SENG 350
- Software Architecture & Design

Shuja Mughal

Architectural Quality

Fall 2024

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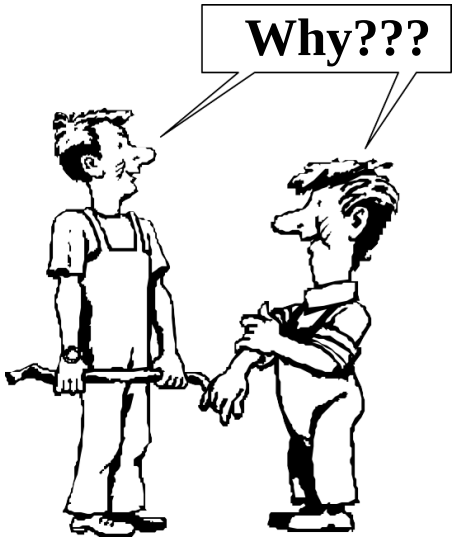
Why Improve Architecture?

- ***Do we really need to?***
- ***Are we improving the right thing?***



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General Techniques

Root Cause Analysis

Root Cause Analysis is a method that is used to address a problem or non-conformance, in order to get to the “root cause” of the problem. It is used so we can correct or eliminate the cause and prevent the problem from recurring.

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Root Cause

- ***Root Cause*** is the fundamental breakdown or failure of a process which, when resolved, prevents a recurrence of the problem.
  - Or, in other words
- For a particular product problem, ***Root Cause*** is the factor that, when you fix it, the problem goes away and doesn't come back.
- ***Root Cause Analysis*** is a systematic approach to get to the true root causes of our process problems.

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Philosophy of Root Cause Analysis

- Each problem is an opportunity ("golden nugget") because it can tell a story about why and how it occurred.
- It is critical that everyone take a personal and active role in improving quality.
- The ***"true"*** problem must be understood ***before*** action is taken.
  - Problems are often masked for a variety of reasons
- To do this well, we must be
  - Both focused and open-minded
  - Both patient and quick
  - Above all, we must be ***relentless***

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5 Why's

- The 5-Whys is a simple brainstorming tool that can help QA teams identify the root cause(s) of a problem. Once a general problem has been recognized (either using the Fishbone Diagram or Process Mapping), ask "why" questions to drill down to the root causes. Asking the 5-Whys allows teams to move beyond obvious answers and reflect on less obvious explanations or causes.

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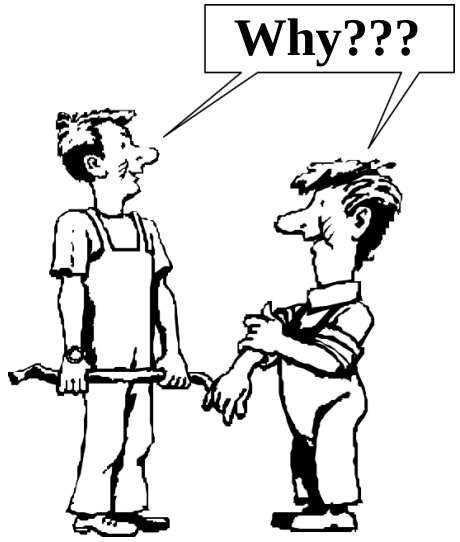
How to do Root Cause Analysis

- Simply put, root cause analysis is asking why the problem occurred and then asking why ***that*** happened until we reach the fundamental process element that failed.
- The following example illustrates the basics of Root Cause Analysis.



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Example:

- WHY 1 :Why my car had stopped ?
- No petrol in tank.

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Example:

- WHY 1 Why did my car stop?
- No petrol in the tank.
- WHY 2: Why did I not have petrol in my tank?
- I did not buy in the morning on my way to work.

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Example:

- WHY 1 Why did my car stop?
- No petrol in the tank.
- WHY 2: Why did I not have petrol in my tank?
- I did not buy in the morning on my way to work.
- WHY 3: Why did I not buy petrol?
- No money in my pockets.

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Example:

- WHY 1 Why did my car stop?
- No petrol in the tank.
- WHY 2: Why did I not have petrol in my tank?
- I did not buy in the morning on my way to work.
- WHY 3: Why did I not buy petrol?
- No money in my pockets.
- WHY 4: Why is there no money in my pockets?
- Evening poker.

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Example:

- WHY 1 Why did my car stop?
- No petrol in the tank.
- WHY 2: Why did I not have petrol in my tank?
- I did not buy in the morning on my way to work.
- WHY 3: Why did I not buy petrol?
- No money in my pockets.
- WHY 4: Why is there no money in my pockets?
- Evening poker.
- WHY 5: Why did I not win a poker game?
- I do not know how to bluff!

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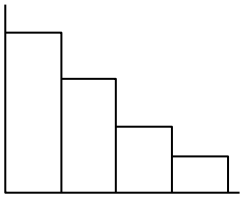
Example:

Cause

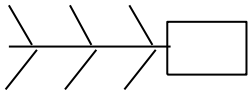
Effect

Tools Used in Root Cause Analysis

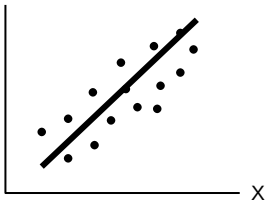
BRAINSTORMING



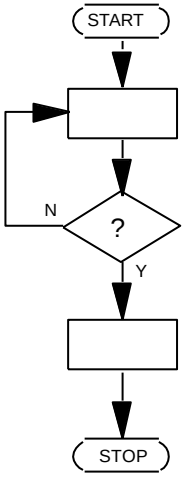
PARETO CHART



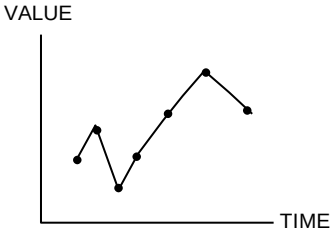
FISHBONE DIAGRAM



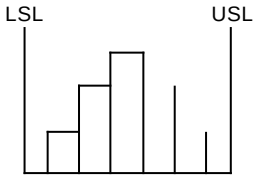
SCATTER DIAGRAM



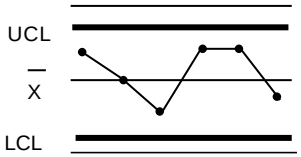
FLOWCHART



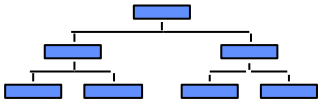
RUN CHART



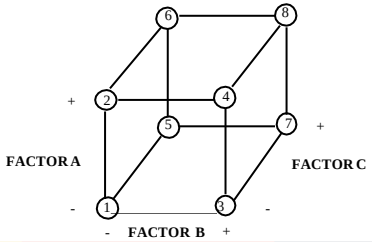
HISTOGRAM



CONTROL CHARTS



TREE DIAGRAM



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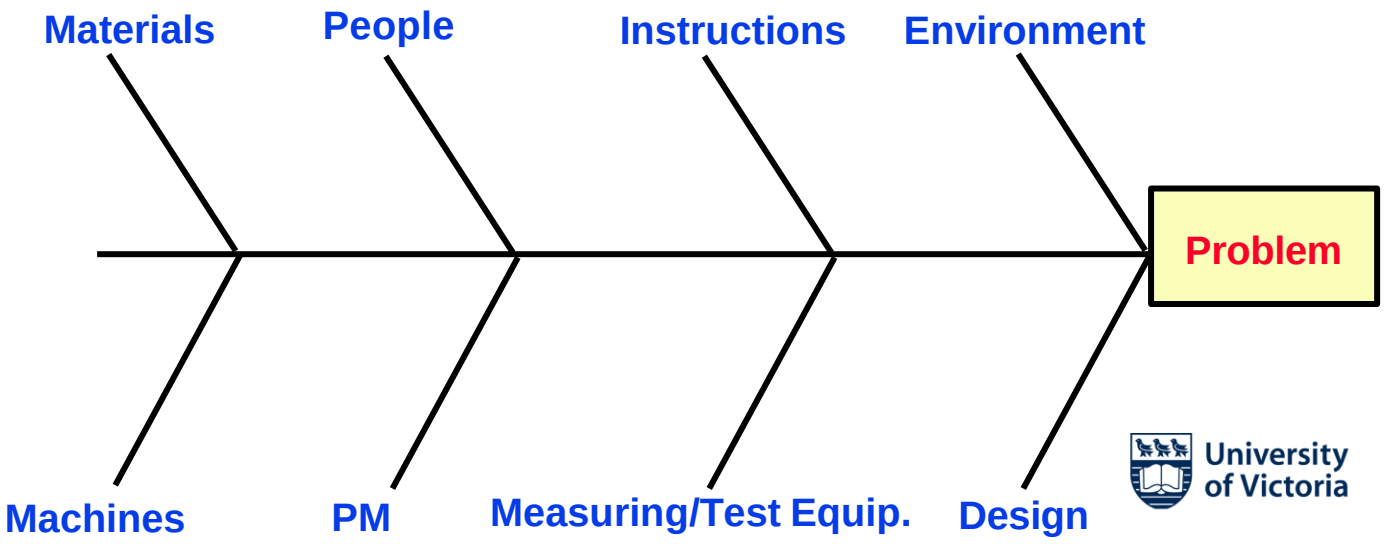
Fishbone Diagram

- Using a fishbone diagram while brainstorming possible *causes* helps you to focus on the various *possibilities*.
  Some useful categories:



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Fishbone Diagram

- ***WHAT IS IT?***
  - The Fishbone Diagram (also known as the Cause-and-Effect Diagram) is a technique for graphically identifying and organizing many possible causes of a problem (effect).

- ***WHY IS IT USEFUL?***
  - Fishbone Diagrams help identify the most likely ROOT CAUSES of a problem. They can also help teach a team to reach a common understanding of the problem. This tool can help focus problem-solving and reduce subjective decision-making.

- ***WHEN IS IT USED?***
  - When the need exists to display and explore many possible causes of a specific problem or condition. This diagram allows the team to analyze cause-and-effect relationships systematically. It can also help with the identification of ROOT CAUSES.

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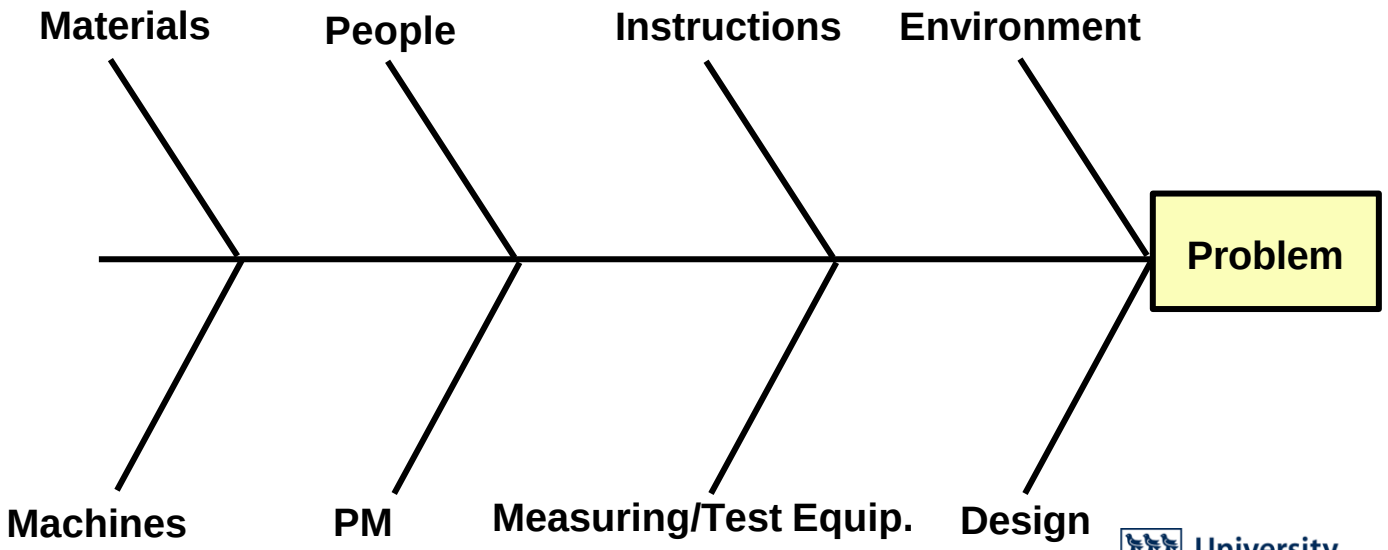
Fishbone Diagram

- ***WHAT DOES IT LOOK LIKE?***
- ***HOW IS IT DONE?***



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Example: The Washing Machine

Problem Description

The machine is 2 weeks old (Serial #2345017).

When doing the fourth load of clothes, I heard a loud noise and the machine stopped!

It wouldn't re-start.

VERIFY THE COMPLAINT

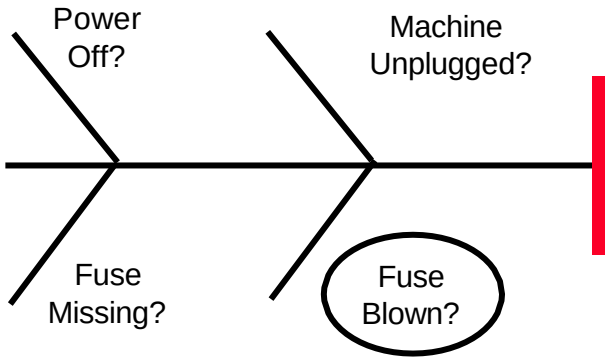
Problem Verification

The service technician checks the washing machine's operation to test the procedure (#8496). The machine does not operate.

Why???

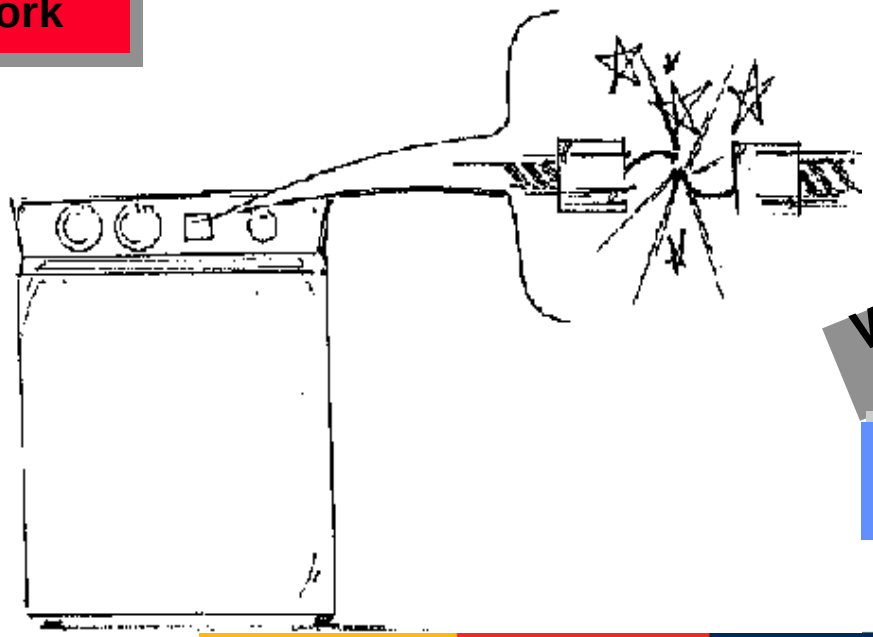
Determine the Cause.

INVESTIGATE WHY?



Machine Doesn't Work

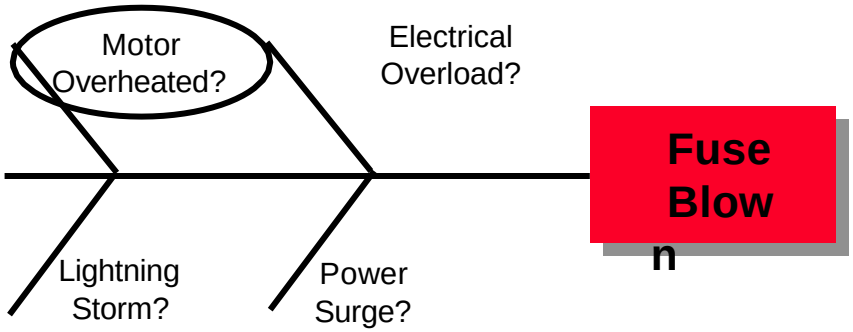
Fuse Blown



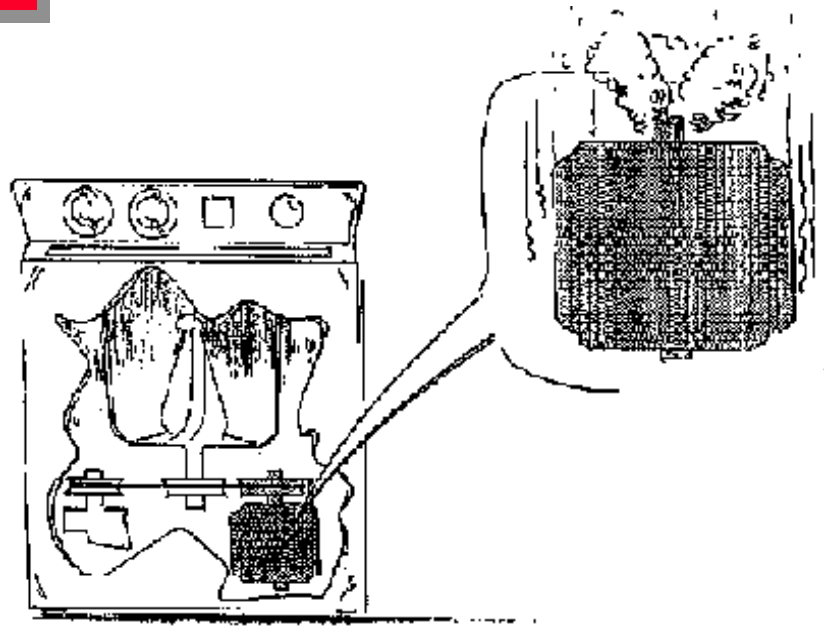
Why?? ?

Determine the Cause.

INVESTIGATE WHY?



Motor Overheated

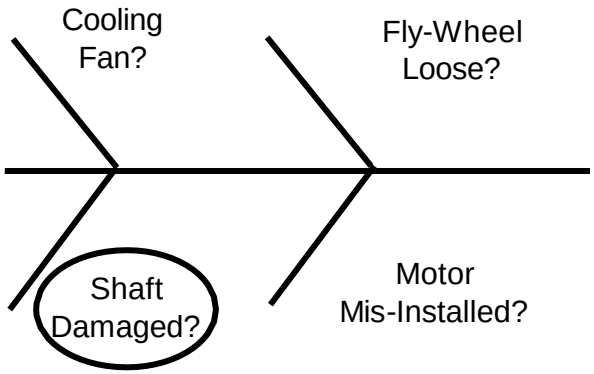


Why??
?

Determine the Cause.

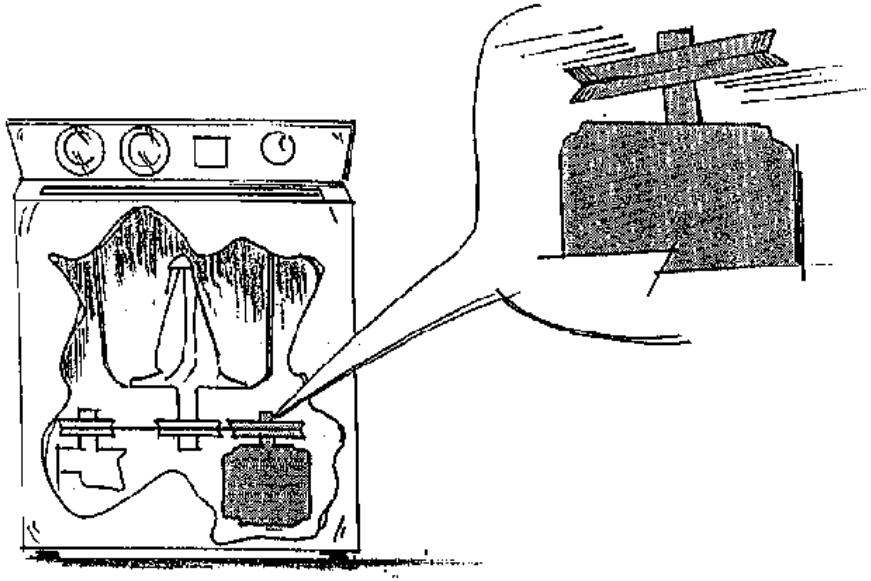
Corrective Action for Specific Deficiency: Replace the Fuse

Example: The Washing Machine



Motor Overheated

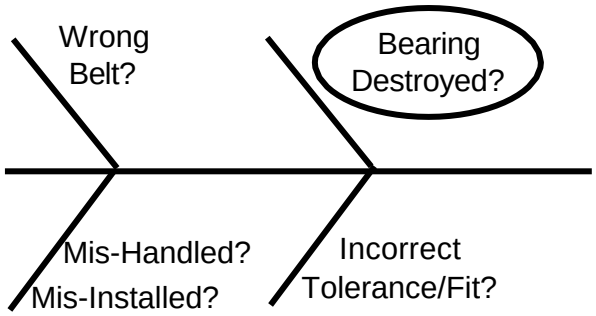
Shaft Damaged



Why??
?

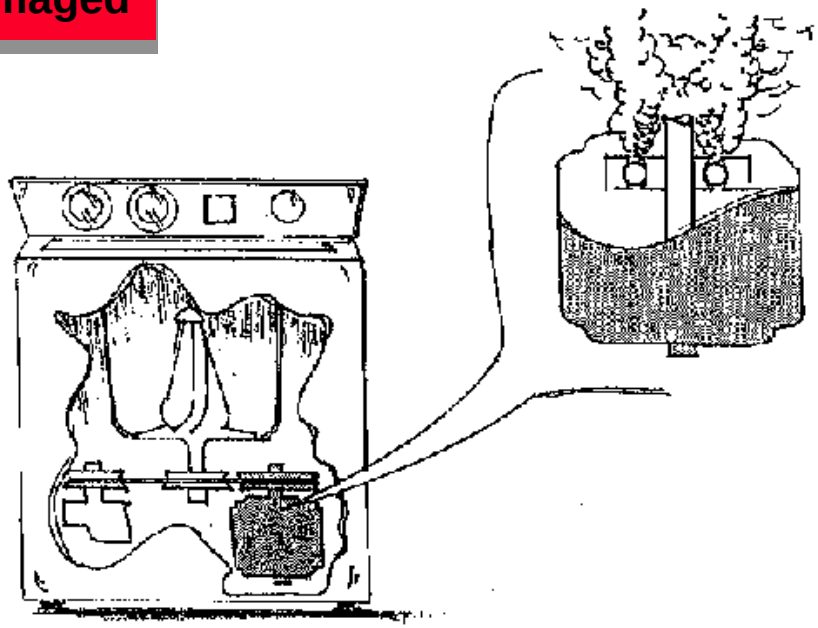
Determine the Cause.

Example: The Washing Machine



Shaft Damaged

Bearing Destroyed



Why?? ?

Determine the Cause.

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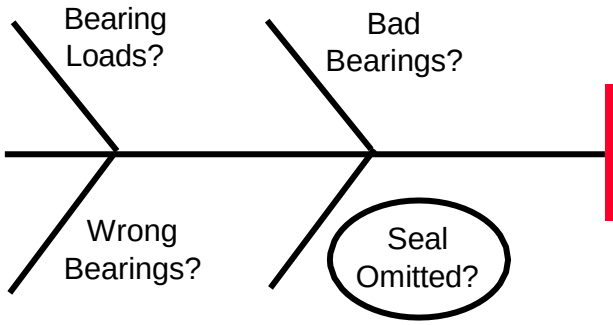
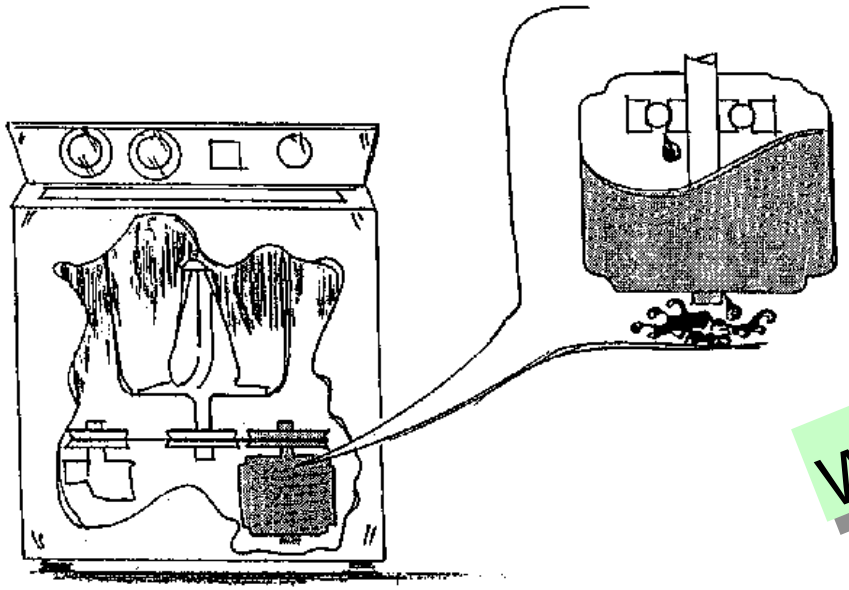
Example: The Washing Machine



Bearing Destroyed

But..... is it?

Cause of Failure: Seal Omitted



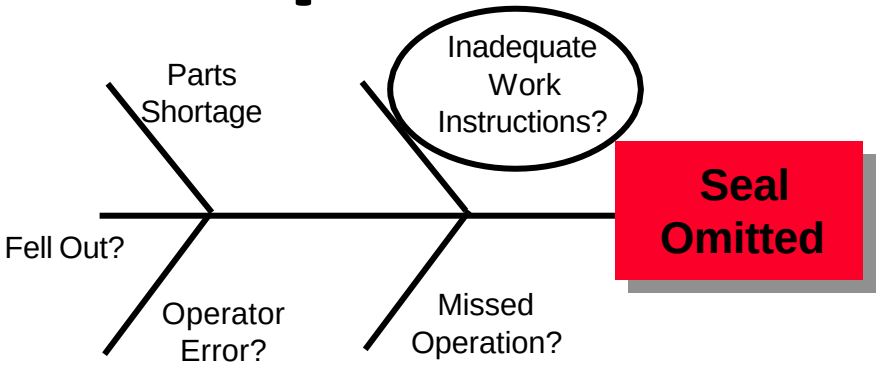
Loss of Lube

Corrective Action for Specific Deficiency: Replace the Motor

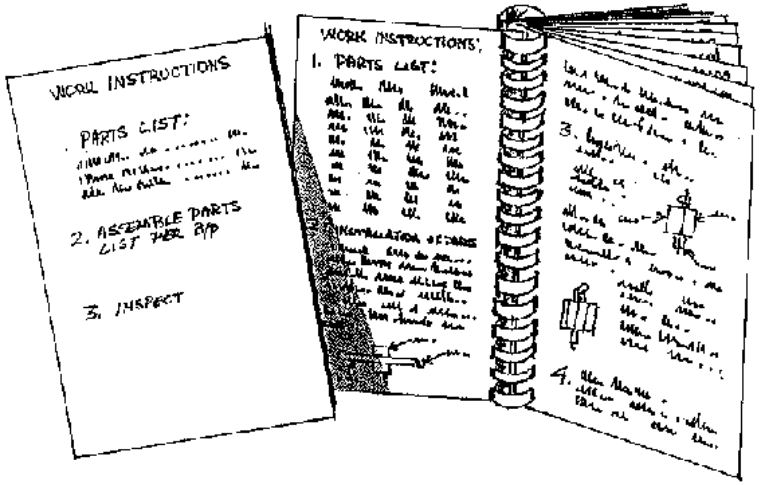
WHY?

Was Seal Omitted??

Example: The Washing Machine



Root Cause - Inadequate Work Instructions



Inadequate **Appropriate**

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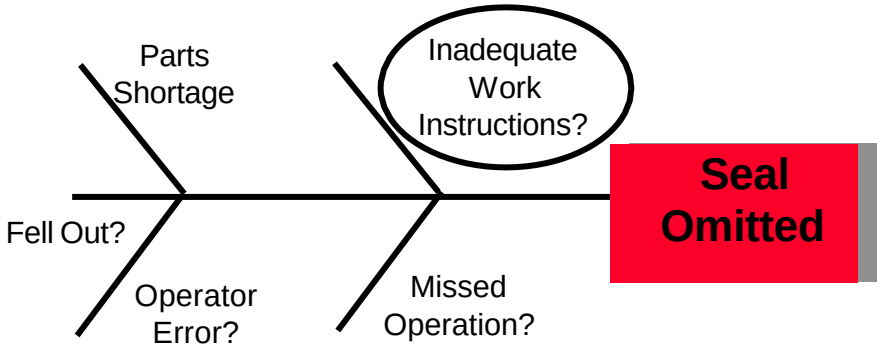
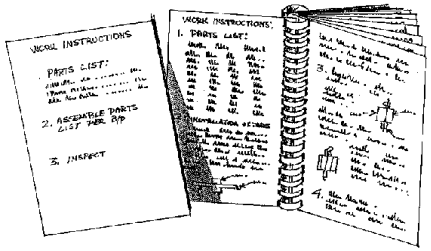
Example: The Washing Machine



Root Cause - Inadequate Work Instructions

Instructions

Inadequate



Appropriate

Can the design be changed to eliminate the need for a seal?

Can the design be changed to make it impossible to omit the seal?

Can a fixture be made to make it impossible to omit the seal?

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Case Study:

Engine Roll-back Investigation

Rob Hardman, Senior Engineer

Following a number of in-service events of roll-back (uncommanded power reduction) on one or more engines WEC engineers undertook a complex root cause investigation. The rollback events occurred during operation at over 27,000ft in particular icing conditions found under the anvil of cumulonimbus cloud formations, which was outside of the natural icing certification envelope.

The root cause was initially thought to be a problem with engine fuel control on maximum thrust limits, but following substantial analysis of data from flight recorders, the root cause was found to be ice accretion on the engine compressor supercharger stage vanes causing the engine core flow to be restricted. The transient nature of icing meant that the evidence was lost when the aircraft was on the ground, so that after the occurrences all maintenance checks showed that engine operation was normal.

The problem was cured by providing additional heating of the supercharging vanes.

Advantages and Disadvantages

- Advantages:
  - Longer lasting solution.
  - Real World Problems
  - Safer Workplace
- Disadvantages:
  - Extra Effort.
  - Extra Time.
  - Extra Money

Activity

- Make a group of 2.
- Think of two problems you faced in Software Engineering.
- Use the root cause analysis.
- Find the cause and the solution to the problem.
- Make sure there are a minimum of 3 fishbone diagrams per problem.
- Submit them to teams.

Goal Question Metric

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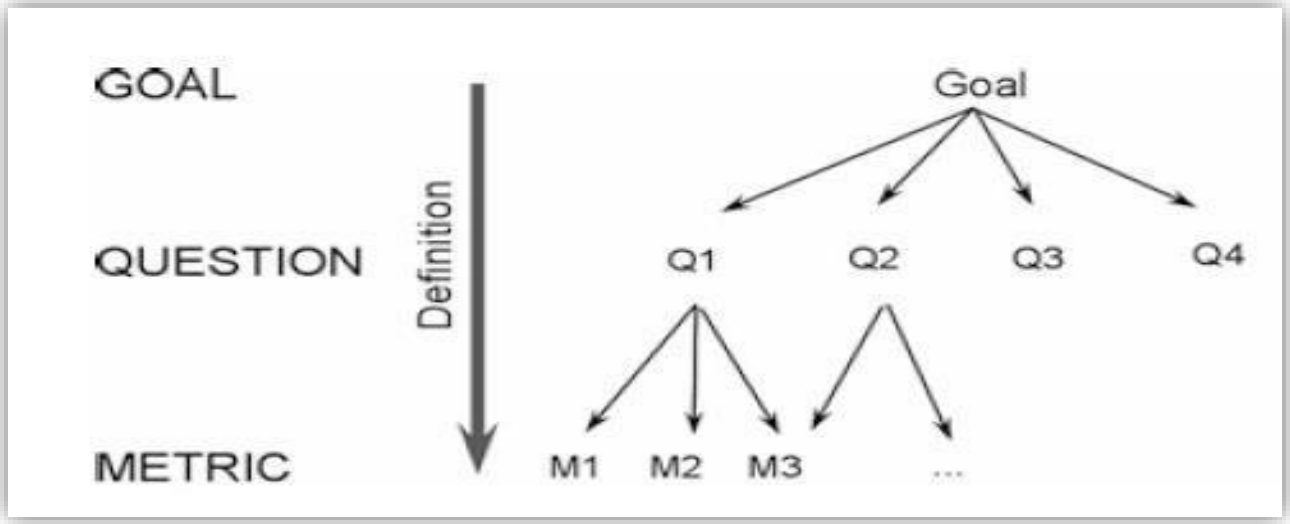
Level of GQM

1. Conceptual level (Define **G**oal)
2. Operational level (Quantify Goal with a **Q**uestion)
3. Quantitative level (A **M**etric to provide answer)



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Example

Goal:

Increase Productivity

Question:

What are the reasons for Bottleneck?

Amount of Code Produced?

Metric

LOC

GOAL

Goal address

- Object – what is being examined
- Purpose – why it is being examined
- Focus – attribute being examined
- Viewpoint - perspective
- Environment - context of scope of examination

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GOAL

Two ways of goal creation

- By making a sentence
- By creating a table

GOAL – Sentence Creation

Analyse {the name of activity or attribute}
for the purpose of {overall goal}
with respect to {the aspect to be considered}
from the viewpoint of {interested people}
in the context of {environment}

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GOAL – Sentence Creation Example

Analyze unit test process to understand the impact of adding additional tests to project K from the viewpoint of project manager.

GOAL – Sentence Creation Example

Analyze unit test process to understand the impact of adding additional tests to project K from the viewpoint of project manager

- Object – what is being examined
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GOAL – Table Creation

TOPIC	RESPONSE
Object – what is being examined	Unit Test Process
Purpose – why it is being examined	Understand
Focus – attribute being examined	Impact of adding additional table
Viewpoint - perspective	Project Manager
Environment - context of scope of examination	Project K

Question

- Moves from conceptual level to operational level
- Clarify Goals
- Involves all stakeholders
- Shared Understanding

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Question - Example

Goal: Analyze unit test process to understand the impact of adding additional tests to project K from the viewpoint of project manager

Question: What is our current test time?

Question: What happened when we added any test last time?

Question: What is the effectiveness of current project?

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Metrics

- Move from operational to quantitate level
- Define which data will be gathered
- Involve people to collect data
- What is available
- How to get it
- Required effort
- Accuracy and Validity

Metrics - Types

Objective – Counts or Events

Absolute – Size of item independent of other things

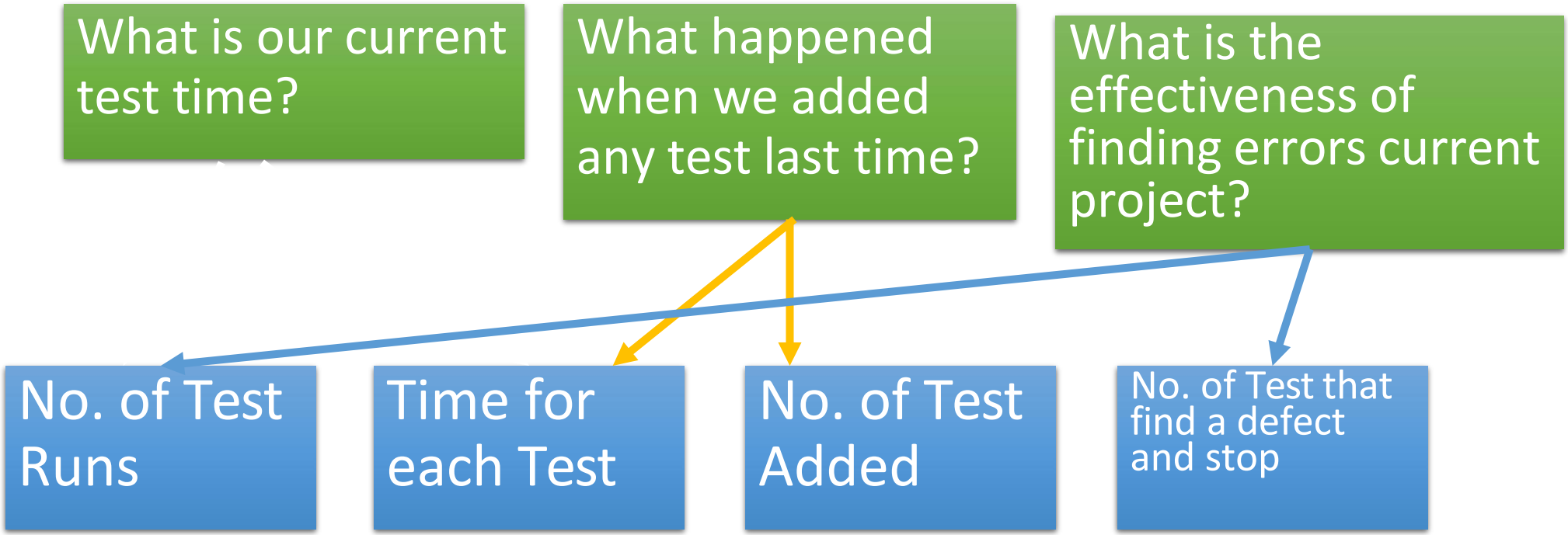
Explicit – Directly obtained

Derived – computed from explicit

Dynamic – time related

Static – independent of time

Metrics - Example



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Case Study

- Analyse the Health Watcher software architecture for the purpose of evaluating architectural components with respect to the ability to make Heath Watcher more extensible from the viewpoint of the software architects performing the work in the context of product enhancement over the next three years.

- Object – what is being examined
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Case Study - Step 2: Questions

Q1: Are architectural components characterized in a manner that modularizes function and related data?

Q2: Is the complexity of each component within bounds that will facilitate modification and extension?

Case Study - Step 3: Metric

Q1: Are architectural components characterized in a manner that modularizes function and related data?

Metric: Coupling and Cohesion

Q2: Is the complexity of each component within bounds that will facilitate modification and extension?

Metric: Component Size and Interface Complexity

Phases

1. Planning Phase
2. Definition Phase
3. Data Collection Phase
4. Interpretation Phase

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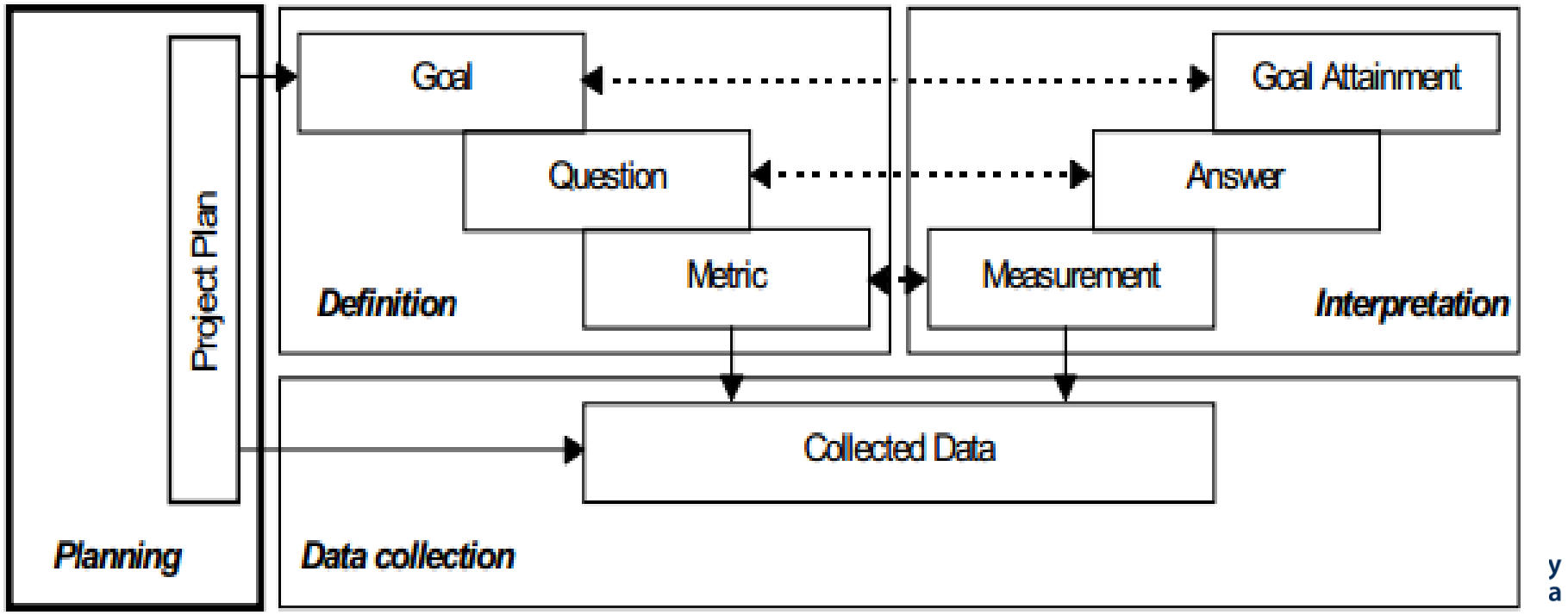
Planning Phases



Planning Phases

- Establish GQM Team
- Select Improvement Area
- Select Application Project and Establish Project Team
- Project Plan

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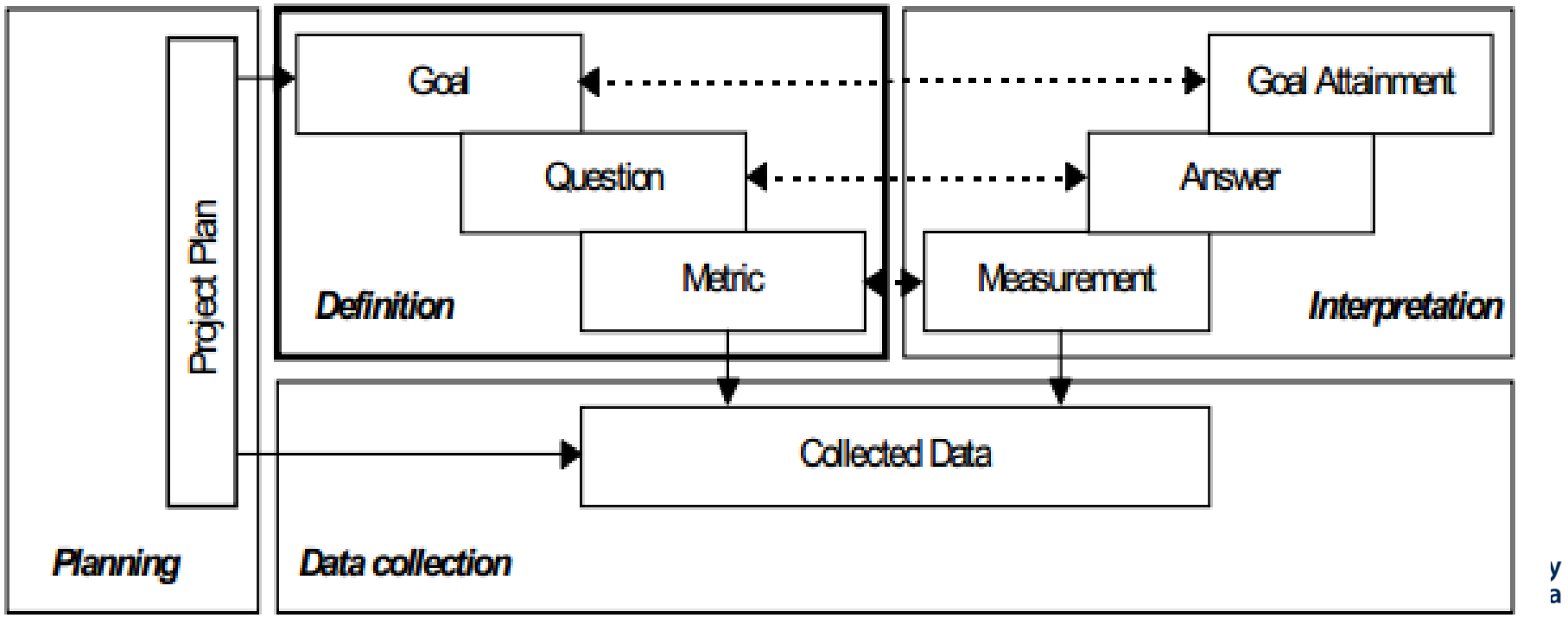
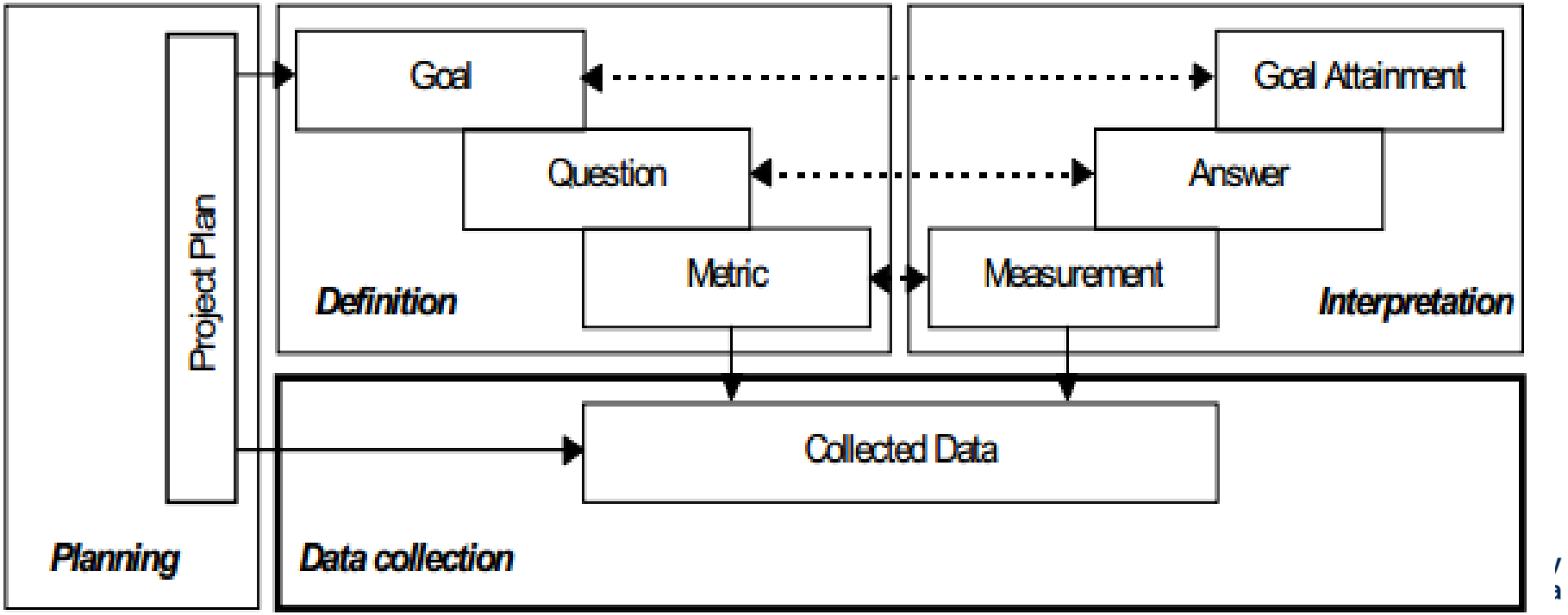
Definition Phases



Definition Phases

- Measurement Goal Definition
- GQM Interviews
- Question and Hypothesis
- Metrics
- GQM Plan
- Measurement Plan
- Analysis Plan

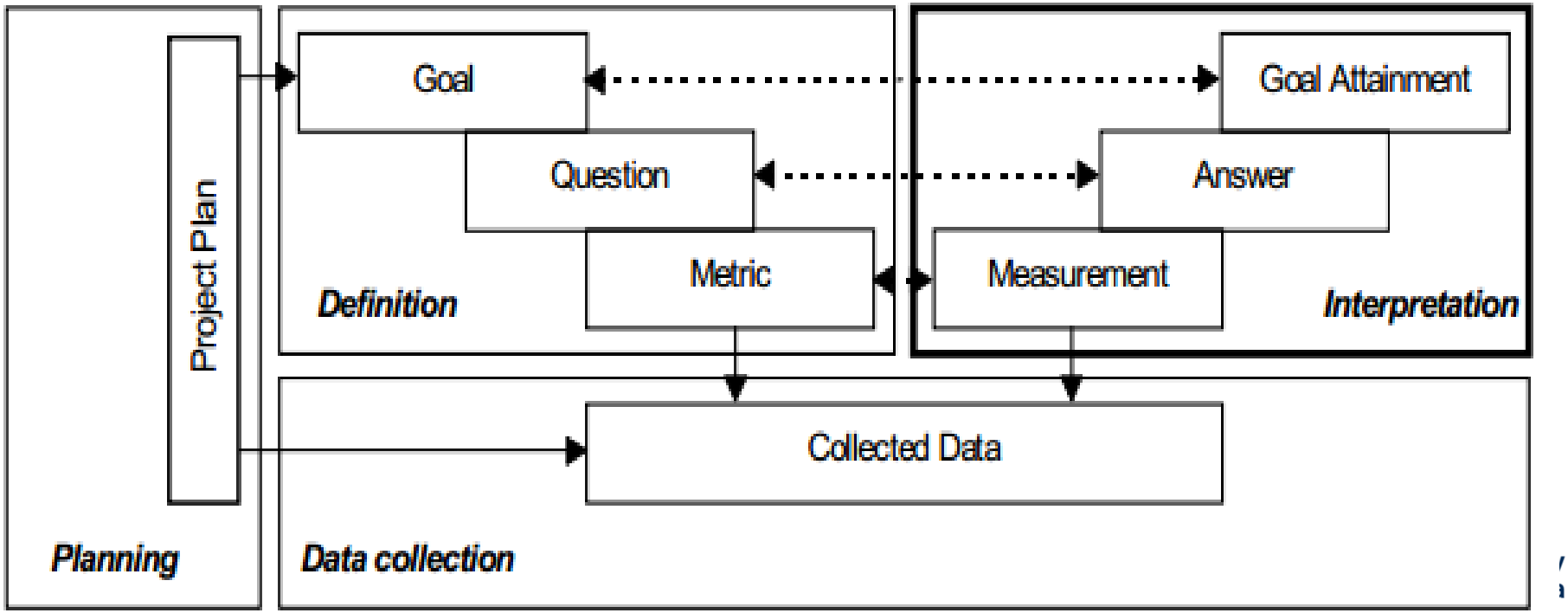
Data Collection Phase



Data Collection Phase

- Metrics Base
- Data Collection Forms
- Store Measured Data
- Analysis and Presentation

Interpretation Phase



Interpretation Phase

- Feedback Session
- Measurement Result
- Cost and Benefit Analysis

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Advantages

- Helps to identify necessary improvement actions in a well informed and appropriate manner
- Achievement of improvement goals
- Financial gains
- Higher capability to perform improvement programs

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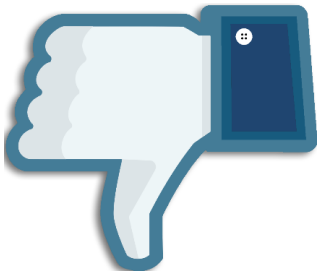
Disadvantages

- It is difficult to know when to stop creating questions, and start defining metrics
- Some questions might be impossible to answer.
- Technological support for GQM is still adequate



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Activity

- Make a group of 2.
- Think of two problems you faced in Software Engineering.
- Use the GQM.
- Make sure there is a table and paragraph notation for Goal in GQM.
- Make sure the Questions and metrics are suitable.
- Submit them to teams.