the group reaches an impasse, the leader can ask for everyone's "wildest idea." An unrealistic idea can stimulate a valid one from someone else.

Rules

Certain rules should be observed by the participants to ensure a successful brainstorming session—otherwise, participation may be inhibited.

1. Do not criticize, by word or gesture, anyone's ideas.
2. Do not discuss any ideas during the session, except for clarification.
3. Do not hesitate to suggest an idea because it sounds silly. Many times a "dumb" idea can lead to the problem solution.
4. Only one idea should be suggested at a time by each team member.
5. Do not allow the group to be dominated by one or two people.
6. Do not let brainstorming become a gripe session.
Aids to Better Brainstorming

A relaxed atmosphere in which people feel free to suggest any kind of idea enhances the brainstorming session. The following techniques may aid in improving brainstorming sessions by giving people ways to come up with new ideas.⁵

1. **Modification** is changing some aspect of an existing product or service. An example is lower priced movie tickets for senior citizens.
2. **Magnification** is enlarging a product or service, such as giant economy size packages.
3. **Minification** is altering a product or service so it becomes smaller or less complex. Examples are portable radios and televisions, electronic calculators, and no-frills airline travel.
4. **Substitution** is using a certain material or service in place of what has traditionally been employed. Examples are polyester instead of cotton, plastic in place of metal, and nurse-midwives instead of physicians.
5. **Rearrangement** is altering the configuration of basic elements in a product or service—for example, some housing developments use several floor plans but each have the same basic features.

An Example of Brainstorming

Consider a group of six people, one from each department of an organization, who meet to brainstorm about the problem of excessive employee absenteeism. They have already decided on the topic to be discussed, so they can proceed to making their lists of causes. After they have completed their lists, they read their ideas, sequentially, one at a time—and the designated leader records the ideas on a flip chart. The first person’s list of possible causes of excessive employee absenteeism is:

1. Low morale.
2. No penalties for absence.
4. Personal problems.

The second person’s list is:

1. Dislike of supervisor.
2. Drug problems.
4. Anger over pay.
5. Work related accidents.

All of the other members have similar lists. After all have read their lists and the causes have been recorded, the leader requests any new ideas that