Step 3: Analyze

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Step 3: Analyze

Objective:

Analyze the problem to identify and verify its primary root causes.

Description:

STEP 3 identifies the problem's primary causes and verifies them with data to ensure they are the **root** causes. To accomplish this task:
(1) Collect as much information as possible concerning the data contained in the "Problem Statement" and identify **potential** causes from "standards, policies or procedures that failed" or "training concerns". Take each potential cause to the **root level** and check reverse logic. (2) **Select** the **most likely** primary causes - those that **potentially** have the greatest impact on the problem. (3) **Verify** a **cause and effect** relationship between the most likely causes and the problem.

It is important to conduct sufficient Analysis so that each primary root cause's **impact** on the gap identified in STEP 2 can be approximated. Analysis should be sufficient to satisfy the reasonable person. Avoid "paralysis by Analysis".

Checkpoints:

9 ✓ **Cause and effect Analysis was taken to the root level.**

Cause and effect Analysis requires that sufficient knowledge concerning the data in the problem statement is collected. This may require subject matter experts or people from other departments. Through close examination of the problematic data within the "Problem Statement" the team can identify the potential root causes.

Step 3: Analyze (Continued)

10 ✓ **Potential causes most likely to have the greatest impact on the problem were selected.**

The team needs to identify causes that appear or are proven to occur more frequently than other causes found in the "Problem Statement" data.

11 ✓ **A relationship between the root causes and the problem was verified with data.**

Verification must be performed with data. Careful thought should be given as to what relationship is to be proven so that an appropriate data collection form can be designed. The team must determine if the data to be collected will be attributes or variables and how long it will take to collect data. **Verification of root causes should be sufficient to satisfy a reasonable person that when the root causes are present the problem exists and when root causes are absent the problem does not exist or is reduced.** There are many statistical tools and techniques to verify cause and effect relationships. This manual only provides the scatter diagram tool for review.

12 ✓ **The impact of each root cause on the gap was determined.**

Sufficiently collected and analyzed data will enable the team to approximate with confidence the impact of root causes on the gap. This is a step critical to cost-benefit Analysis, which will be done in STEP 4 when feasibility is evaluated.

Step 3: Analyze (Continued)

Recommended Tools and Techniques

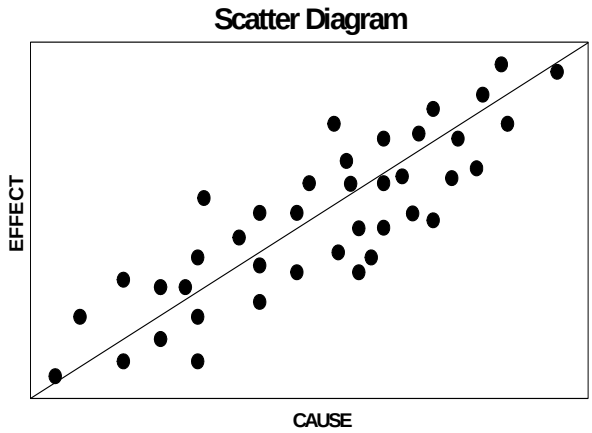
Tools commonly used with STEP 3 may include:

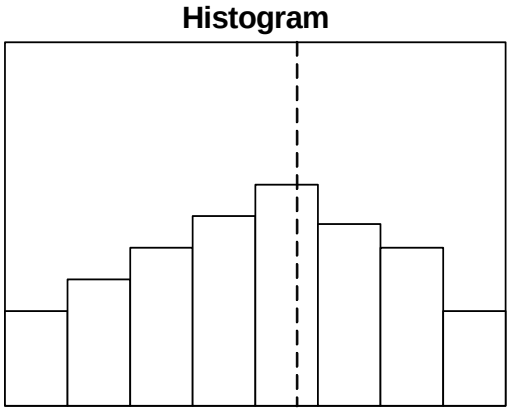
- Cause and Effect Diagram
- Checksheet/Spreadsheet
- Histogram
- Pareto Chart
- Scatter Diagram

Techniques that may be helpful include:

- Brainstorming
- Single Case Bore Analysis
- Contingency Table (and Chi-Squared Test)
- Multivoting
- Failure Mode and Effects Analysis (FMEA)
- Cause and Effect Diagram with the addition of Cards (CEDAC)

Single Case Bore Analysis				
Reason or Factors	**CASES**			
	1	**2**	**3**	**4**





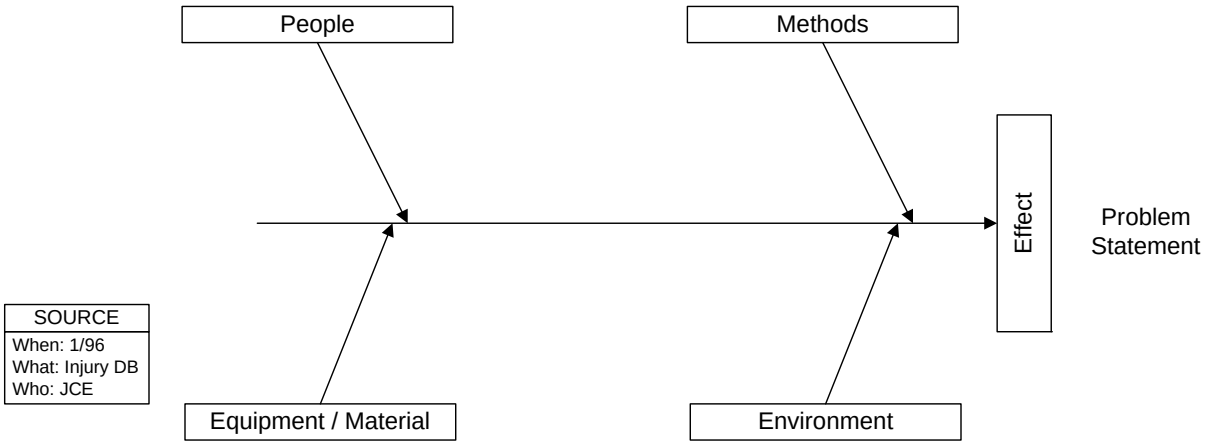
Cause and Effect (Fishbone) Diagram (Tool)

A **Cause and Effect** (or Fishbone) Diagram is used to determine the relationship between the "effect" (or problem statement) and the possible "causes" influencing it. Cause and Effect Diagrams are drawn to clearly illustrate the various causes (generated by the group after studying the data) that affect a process, or outcome. For every effect there are can be several major categories of causes. Usually the categories can be summarized under general headings such as Environment, Equipment/Materials, Methods, and People. However, they may vary according to the area of improvement on which the group is working. From this well-defined list of possible causes, the "most likely" are identified and selected for further Analysis with data. The Cause and Effect Diagram, when finished, will take on the shape of fish bones, hence the nickname "fishbone" diagram.

How To Construct A Cause And Effect (Fishbone) Diagram

1. **Draw a Naked Cause and Effect Diagram (Fishbone)** with the effect, or problem statement (box) on the right and the major bones directly to the left of the problem statement box. The major bone closest to the head of the fish is considered to be the greatest impact on the effect (e.g., the “Methods” bone).

Example of a Naked Fishbone:



Cause and Effect (Fishbone) Diagram (Tool) (Continued)

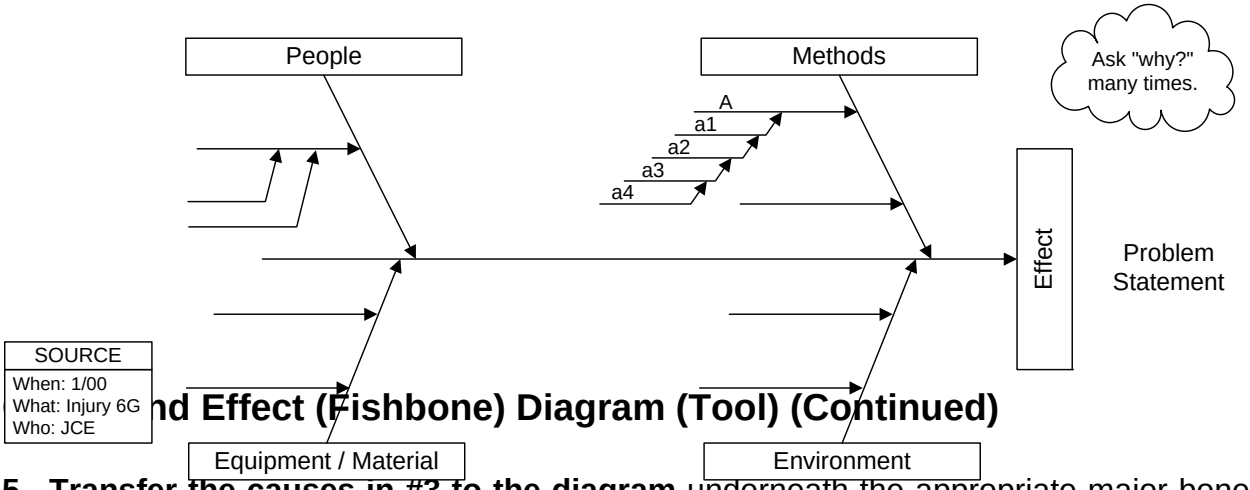
2. **Write the problem statement in the head of the diagram.**

3. **Determine the causes that were found to link to the effect.** It is important to involve as many people as possible that have practical knowledge of the problem. Most causes will fall into one of the following two groups:
   1) **Standards, policies or procedures** that may be absent, poorly designed, or out-of-date.
   2) **Training** found to be absent or inadequate.

   - Causes should be actionable. If the cause identified cannot be acted upon, the problem will not be solved.

   - Analyze each step of a process involved in the data contained in the Problem Statement to search for causes.

4. **Identify the primary causes or major categories as the big bones** by grouping the identified causes in #3 and determining an appropriate title for each group. Place a title in each of the rectangles using the generic categories of Environment, Equipment/Materials, Methods, and People and then describe each of the causes.



nd Effect (Fishbone) Diagram (Tool) (Continued)

5. **Transfer the causes in #3 to the diagram** underneath the appropriate major bone categories. Begin with the major category that the team identified as most likely to produce the actionable root cause (the category aligned most closely to the effect) and ask "why?" Why does this occur? Why does this condition exist? Ask this question several times until an actionable cause is formed (usually involving a failed standard, policy, procedure, or training).

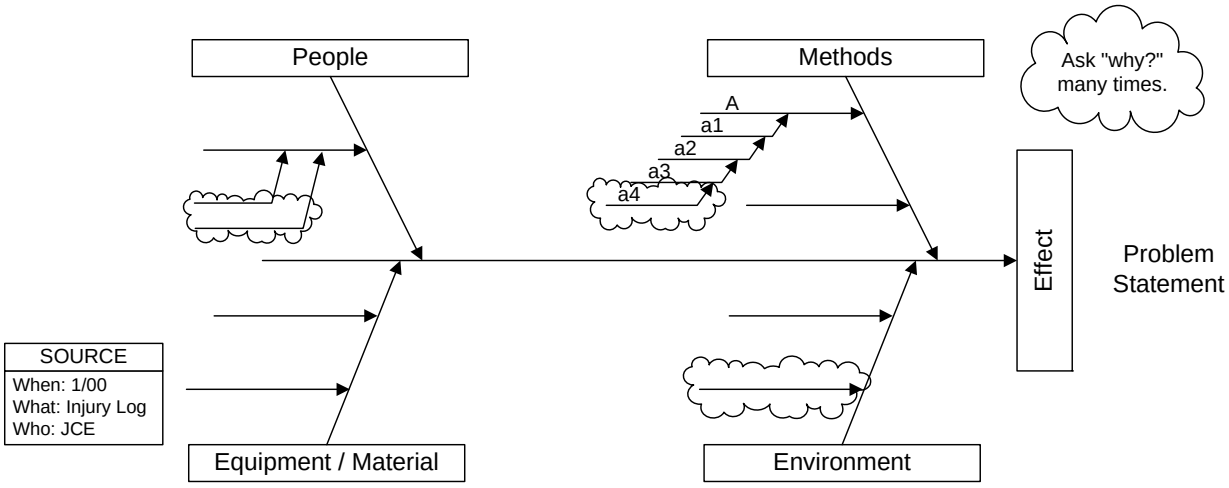
Tip

*Be sure to "walk" through the logic of your diagram in both directions, as shown below (This **a1** is caused by this **a2**, which is caused by this **a3** which is caused by this **a4**). Then, in reverse, **a4** caused **a3**, **a3** caused **a2**, which caused **a1**. Often logic problems will not surface until the second direction is tried. This completes one "logic chain".*

Now revisit each sub-bone for additional causes; specifically, move back to **a2** and ask again, "Why does **a2** occur?" Next, ask again "Why does **a1** occur?" and continue this process of asking "why?" back to the major bone. This process is critical to identifying actionable potential root causes.

Cause and Effect (Fishbone) Diagram (Tool) (Continued)

6. **Indicate**, **by "clouding" or highlighting in some way, the <u>most</u> <u>likely</u> root cause(s)** (see below).



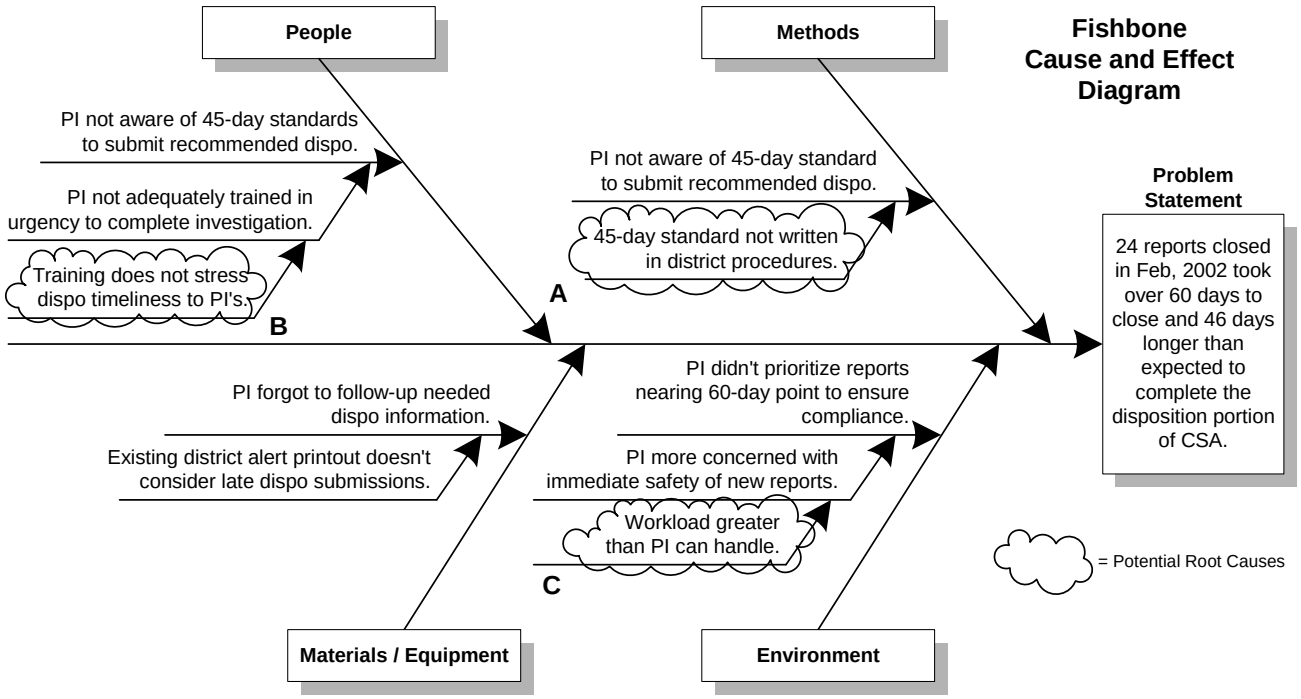
Completion of the Cause and Effect Diagram will provide the team with its most likely root cause(s). We must now verify that a change in our potential root cause results in a change to our quality characteristic (effect). Once we **verify this relationship with data**, we can proceed to **Countermeasures**, STEP 4.

Tip

A Pareto Chart or Scatter Diagram can be particularly useful in verifying a root cause. After the Cause and Effect Analysis, collect data on the problem and categorize by cause on a Pareto Chart. This will show to what extent the potential causes affect the quality characteristic, resulting in non-conformance. The Scatter Diagram can enable us to determine, with varying degrees of confidence that a cause and effect relationship exists between variables.

Cause and Effect (Fishbone) Diagram (Tool) (Continued)

Example:



Cause and Effect (Fishbone) Diagram Exercise

PURPOSE

To practice constructing a Cause and Effect (Fishbone) Diagram.

AGENDA

1. Instructor assigns topic
2. Instructor to divide class
3. Construct Cause and Effect (Fishbone) Diagram
4. Select spokesperson to present to full group

LIMITS

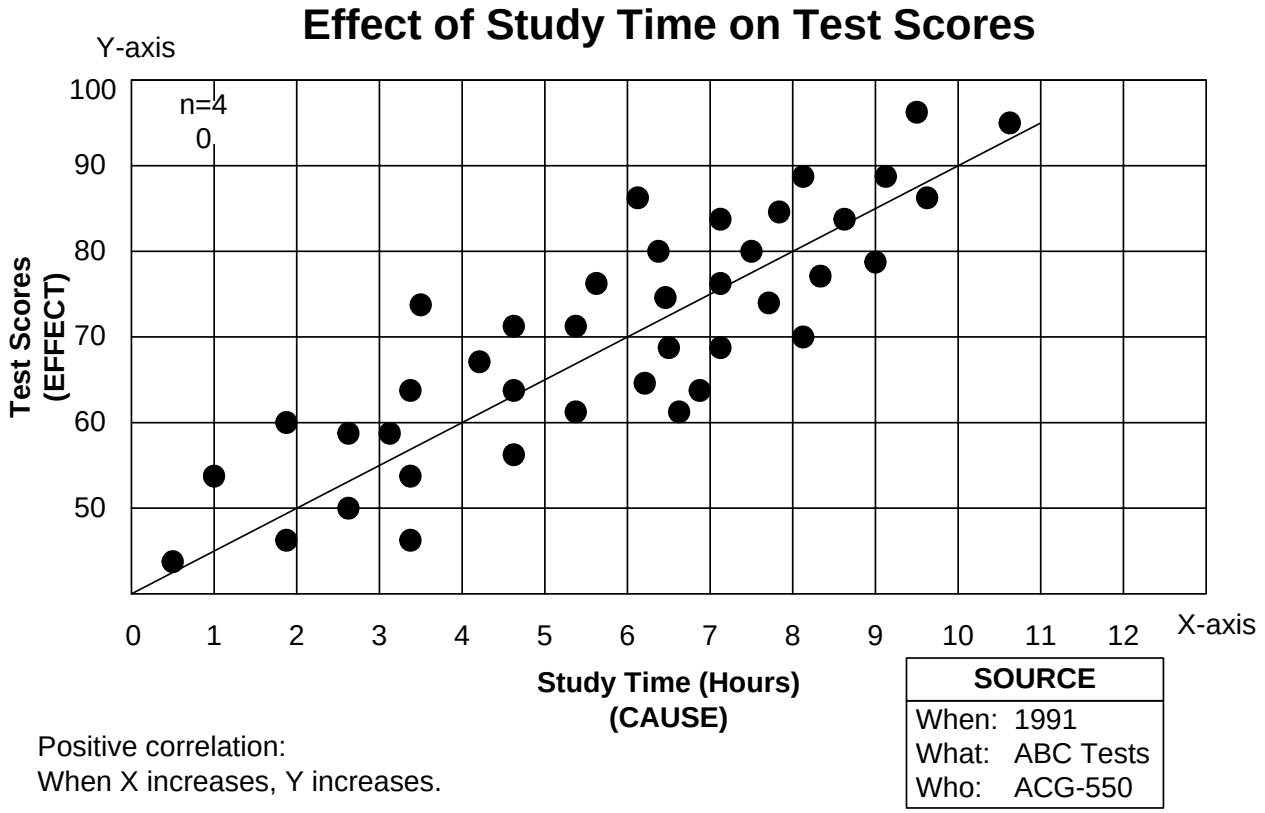
30 minutes in teams

15 minutes in full group presentations

Scatter Diagrams (Tool)

The **Scatter Diagram** is used to determine if there is a relationship (or correlation) between two variables. It is used to display what happens to one variable when another variable changes in order to test a theory that the two variables are related. The data displayed on the scatter diagram clearly show if there is a positive, negative or no relationship between the two variables.

Example:



Scatter Diagrams (Tool) (Continued)

How To Create A Scatter Diagram

1. **Collect at least 30 sets of paired data ("X" and "Y").**

2. **Find the maximum and minimum values** of "X" and "Y".

3. **Draw "X" and "Y" axes.** Determine the scales of the axes so that they are more or less equal in length (try not to have more than ten graduations).

4. **Label the "X" axis as the suspected "driving factor" (independent variable or cause). Label the "Y" axis as the one influenced by it (dependent variable or effect).** Complete the chart by adding other pertinent information (source block, sample size, title, for example). The "X" axis is the potential root cause and the "Y" axis is the effect or quality characteristic.

5. **Plot the data** by drawing a point where the paired numbers intersect on the graph.

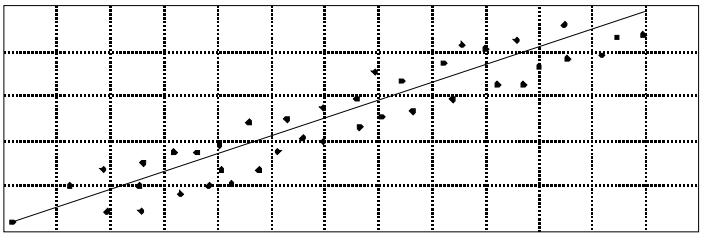
6. **Draw a "trend line" through the approximate “middle” of the data points.** The direction of this line tells you what type of relationship, if any, exists. The strength of the relationship is determined by how close the data points are on the line.

Scatter Diagrams (Tool) (Continued)

How To Interpret Scatter Diagrams

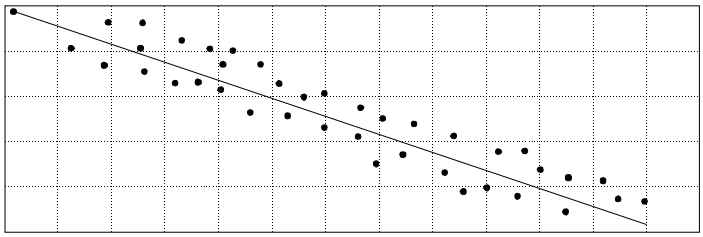
Positive Relationship:

A positive correlation exists when the data points form an upward slant to the right. A positive pattern tells us that as the independent variable increases, the dependent variable also increases.



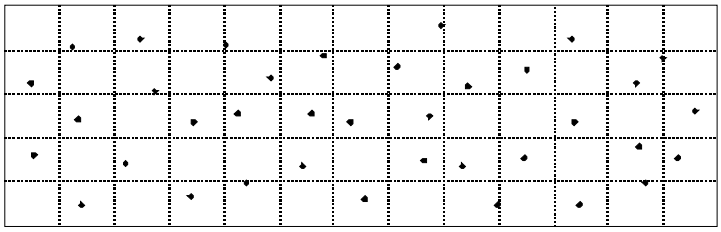
Negative Relationship:

A negative correlation exists when the data points form a downward slant to the right. A negative pattern tells us that as the independent variable increases, the dependent variable decreases.



No Relationship:

When the data points do not form any identifiable shape, we can say that no relationship seems to exist between the two variables.



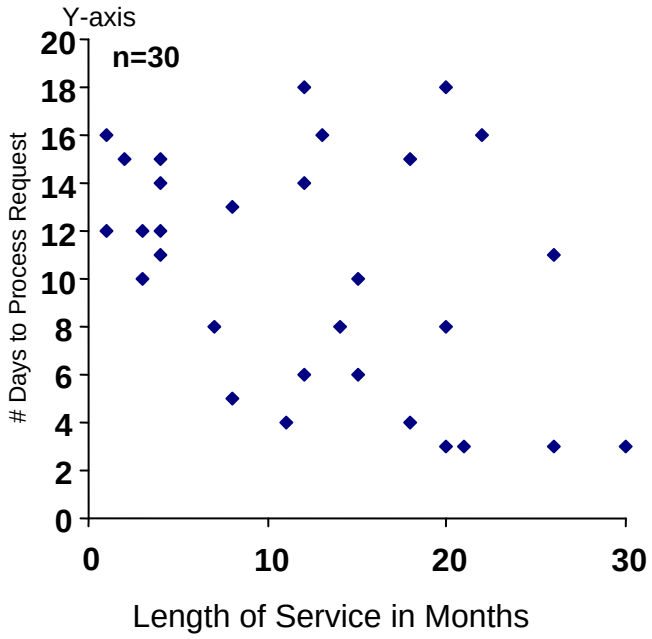
Scatter Diagrams (Tool) (Continued)

Scatter Diagram (Exercise)

Example:

Variables		Request #																												
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Cause (Independent)	Providers Length of Service working for organization (months)	3	4	20	4	26	21	3	1	30	4	20	1	8	11	18	2	15	4	7	14	12	15	26	8	12	18	22	13	20	12
Effect (Dependent)	# Days to Process Request	10	15	8	11	3	3	12	12	3	12	3	16	5	4	4	15	6	14	8	8	6	10	11	13	14	15	16	16	18	18

Days to Process Request/Length of Service



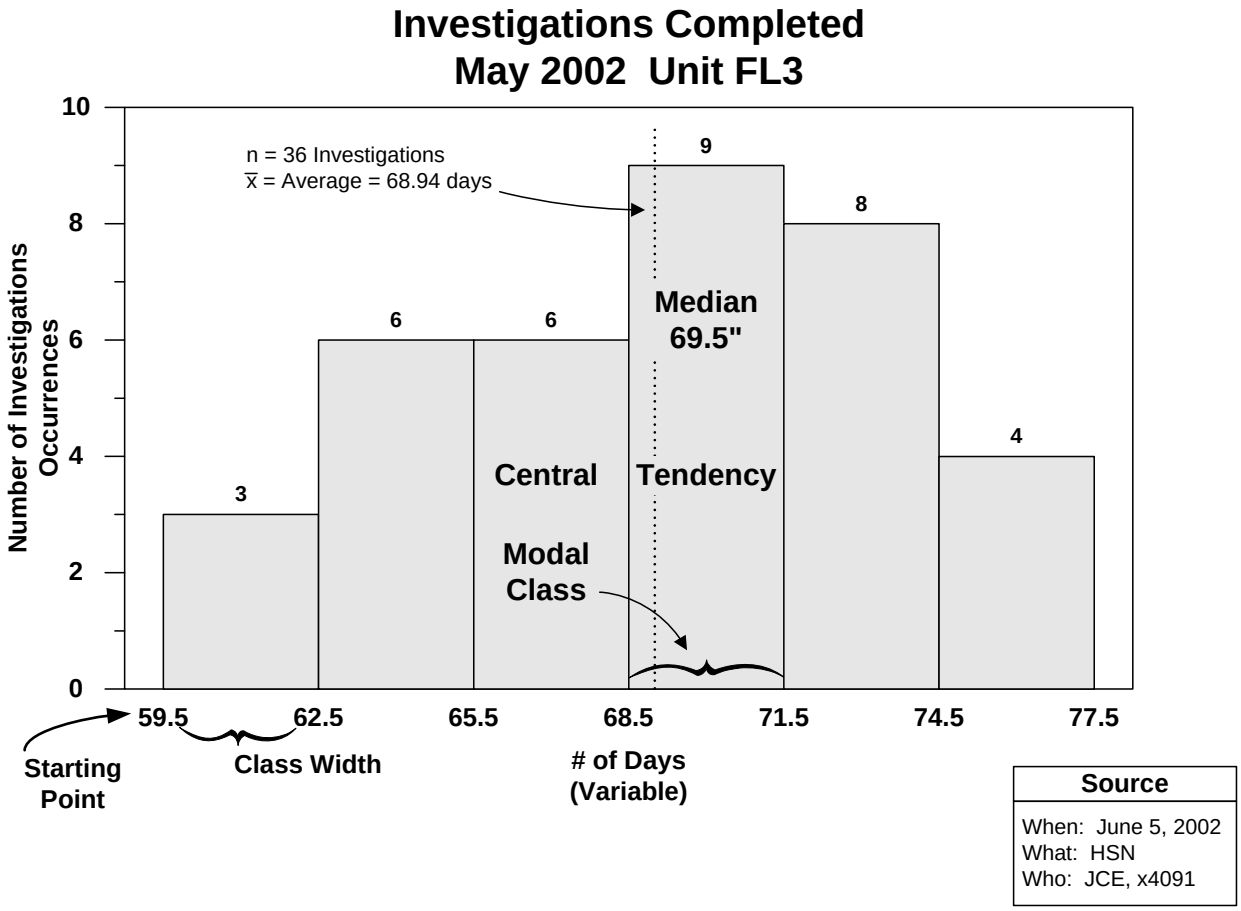
Source
When: 1991
What: Request DB
Who: ACG

Conclusion: No relationship

Histogram (Tool)

A **Histogram** is a visual distribution of data that plots a variable against the number of occurrences. A histogram takes variables (continuous or measurable) data from a process (temperature, weight, height and time, etc.) and displays its distribution.

Histogram Example:



Note: Calculations for this histogram are on the next 3 pages.

Histogram (Tool) (Continued)

How To Create A Histogram

	STEP	EQUATION	EXAMPLE
1	Start with a set of at least 30 data points. (e.g., wait time in minutes)		64,63,66,73,60,69,68,70,65, 61,66,76,69,71,73,62,70,65, 72,63,73,74,70,66,68,72,75, 76,69,70,72,70,76,73,65,69
2	Arrange the data point values by increasing or decreasing order.		60,61,62,63,63,64,65,65,65, 66,66,66,67,68,68,69,69,69, 70,70,70,70,70,71,72,72,72, 73,73,73,73,74,75,76,76,76
3	Each value is a data point. Count the number of data points.	n	n = 36
4	The range (R) of the set is the smallest (minimum) data point value subtracted from the largest (maximum) data point value.	R = (Largest Value)- (Smallest Value)	R = 76 - 60 R = 16
5	The class (K) is used to determine the number of bars on the histogram. Class is equal to the square root of n. The # of bars in the Histogram will be "K" if a whole number or "K" rounded up to the next whole number.	K = squared root of n	K = squared root of 36 K = 6
6	The class width (W) is used to determine the width of the bars. It is calculated by dividing the range (R) by the class (K).	$W = \frac{R}{K}$	$W = \frac{16}{6}$ W = 2.6 ➔ W = 3 (Round up to the next whole # to determine the width of each bar)
7	To begin constructing the histogram, establish the starting point (SP) for the first class. This is calculated by: · Taking the measurement unit (e.g., single minute) and dividing this value by 2, then · Subtracting the above result from the minimum value in the data set.	Measurement Unit (M) This M=1 minute SP = minimum value -½ Tip: Where data are whole #'s simply subtract ½ from the lowest value.	SP = 60 - ½ = 59.5

Histogram (Tool) (Continued)

	STEP	EQUATION	EXAMPLE		
8	Develop a frequency table to categorize your data points by class limit.		Class Limits	Tally	Frequency
9	For the "Class Limits" column, add the class width (W) to the starting point.	59.5 + (Rounded Up) W	59.5 + 3 Class Width is 59.5 - 62.5, 62.5 - 65.5, etc.		
10	For the "Tally" column, go back to your original set of data points. Tally those that fall within each class' limits. Add the items in the "Tally" column for each class and enter the result in the "Frequency" column.		Class Limits	Tally	Frequency
			59.5 - 62.5	|||	3
			62.5 - 65.5	𝍸 |	6
			65.5 - 68.5	𝍸 |	6
			68.5 - 71.5	𝍸 ||||	9
			71.5 - 74.5	𝍸 |||	8
			74.5 - 77.5	||||	4

Tip

To construct the histogram, draw horizontal and vertical axes. The horizontal (X-axis) shows class limits; the vertical (Y-axis) shows frequencies. Draw a bar to represent the frequency of data in each class. ***The histogram bars should be touching each other****. There should be a half class width between the Y-axis and the left-most bar.*

Measures Of Central Tendency

There are three measures of central tendency:

- **Mean (Average)** - The sum of all the measured or counted data divided by the total number of data points; for example, all the data points listed in Step 1 on the previous page, added together equal 2,482; divided by 36 equal 68.94 minutes.

- **Mode** - The value repeated most often in the raw data. In this example it is 70 minutes. If the data are presented as grouped frequency as a histogram, we refer to

the modal class instead of the mode. Modal class is the class interval with the highest frequency. In this example, the modal class is 68.5 - 71.5 minutes.

Histogram (Tool) (Continued)

- **Median** – A Median is the middle value in a distribution arrayed by size, above and below which lie an equal number of values. Unlike averages, medians are less sensitive to extreme values and are therefore, preferred in Analysis pertaining to compensation. For example, in our data of 36 samples the median value is the average of the two middle values since there is not a single middle value (69+70=139 divided by 2 = 69.5 minutes).

When Should You Use A Histogram?

1. **To set goals or targets.** Once the histogram is constructed, the team may choose a target (or specification limit) near the tail(s) of histogram.
2. **To show process capability.** If specification limits or the customer's requirements are available, they can be displayed on the histogram to show how much of the histogram is outside of specification limits.
3. **To stratify data.** The tails of histograms generally provide the pertinent data desired in stratifications.
4. **To confirm results.** By comparing histograms **before** and **after** countermeasures have been implemented, a shift in the average and/or tightening up of the distribution can indicate the effectiveness of countermeasures in attacking root causes of the problem.

Variation

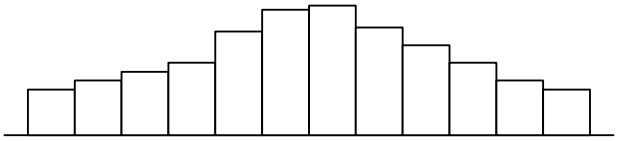
Understanding and controlling variation are the keys to successful quality control. This is accomplished by taking samples from a process output, measuring the variations of that output using a histogram, and then implementing countermeasures to reduce the

variation displayed in the histogram. Histograms are used for variables (measurable) data only. Attribute data are shown on a frequency chart.

Histogram (Tool) (Continued)

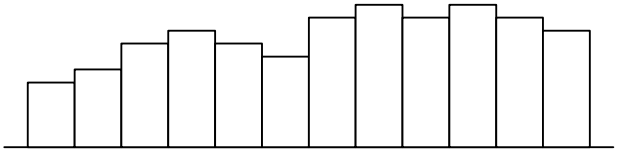
Common Distribution Patterns

When any of these shapes are encountered, the probable interpretations listed should be investigated.



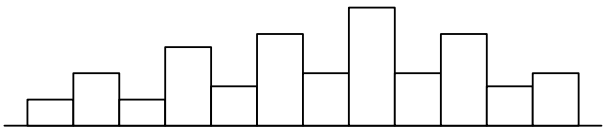
Normal (Symmetric) Type

- most commonly occurring histogram
- variation balanced on both sides of the center
- mean, median and mode are the same



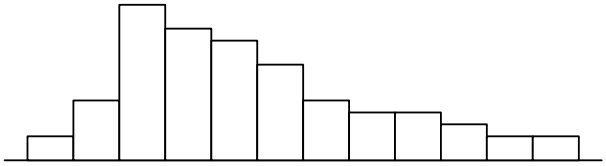
Plateau

- several distributions mixed



Comb

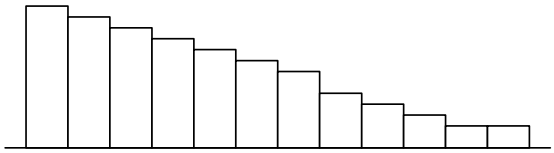
- measurement error
- rounding or grouping bias
- construction error



Skewed

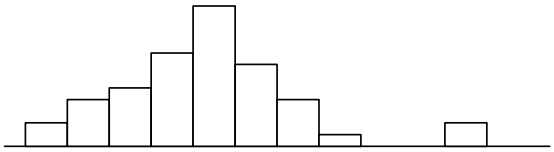
- expected in process time data, tasks cannot be completed in less than a certain time
- skewed variation demonstrates most values in the sample falling on the positive (left side) or negative (right side) of the center of distribution

Histogram (Tool) (Continued)



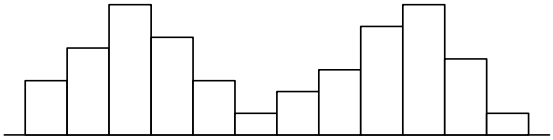
Precipice

- screening, loss of data
- can be positively (left side) or negatively) right side) of center distribution



Outlier

- abnormality in process
- data error



Bi-Modal

- two processes mixed (twin-peaked)
- occurs when two different data groups are mixed (e.g., population of very short people is added to a population of extremely tall people); in effect, we have two histograms “pushed” together

Histogram (Tool) (Continued)

Purpose

To practice constructing histograms.

Agenda

1. Instructor to divide class into groups.
2. Using histogram construction steps, construct a histogram with the given data.
3. Identify type of distribution pattern(s) seen.
4. Share histogram with full group.

Limit

20 minutes in teams

10 minutes in full group

P.A.L. (Purpose-Agenda-Limit)

A. What Is An Effective Meeting?

An effective meeting is a meeting:

- which is necessary.
- which includes all individuals required to accomplish the intended **PURPOSE***.
- which covers the **AGENDA***.
- where people know what is expected of them.
- where the real issues are on the table and being dealt with and where most hidden agendas are legitimized and surfaced for discussion.
- where decisions and commitments are made, plans are developed, problems are solved.
- where people leave knowing what was accomplished and what they are to do.
- which meets its intended **PURPOSE***.
- which respects people by starting and ending on time **(LIMIT*)**.

B. Why Are Effective Meetings Important?

Because organizations spend 7.15% of their personnel budgets, 35% of middle management's time, and 60% of top management's time in meetings.

C. When Are Meetings Needed?

Meetings are useful:

- for group problem solving.
- for sharing information or advice.
- for building commitment to a common goal.
- for addressing problems or issues that involve a number of people.
- for planning.
- for defining accountability and responsibility.

- for group decision-making.

P.A.L. (Purpose-Agenda-Limit) (Continued)

D. How Are They Created?

- **Send a draft of the agenda.** The person calling the meeting should send out information on the agenda so that the purpose, time frames and topics are clear before people come to the meeting.
- **Start the meeting on time.**
- **Revise and agree on an agenda.** Add agenda items suggested by others attending the meeting, as appropriate. Finalize and agree on the agenda.
- **Agree on ground rules.**
- **Encourage active participation from all members.**
- **Choose a process facilitator.** To ensure an effective meeting, someone needs to take responsibility for managing the process portion of the meeting. Frequently, because of their involvement in the content of a meeting, Team Leaders and other accountable people are unable to manage both the process and the content of a meeting. At such times, it is helpful to assign the role of facilitating the process to another team member or to bring in a facilitator. The process of facilitation helps the group stay focused on the intended purpose and agenda, manages the time limits and renegotiates them if necessary. Meeting participants are expected to help the "process person" manage the meeting time and content. There should be a clock visible to participants.
- **Focus the discussion.** Clarify and summarize as necessary to facilitate mutual understanding of perspectives and ideas. When people wander off the subject, point out that the group has changed topics. Should this happen repeatedly, encourage the group to choose to either return to the intended focus or, if necessary, to deliberately re-direct the purpose of the meeting. Make the decision to change the content of the meeting continuously and explicitly, don't just let the conversation wander.

P.A.L. (Purpose-Agenda-Limit) (Continued)

D. How Are They Created? (Continued)

- **Decide how to decide.** Determine how decisions will be made in the meeting - by consensus, by multivoting, by majority voting, or by the team leader.
- **Address all items raised.** Insure that all items raised are addressed by the end of the meeting and that the person who raised the item knows what the next step will be, specifically:
  - Decide whether or not the item will be addressed by this particular group.
  - If yes, decide whether it will be addressed:
  - in this meeting
  - in another meeting
  - by being assigned to a person or group.

  Check with the person who raised the issue to ensure they know what needs to happen next to get the issue addressed and that the proposed plan meets their needs.

Parking Lot

Parking Lot is a strategy for recording and postponing items raised during a meeting. Create a side list of items to be addressed later. Before the meeting adjourns, review ALL "parked" items and decide:

- whether this group will address the item or refer it elsewhere, and if the item will be addressed by the group, decide when and how it will be addressed - (e.g., agenda next meeting, assign).
- communicate decisions to the person who raised the item.

- **Summarize results, agreements, and next steps.** Acknowledge agreements. At the close of the meeting review the decisions and agreements and other accomplishments that happened in the meeting, and review the next steps. WRITE IT ALL DOWN! Acknowledging and celebrating what was accomplished at a successful meeting gives people a sense of progress, and rewards them for the time and effort the meeting required. It also encourages them to work to make the next meeting productive.

- **End the meeting on time.**