Learning Statistical Thinking
Through Games

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Introduction
Learning objectives / Key concepts

1. **Existence** of process variation, over time (natural, unnatural)
2. **Impact** on reduced process performance
3. **Consequence** of over-acting to natural variation (‘tweaking’)
4. **Reducing** variation via thoughtful experiments

Overarching Motivation

Variation happens (σ)

\[ σ = ☹ = \]

Averages not enough
Key part of Deming’s message

“If I had to boil my entire message to management down to just one thing, I’d say it all has to do with … reducing variability.”

Workshop outline

<table>
<thead>
<tr>
<th>Time</th>
<th>Key Concept</th>
<th>Learning Exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:15 - 9:00</td>
<td><strong>Existence</strong> of variation</td>
<td>Deming’s red bead game</td>
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<tr>
<td></td>
<td><strong>Consequence</strong> of variation</td>
<td><strong>Lean flow exercise</strong></td>
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<tr>
<td>9:00 - 9:45</td>
<td><strong>Reacting</strong> to variation</td>
<td>Nelson’s funnel exercise</td>
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<tr>
<td>10 - 10:30</td>
<td>Break</td>
<td></td>
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<tr>
<td>10:30-11:30</td>
<td><strong>Reducing</strong> variation</td>
<td>Box’s catapult exercise</td>
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</table>

- 45-60 minutes each
- Exercises + debrief
1. Deming’s Red Bead Game

Deming Healthcare - Now Hiring!

Immediate openings for:

(1) Chief quality officer
(4) Department chiefs
(1) Quality assurance staff
(1) Data analyst

Compensation based on past experience and future performance
Results

- histogram
- run chart

Interpretation
- Stable or special cause variation
- Impact of changes? Did no good or harm?

Anatomy of a Shewart control chart?

- Run chart with statistical limits
- ‘Hypothesis test over time’, simpler to use
Boring but important

Type of variation → type of improvement action

- **Type of variation**
  - Common cause
  - Special cause

- **Improve the standardized process** → **Reduce natural normal variation**

- **Establish one standard work process**
- **Standard work, Remove unnatural variation**

Discussion 1 – ‘What did we learn?’

- **Statistical insights**
- **Management insights**

Where do these ideas apply in your organizations and processes?
2. Nelson’s Funnel Game

Funnel exercise instructions

**Team Instructions**

1. **Baseline data** (rule 1) **10 mins**
   - (A) Drop ball 20 times
   - (B) Measure distance from target, mark spot with dot
   - (C) Plot on run chart & histogram

2. **Test another policy** **(10 mins)**
   - Repeat as above, 20 more times
   - Adjust funnel between ball drops using your assigned rule
   - Discuss results at your table

**Team Roles**

- (A) Dropper (1): _________
- (B) Measurer (1): _________
- (C) Plotters (2): ________, ________
- (D) Supervisor (1): _________
### Process management policies

<table>
<thead>
<tr>
<th>Rule 1 (baseline)</th>
<th>Rule 2</th>
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</thead>
<tbody>
<tr>
<td>• No adjustment. Leave the process alone</td>
<td>• Adjust equal amount in opposite direction from last point</td>
</tr>
<tr>
<td>• Assumes: Content with current performance</td>
<td>• Assumes: Last point = mean performance if left alone</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rule 3</th>
<th>Rule 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Adjust equal amount in opposite direction from target</td>
<td>• Set funnel over last point</td>
</tr>
<tr>
<td>• Assumes: Last point = error from target if left alone</td>
<td>• Last point = new target</td>
</tr>
<tr>
<td></td>
<td>• Assumes: Performance currently = benchmark target</td>
</tr>
</tbody>
</table>

### Results

- scatter plots
- run chart

### Interpretation

- Stable or special cause variation
- Impact of changes? Did no good or harm?
What would Shewhart say?

*Controlling Variation in Healthcare: A Consultation from Walter Shewhart, Berwick, 1991, Medical Care, 29 (12), 1212-25*

Measure prothrombin times and change anticoagulants. Measure oxygen tensions and change respirator settings. Measure fever and change antibiotics. Measure blood pressure and change anti-hypertensive. Measure leukocytes and change chemotherapies. Measure pain and change analgesia. Measure electrolytes and change...

Discussion 2 – ‘What did we learn?’

1. Best policy?

2. Consequences of reacting to natural variation?
   a. On process variation?
   b. On process stability?

3. Relevance to your organizations and processes?
3. Box’s Catapult Exercise

https://www.youtube.com/watch?v=JEU6KwenIk
https://www.youtube.com/watch?v=2_RYKsqR_78

Catapult exercise instructions

1. **Round 1** (baseline, 10 minutes)
   - Settings: 1 band, 30°, 60°
   - 2 tosses each person (2 people)
   - Mark distance to target (RED dots)

2. **Round 2** (learning, 20 minutes)
   - Settings: Follow experiment plan
   - Visually note/agree on distance
   - Record data in table + Excel file

   See instructors when ready

3. **Round 3** (improvement, 10 minutes)
   - Settings: Use Excel answers or experimental insights
   - 12 tosses (6 per person)
   - Mark distance (GREEN dots)

**Team Roles**

- Launchers (2): ________, ________
- Measurer (1): ________
- Recorder (1): ________
- Returners (2): ________, ________

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System view (doomed?)

Uncontrollable factors
- Air flow
- Band elasticity

Controllable factors
- Bands
- Angle
- Release

Responses of interest
- Distance mean and SD

Different use conditions
- Operators, patients (balls), technique

More thoughtful view (experiments)

<table>
<thead>
<tr>
<th>Design Matrix</th>
<th>Analysis Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run</td>
<td>Bands</td>
</tr>
<tr>
<td>X1</td>
<td>X2</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
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<tr>
<td>8</td>
<td>2</td>
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</tbody>
</table>
Discussion 3 – ‘What did we learn?’

1. Best process design?
   - (achieve desired performance with minimal variation)

2. Scientific testing approach:
   a. Differences/similarities to PDSA?
   b. Value(s)?
   c. Challenge(s)?

3. Relevance to your organizations and processes?

Thank you!