Lessons from the Masters
Reflections from 25 years as a Quality Professional

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M and M Consulting, LLC

ASQ Grand Rapids – Section 1001
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Who are the Masters?

The Masters are people, living and passed, who have influenced my life in some significant way.

Sculpture by Franklin Simmons (1903)
Looking for Truth

It was a puzzling thing. The truth knocks on the door and you say, “Go away, I’m looking for the truth,” and so it goes away. Puzzling.

Two Letters Cross Paths

seeker of truth
follow no path
all paths lead where truth is here

e.e. cummings
On the Shoulders of Giants

“If I have seen a little bit further it is by standing on the shoulders of Giants.”

Sir Isaac Newton (1676)
Regarding Plagiarism

“How lucky Adam was. He knew when he said a good thing, nobody had said it before.”

Mark Twain (1867)
My Goal…

If I could leave you with only three thoughts…

1. Refuse to do what’s wrong.
2. You need management support.
3. You can’t own the solution.
A Good Place to Start…

W. Edwards Deming

Refuse to do what’s wrong!
More Advice from Dr. Deming

• No Inspection without Recording

• No Recording without Analysis

• No Analysis without Action
Variation in all Things

Individual Measurements

More Measurements

More Measurements

Natural Process Variation
All Parts are Not the Same

Material

Methods

People

Equipment

Environment
Walter A. Shewhart

Invented tools that give us a rational basis to know whether data is random or is affected by assignable causes.
Natural Variation Inherent in the Process
Causes and Effects

- Equipment
- Environment
- Methods
- Material
- People

Result
Impact of Changes in Behavior

- Normal Distribution
- Change in Location
- Change in Dispersion
- Change in Shape
“A process may be in statistical control; it may not be. In the state of statistical control, the variation to expect in the future is predictable.”

“If the process is not stable, then it is unstable. Its performance is not predictable.”

W. Edwards Deming, Ph.D.
What are Control Charts?

• Control charts are a graphical technique used to analyze data in the order taken.

• They provide a scientific basis for identifying assignable (special) causes of variation.

• Dr. Shewhart taught us to use control charts to identify and eliminate special cause variation.
Some Processes are Predictable

• Absence of Unexpected Changes
• Common Cause Variation
• In Statistical Control
• Process is Stable
Other Processes Lack Stability

- Presence of Unexpected Changes
- Special Causes are Present
- Significant Changes Occur
- Process Out of Control
- Unstable
A Few Words about Outliers

• Outliers are not necessarily good or bad.
• They are simply different.
• They provide the opportunity to learn.
• Send them to the laboratory.
Two Serious Mistakes

*Two mistakes* are frequently made in attempts to improve results, and *both are costly*.

1. To react to an outcome as if it came from a special cause, when it actually came from common cause variation.

2. To treat an outcome as if it came from common causes of variation, when it actually came from a special cause.
X Bar and R Chart

- X Chart
- Range Chart
Increase in Variation

X Chart

Range Chart
Drifting Off Target

\[ X \text{ Chart} \]

\[ \bar{X} \text{ Chart} \]

\[ \text{Range Chart} \]
An Ideal Bowl Experiment

- This is a distribution of the sum of two fair dice.
- Each individual solution is equally likely.
- From this distribution we draw samples of four, with replacement.
**X Bar and R Chart**

Sample Data from Ideal Bowl:  \( n = 4 \)

<table>
<thead>
<tr>
<th></th>
<th>4</th>
<th>2</th>
<th>6</th>
<th>6</th>
<th>2</th>
<th>2</th>
<th>2</th>
<th>5</th>
<th>3</th>
<th>4</th>
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<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>8</td>
<td>3</td>
<td>7</td>
<td>5</td>
<td>6</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>7</td>
<td>9</td>
<td>8</td>
<td>6</td>
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<td>8</td>
<td>6</td>
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<td>6</td>
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<tr>
<td>3</td>
<td>7</td>
<td>10</td>
<td>10</td>
<td>8</td>
<td>9</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>11</td>
<td>9</td>
</tr>
</tbody>
</table>

\[ \bar{X} = 6.2 \]

\[ \text{UCL} = \bar{X} + A_2 \times \bar{R} = 10.0 \]

\[ \bar{R} = 5.2 \]

\[ \text{UCL} = \bar{R} \times D_4 = 11.9 \]

\[ \text{LCL} = \bar{X} - A_2 \times \bar{R} = 2.4 \]
Red Beads and Life

Vacancies: 10

6 Willing Workers
2 Inspectors
1 Inspector General
1 Recorder
### 4 Paddles, 2 Sets of Beads

<table>
<thead>
<tr>
<th>Paddle</th>
<th>Set of Beads</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>11.3</td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>9.6</td>
</tr>
<tr>
<td>3</td>
<td>B</td>
<td>9.2</td>
</tr>
<tr>
<td>4</td>
<td>B</td>
<td>9.4</td>
</tr>
</tbody>
</table>

“No one could project what average will cumulate for any given paddle.”
A Most Important Lesson

Knowledge of the proportion of red beads in the incoming material provides no basis for predicting the proportion red in the output.

The work loads were not drawn by random numbers from the supply.

They were drawn by mechanical sampling.
The Genius of…

Waloddi Weibull

Invented a tool that allows data itself to define the shape of the distribution.
## Failure Data for Five Components

<table>
<thead>
<tr>
<th>Time to Failure (in hours)</th>
<th>Median Rank Values (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>452</td>
<td>13.0</td>
</tr>
<tr>
<td>583</td>
<td>31.5</td>
</tr>
<tr>
<td>820</td>
<td>50.0</td>
</tr>
<tr>
<td>915</td>
<td>68.5</td>
</tr>
<tr>
<td>1202</td>
<td>87.0</td>
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</tbody>
</table>
Data on Weibull Probability Paper

Weibull Plot

<table>
<thead>
<tr>
<th>Occurrence</th>
<th>CDF</th>
</tr>
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<tbody>
<tr>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

Datum (Units)

parameters: Eta, Beta, r^2, n/s

YR1999 M09D21
The Math Looks Complicated…

Weibull Probability Function

\[ f(t) = \frac{\beta(t-\gamma)^{\beta-1}}{\eta^\beta} \exp\left[ -\left( \frac{t-\gamma}{\eta} \right)^\beta \right], t \geq \gamma \]

Failure Function

\[ F(t) = \int_{-\infty}^{t} \frac{\beta(t-\gamma)^{\beta-1}}{\eta^\beta} \exp\left[ -\left( \frac{t-\gamma}{\eta} \right)^\beta \right] dt, t \geq \gamma \]
Data Defines the Distribution’s Shape

Probability Density Function

\( \text{Datum (Units)} \)

\( \text{PDF} \)

\( \text{Weibull} \)

\( \text{eta} = 898.1674; \text{beta} = 2.727331 \)

\( \text{YR1999 M09D21} \)
Statistical Function of Wide Applicability

Weibull Plot

\[ \ln \ln \left( \frac{1}{1 - F(t)} \right) = \beta \ln t - \beta \ln \eta \]

\[ y = mx + b \]

Datum (Units)

<table>
<thead>
<tr>
<th>Eta</th>
<th>Beta</th>
<th>( r^2 )</th>
<th>n/s</th>
<th>YR1999</th>
<th>M09D21</th>
</tr>
</thead>
<tbody>
<tr>
<td>898.2</td>
<td>2.727</td>
<td>0.981</td>
<td>5/0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Reliability Bath Tub Curve

Likelihood of Failure

- $\beta < 1$
- $\beta = 1$
- $\beta > 1$

Time

Run-in  Design Life  Wear Out
Welding Assembly Tooling
12,000 Cycle Dry Run Data

\[ \beta = 3.6 \]

\[ n = 7 \]
Reliability Bath Tub Curve

- Run-in: $\beta < 1$
- Design Life: $\beta = 1$
- Wearout: $\beta > 1$

Failure Rate vs. Time

ASQ
12,000 Cycle Dry Run Data

n = 54

Likelihood of Failure

\( \beta = 0.58 \)

Time in Cycles
12,000 Cycle Dry Run Data

Frequency of Failure

Thousands of Cycles
12,000 Cycle Dry Run Data

Likelihood of Failure

Time in Cycles

$\beta = 0.98$

$n = 37$
Need to be Right
Post Event Analysis

Post Event Data

Time (days)
Correcting the Event Period

The event periods that were the basis of my original analysis were not true.
Post Event Data with Corrected Timing for Event

Time (days)
The Genius of Hans J. Bajaria

Dr. Hans Bajaria synthesized the work of the masters into a practical and effective structure to identify and resolve problems.
Pareto Principle

• Joseph Juran pointed out that the Pareto Principle applies broadly within the field of quality.

• Juran suggested we focus on the significant few instead of the trivial many.

• In a practical sense, the *Pareto Principle* guides us to select one of five problems most likely to provide the greatest return.

• With this approach, we are on the right path.
Walter A. Shewhart advocated that problems of instability be removed before we tackle problems under stable conditions.

- Instability makes it difficult to apply physics, statistics, social science, or any science.

- The *Shewhart Principle* can guide us to select which problem to work on first.

- If the instability is not removed, it can fog our problem solving efforts.
Improvement in Life Expectancy*
(All Americans)

*Source: National Vital Statistics Reports, Vol. 48, No.18

The influence of WE Deming

Spanish 'flu
Hans Bajaria’s Synthesis of the Shewhart and Pareto Principles

<table>
<thead>
<tr>
<th>Number of Runs</th>
<th>120</th>
<th>100</th>
<th>125</th>
<th>100</th>
<th>133</th>
<th>167</th>
<th>100</th>
<th>100</th>
<th>117</th>
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<tbody>
<tr>
<td>Number of Accidents</td>
<td>6</td>
<td>8</td>
<td>5</td>
<td>3</td>
<td>8</td>
<td>15</td>
<td>4</td>
<td>5</td>
<td>7</td>
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<tr>
<td>Hernias</td>
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<td>///</td>
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<td>///</td>
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<tr>
<td>Sprained Ankles</td>
<td>/</td>
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<td>/</td>
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<tr>
<td>Eye Injuries</td>
<td>//</td>
<td>//</td>
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<td>//</td>
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<td>//</td>
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<tr>
<td>Severe Cuts</td>
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<td>Back Injuries</td>
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<tr>
<td>Smoke Inhalation</td>
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<tr>
<td>Broken Bones</td>
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<td>Injury Type 9</td>
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<tr>
<td>Injury Type 10</td>
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<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Proportion of Accidents</td>
<td>.05</td>
<td>.08</td>
<td>.04</td>
<td>.03</td>
<td>.06</td>
<td>.09</td>
<td>.04</td>
<td>.05</td>
<td>.06</td>
</tr>
</tbody>
</table>

Circle indicates a concentration of occurrences.
p Chart for Proportion Defective

UCL = p + 3 \left( (p (1-p) / n)^{1/2} \right) = .056 + .069 = .125

\bar{p} = .056

LCL = 0

Control Limits = \bar{p} \pm 3 \sqrt{\frac{p(1-p)}{n}}
### c Chart for Number of Defects

<table>
<thead>
<tr>
<th>Accidents per Week</th>
<th>6</th>
<th>8</th>
<th>5</th>
<th>3</th>
<th>8</th>
<th>15</th>
<th>4</th>
<th>5</th>
<th>7</th>
</tr>
</thead>
</table>

**Control Limits**

\[
\text{UCL} = \bar{c} + 3 \sqrt{\bar{c}} = 6.8 + 7.8 = 14.6
\]

\[
\text{LCL} = 0
\]

\[
\text{Control Limits} = \bar{c} \pm 3\sqrt{\bar{c}}
\]

---

Accidents per Week: 6, 8, 5, 3, 8, 15, 4, 5, 7
3 Questions from Hans Bajaria

1. Is the process unstable?
   ➢ If so, find and eliminate assignable causes first.

2. Is there too much variation?
   ➢ If so, take action to reduce variation second.

3. Is the process off target?
   ➢ If so, shift the process on target and you’re done.
A problem well defined is half solved.
A poem from Rudyard Kipling

I keep six honest serving men,
(they taught me all I knew)
Their names are
What and Why and When
and How and Where and Who.

from Just So Stories (1902)
A quote from C. Vallee
as presented by Dr. Jay Zhou

Why ask why
when you should ask what?
A quote from Albert Einstein

The formulation of a problem is far more often essential than its solution…
What is the Problem?

Precise problem definition is a challenging task.

1. Where is the problem?
2. What are the problem symptoms?
3. When do the symptoms occur?
4. How extensive is the problem?
Operational Definitions

Three Elements

1. Define the Test
2. Set Criteria
3. Ability to Decide
Operational Definitions

50% Wool  50% Cotton
Four Conceptual Models of Failure

Stress vs. Strength

Damage vs. Endurance

Challenge vs. Response

Tolerance vs. Requirements

Ralph Evans, PhD (1996)
A New Matrix to Identify Causes

Synthesis by Mark A. Morris
By systematically identifying where the problem is not, you will find where the problem is more quickly.
Balancing Reliability

Realities Of Business

Principles of Physics

A thought from Hans Bajaria
You Need Management Support
Lessons Learned

“Why aren’t Lessons Learned learned?”
Morris & Jambor, 2003
Management Support

Deming, Juran, Crosby, Feigenbaum, and others all spoke to the need of management support:

- Vision
- Resources
- Commitment
A quality management system can pay for itself in the following ways:

– Increase marketability.

– Reduce the frequency of failures.

– Prevent failures.
How to provoke responsible action…

• When you’ve used the principles of physics and the realities of business…

• And you know that you’re right…

• And more that that, you know that you know that you’re right…

• How do you get management on board?
Life of an Executive

• Executives tend to have short attention spans.

• Think about it, they may focus on 20 – 40 issues or more in any given hour.

• They’ve been trained to have short attention spans.

• You have 30 seconds to get your point across.

• The solution: *Single Point Lessons*
Single Point Lessons

Key Point:
When it’s important to communicate...

So What:
They drive action

Important Facts:
It’s a structure that works

Examples of Application:
Weibull based vignettes

What You Should Know:
What, why and how
Evaluation of Single Point Lessons

- Singular
- Unexpected
- Concrete
- Credible
- Emotional
- Story Based
- So What?

Credit to: Chip and Dan Heath
Made to Stick (2008)
You Get What You Reward…

Lack of quality planning leads to wonderful opportunities for creative problem solving.

Mark A. Morris
You Can’t Own the Solution
Read and React Course Objectives…

• To find the essence of the author’s thoughts.

• To understand a process of continual improvement.

• To learn and to grow, both personally and professionally.
The Juran Trilogy® Diagram

- Quality Planning
- Quality Control (during operations)

- Cost of Poor Quality
- Sporadic Spike
- Original Zone of Quality Control
- New Zone of Quality Control
- Quality Improvement

Start of Operations

Lessons Learned
“Make no small plans!”
Dr. Joseph M. Juran, 1989, p. 351
How *Read and React* Works…

• Read assigned reading prior to class.

• Question things you don’t understand.

• Speak freely, but don’t dominate the room.

• Participate, have fun, learn and grow.

• This is an interactive learning experience.
The Goal

• In last year’s Read and React course, we studied *The Goal* by Eli Goldratt.

• Jonah was a consultant who helped save a plant, and careers too.

• In the whole story, Jonah never does suggest solutions.

• Instead he asks thought provoking questions.
The Goal

• Goldratt and Fox wrote the goal in the format of a novel.

• They give enough time to allow the readers to find the solution before Alex and his team find it.

• They want the readers to own the solutions, too.
Seven Habits…

Seek first to understand, before you ask to be understood.

Stephen Covey
My Goal…

If I could leave you with only three thoughts…

1. Refuse to do what’s wrong.
2. You need management support.
3. You can’t own the solution.
A Parting Thought…

I am always doing that which I cannot do, in order that I may learn how to do it.

Pablo Picasso
Thank You