# UNIT 5 — SIX SIGMA (COMPLETE)

Six Sigma is **not a philosophy like BPR**.
It is a **measurement-driven discipline** focused on **variation control**.

Where **BPR asks**:

> "Is this process fundamentally wrong?"

**Six Sigma asks**:

> "Why does this process behave inconsistently?"

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## 5.1 What is Six Sigma?

### Formal definition

**Six Sigma** is a data-driven methodology aimed at **reducing variation and defects** in a process so that outputs consistently meet customer requirements.

The core idea:

> If variation is reduced, defects automatically reduce.

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### What "Sigma" actually means

- Sigma (σ) = **standard deviation**
- Standard deviation measures **spread / variability** of data
- Smaller σ → more consistency
- Larger σ → more unpredictability

Six Sigma does **not** mean "six steps" or "six tools".
It refers to **how far the process mean is from the specification limit**, measured in standard deviations.

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### Example (simple)

If average tea delivery time is 5 minutes but:

- Sometimes 3 minutes
- Sometimes 9 minutes

→ High variation → unhappy customers
→ Low sigma level

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# 5.2 Variation (MOST IMPORTANT CONCEPT)

## Definition

**Variation** is the natural fluctuation in process output over time.

No real process is perfectly constant.

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## Types of variation

### 1. Common cause variation

- Inherent to the process
- Always present
- Predictable within limits

**Example:**
Minor differences in how fast staff pour tea.

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### 2. Special cause variation

- Unusual, assignable
- Comes from specific events

**Example:**
Water heater malfunction, missing ingredients, staff absence.

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## Why Six Sigma focuses on variation

Customers don't experience averages — they experience **individual outcomes**.

A process with a good average but high variation still fails.

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### Exam question

**Q. Why does Six Sigma focus on reducing variation rather than improving averages?**
Because customers experience individual outputs, not averages. High variation means inconsistent performance, which leads to defects even if the average output appears acceptable.

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## 5.3 Mean, Standard Deviation & Distribution

### Mean (μ)

- Arithmetic average of data
- Shows central tendency

**Example:**
Average tea delivery = 5.68 minutes

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### Standard Deviation (σ)

- Measures spread of data around the mean
- High σ = wide spread
- Low σ = tight clustering

In your activity:

- σ ≈ 1.79 minutes
  This indicates **large variation**

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### Distribution (bell curve intuition)

- Most Six Sigma analysis assumes **normal distribution**
- Mean at center
- Spread defined by σ

If delivery times are widely spread → more late teas.

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### Kurtosis (advanced but mentioned in class)

- Measures **peakedness** of distribution
- High kurtosis → data tightly clustered
- Low kurtosis → flatter curve, more extreme values

Low kurtosis = more outliers = worse consistency

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# 5.4 Defects, Opportunities & Metrics

### Defect

A **defect** occurs when output fails to meet a customer-defined requirement.

**In your activity:**
Tea delivered **after 5 minutes** = defect

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### Opportunity

An **opportunity** is a point where a defect *can* occur.

In tea delivery:

- Each order = 1 opportunity

In teaching example:

- Start of class
- Explanation phase
- Practice phase
- Recall phase

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# 5.5 DPU — Defects Per Unit

### Definition

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\text{DPU} = \frac{\text{Number of Defects}}{\text{Number of Units}}
$$

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### Tea Example

- Total orders = 50
- Late orders = 18

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\text{DPU} = \frac{18}{50} = 0.36
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Meaning:

- On average, **36% of units are defective**

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### Interpretation (business language)

For every 100 customers:

- 36 are unhappy

This is **very poor performance**.

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## 5.6 DPMO — Defects Per Million Opportunities

### Definition

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\text{DPMO} = \frac{\text{Defects}}{\text{Units} \times \text{Opportunities}} \times 1{,}000{,}000
$$

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### Tea Example (1 opportunity per order)

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\text{DPMO} = \frac{18}{50} \times 1,000,000 = 360,000
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### Why DPMO is used

- Standardizes performance
- Allows comparison across industries
- Used to estimate sigma level

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### Interpretation

360,000 defects per million → extremely inconsistent process.

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## 5.7 Sigma Level (Capability Interpretation)

### Concept

Sigma level indicates **how capable a process is** of meeting requirements.

Higher sigma = fewer defects.

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### Approximate mapping (exam-safe)

| Sigma Level | Defects per million |
|---|---|
| 1σ | ~690,000 |
| 2σ | ~308,000 |
| 3σ | ~66,800 |
| 4σ | ~6,210 |
| 5σ | ~233 |
| 6σ | ~3.4 |

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### Tea Example

- DPMO ≈ 360,000
- Sigma ≈ **1.9σ**

This is **below 2 Sigma**, meaning:

- Process is highly unreliable
- Customers frequently experience failure

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### Interpretation (business framing)

The cafeteria cannot meet its service promise consistently. Improvement is mandatory, not optional.

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## 5.8 Linking Numbers to the Process (VERY IMPORTANT)

Six Sigma is **not just math**.

After measurement, you must **go back to the process**.

From your activity, delays came from:

- Water heating (machine)
- Missing materials
- Payment & receipt steps
- Counter congestion
- Role confusion

This aligns with the fishbone categories you identified

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### Key insight

The process is failing **not because of one big problem**, but because **small variations accumulate**.

This cumulative variation pushes delivery beyond 5 minutes.

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# 5.9 Six Sigma vs BPR (EXAM FAVORITE)

### Core difference

| Aspect | Six Sigma | BPR |
|---|---|---|
| Focus | Variation reduction | Process redesign |
| Nature | Incremental | Radical |
| Tools | Statistics, data | Mapping, redesign |
| Question | “Why inconsistent?” | “Why does this exist?” |
| Output | Stable process | New process |

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### How they complement

- BPR fixes **structural problems**
- Six Sigma stabilizes the redesigned process

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### Exam question

**Q. Why is Six Sigma insufficient when a process is fundamentally broken?**
Because Six Sigma improves consistency within an existing process. If the process structure itself is inefficient or unnecessary, reducing variation will not eliminate waste or delays. In such cases, BPR is required before Six Sigma can be effective.

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# 5.10 Explaining Six Sigma in Business Language (CRITICAL)

Examiners expect **translation**, not formulas.

### Bad explanation

“Sigma is low, DPMO is high.”

### Good explanation

“Over one-third of customers receive late service. This inconsistency damages customer trust and increases operational stress. Reducing variation in heating, material availability, and role coordination is essential to meet service promises.”

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# UNIT 5 — EXAM QUESTION BANK

1. Define Six Sigma and explain its core objective.
2. What is variation and why is it dangerous?
3. Explain mean and standard deviation with an example.
4. Define defect and opportunity.
5. Calculate DPU and interpret it.
6. Calculate DPMO and explain what it means.
7. What does a low sigma level indicate?
8. Why must Six Sigma analysis return to the process steps?
9. Compare Six Sigma and BPR.
10. Explain Six Sigma results in business terms.