

# Quality Engineering Class Notes (experimental)

Jonathan Rosenblatt

October 29, 2015

# Contents

<b>1</b>	<b>Introduction</b>	<b>3</b>
1.1	Terminology and Concepts . . . . .	5
1.1.1	Basic Terminology . . . . .	5
1.1.2	Statistical Terminology . . . . .	6
1.2	Some History . . . . .	7
1.3	Management Aspects of Improving Quality . . . . .	8
<b>2</b>	<b>Descriptive Statistics</b>	<b>10</b>
2.1	Summary Statistics . . . . .	10
2.1.1	Categorical Data . . . . .	10
2.1.2	Continuous Data . . . . .	10
2.2	Visualization . . . . .	11
2.2.1	Categorical Data . . . . .	11
2.2.2	Continuous Data . . . . .	11
<b>3</b>	<b>Statistical Inference</b>	<b>12</b>
<b>4</b>	<b>System Capability Analysis</b>	<b>13</b>
<b>5</b>	<b>Statistical Process Control</b>	<b>14</b>
5.1	Univariate Control Charts . . . . .	14
5.1.1	Control Charts for Variables . . . . .	14
5.1.2	Control Charts for Attributes . . . . .	14
5.2	Multivariate Control Charts . . . . .	14
5.3	Non-Statistical Target Functions . . . . .	14
<b>6</b>	<b>Design of Experiments</b>	<b>15</b>
<b>7</b>	<b>Acceptance Sampling</b>	<b>16</b>
<b>8</b>	<b>Reliability</b>	<b>17</b>



# Chapter 1

## Introduction

Quality Engineering is the study and design of practices aimed improving the “quality” of production. Production is understood in a wide sense, and includes services as well. Quality is understood in many senses. Here are several definitions compiled verbatim from Montgomery [2007] and Wikipedia [2015b]:

1. Montgomery: “Fitness to use”.
2. Montgomery: “The reciprocal of variability” (stability?) .
3. American Society for Quality: A combination of quantitative and qualitative perspectives for which each person has his or her own definition; examples of which include, “Meeting the requirements and expectations in service or product that were committed to” and “Pursuit of optimal solutions contributing to confirmed successes, fulfilling accountabilities. In technical usage, quality can have two meanings: (a) The characteristics of a product or service that bear on its ability to satisfy stated or implied needs. (b) A product or service free of deficiencies.”
4. Subir Chowdhury: “Quality combines people power and process power”.
5. Philip B. Crosby: “Conformance to requirements.”
6. W. Edwards Deming: “The efficient production of the quality that the market expects”.
7. W. Edwards Deming: “Costs go down and productivity goes up as improvement of quality is accomplished by better management of design, engineering, testing and by improvement of processes.”

8. Peter Drucker: “Quality in a product or service is not what the supplier puts in. It is what the customer gets out and is willing to pay for.”
9. Victor A. Elias: “Quality is the ability of performance, in each Theme of Performance, to enact a strategy.”
10. ISO 9000: “Degree to which a set of inherent characteristics fulfills requirements.”
11. Joseph M. Juran: “Fitness for use.”
12. Noriaki Kano and others, present a two-dimensional model of quality: “must-be quality” and “attractive quality.” The former is near to “fitness for use” and the latter is what the customer would love, but has not yet thought about. Supporters characterize this model more succinctly as: “Products and services that meet or exceed customers’ expectations.”
13. Robert Pirsig: “The result of care.”
14. Six Sigma: “Number of defects per million opportunities.”
15. Genichi Taguchi: “Uniformity around a target value.”
16. Genichi Taguchi: “The loss a product imposes on society after it is shipped.”
17. Gerald M. Weinberg: “Value to some person”.
18. Jonathan D. Rosenblatt: “The efficient fulfilment of a promise”.

#### Collecting ideas

1. Quality is not only about production.
2. Quality is the means, not the end.
3. Quality may deal with the **design** or with **conformance** to a given design.

Almost all of the above definitions, may apply to different characteristics, we call *dimensions of quality*. Following Wikipedia [2015a] :

**Performance** Performance refers to a product’s primary operating characteristics. This dimension of quality involves measurable attributes; brands can usually be ranked objectively on individual aspects of performance.

Dimen-  
sions of  
Quality

Features	Features are additional characteristics that enhance the appeal of the product or service to the user.
Reliability	Reliability is the likelihood that a product will not fail within a specific time period. This is a key element for users who need the product to work without fail.
Conformance	Conformance is the precision with which the product or service meets the specified standards.
Durability	Durability measures the length of a product's life. When the product can be repaired, estimating durability is more complicated. The item will be used until it is no longer economical to operate it. This happens when the repair rate and the associated costs increase significantly.
Serviceability	Serviceability is the speed with which the product can be put into service when it breaks down, as well as the competence and the behavior of the service person.
Aesthetics	Aesthetics is the subjective dimension indicating the kind of response a user has to a product. It represents the individual's personal preference.
Perceived Quality	Perceived Quality is the quality attributed to a good or service based on indirect measures.

## 1.1 Terminology and Concepts

### 1.1.1 Basic Terminology

Quality Characteristics	A.k.a. <i>Critical to Quality Characteristics</i> (CTQs). May be physical, sensory, or temporal properties of a process/product. Obviously related to the dimensions of quality.
Quality Engineering	"The set of operational, managerial, and engineering activities that a company uses to ensure that the quality characteristics of a product are at the nominal or required levels and that the variability around these desired levels is minimum." [Montgomery, 2007]
Variables	Continuous measurements of some CTQ.
Attributes	Discrete measurements of some CTQ.
Target Value	The desired level of a particular CTQ. A.k.a. <i>nominal</i> value.

Specifications The set of target values of a process.

USL & LSL Largest and smallest allowable values of a CTQ.

Non-conformity A non conforming product is one that fails to meet the specification.

Defect A non-conformity that is serious enough to affect the use of the product.

### **1.1.2 Statistical Terminology**

Exploratory Statistics

Causal Inference

Predictive Analytics

SPC Statistical Process Control

DOE Design of experiments

Acceptance Sampling

Control Chart

Controllable Inputs

Uncontrollable Inputs

Factorial Design

Off-line quality control

On-line quality control A.k.a. *in-process* procedure.

Engineering control A.k.a. *automatic control*, or *feedback control*.

Ingoing Inspection

Outgoing Inspection

# 1.2 Some History

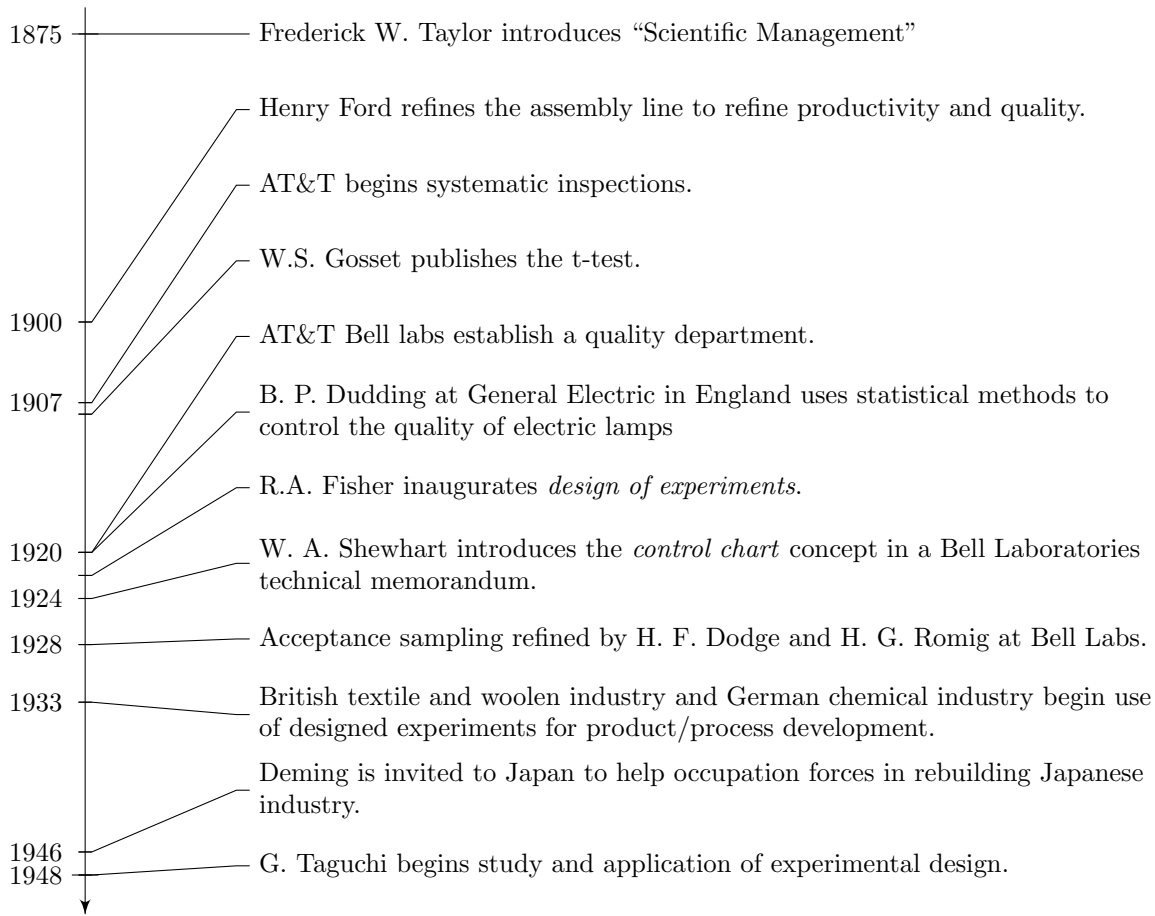


Table 1.1: Adapted from [Montgomery, 2007, Table 1.1].



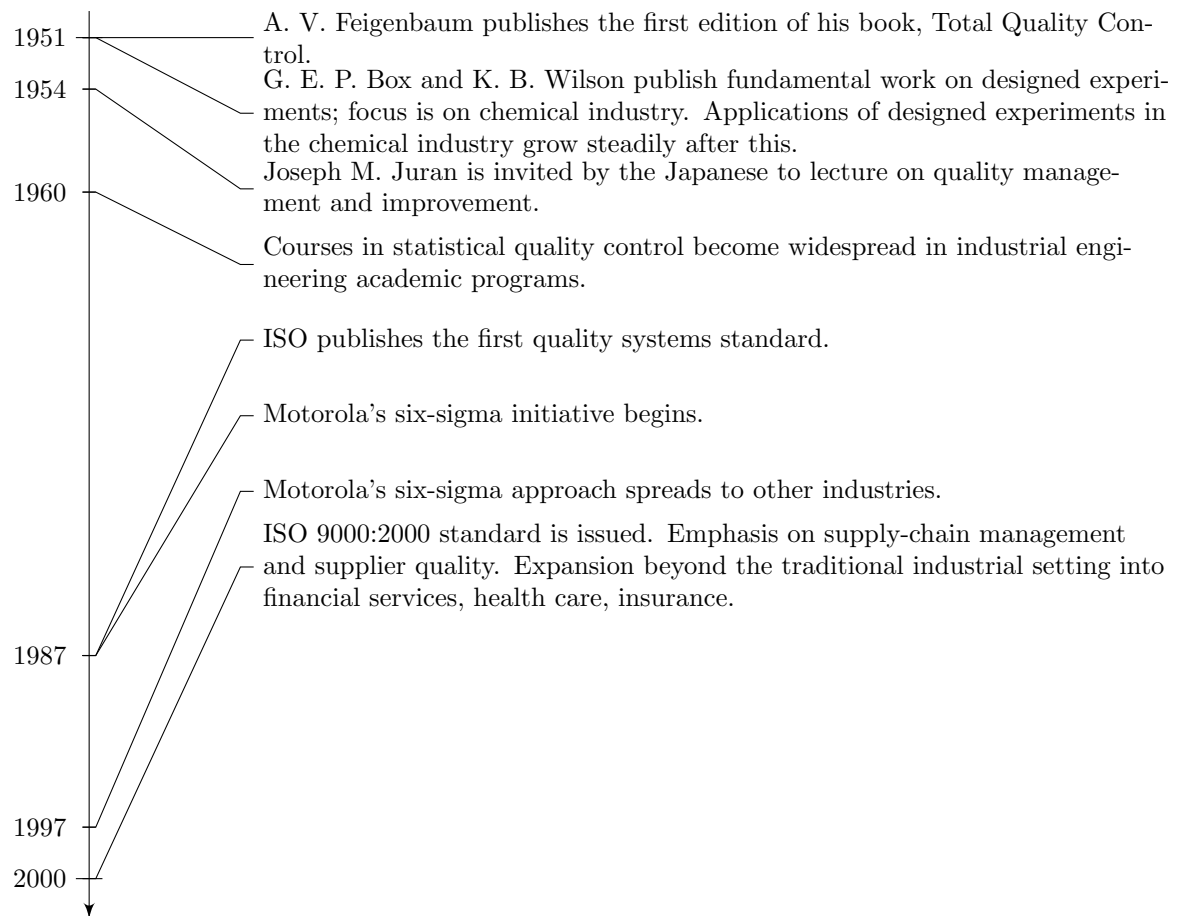


Table 1.2: Adapted from [Montgomery, 2007, Table 1.1].

## 1.3 Management Aspects of Improving Quality

The founding fathers of QC have many dos-and-don'ts for managers. See Montgomery [2007, Sec 1.4] for details. As usual, we collect recurring ideas:

1. The responsibility for quality rests with management.
2. QC is not a one-time project, but an on-going process. It may advance continuously, or incrementally.
3. QC is (or should be) manifested in organizational structure, training, recruitment, incentives, knowledge management, to name a few.

# Chapter 2

## Descriptive Statistics

### 2.1 Summary Statistics

#### 2.1.1 Categorical Data

Univariate

Bivariate

#### 2.1.2 Continuous Data

Univariate

Location measures

Scale measures

Asymmetry measures

**Bivariate**

Correlation

## **2.2 Visualization**

### **2.2.1 Categorical Data**

Univariate

Bivariate

### **2.2.2 Continuous Data**

Univariate

Bivariate

Multivariate Data

## **Chapter 3**

# **Statistical Inference**

## Chapter 4

# System Capability Analysis

# Chapter 5

## Statistical Process Control

### 5.1 Univariate Control Charts

#### 5.1.1 Control Charts for Variables

#### 5.1.2 Control Charts for Attributes

### 5.2 Multivariate Control Charts

### 5.3 Non-Statistical Target Functions

## **Chapter 6**

# **Design of Experiments**



## Chapter 7

# Acceptance Sampling

# Chapter 8

## Reliability

# Bibliography

D. C. Montgomery. *Introduction to statistical quality control*. John Wiley & Sons, 2007.

Wikipedia. *Eight dimensions of quality* — *Wikipedia, The Free Encyclopedia*. 2015a.

Wikipedia. *Quality (business)* — *Wikipedia, The Free Encyclopedia*. 2015b.