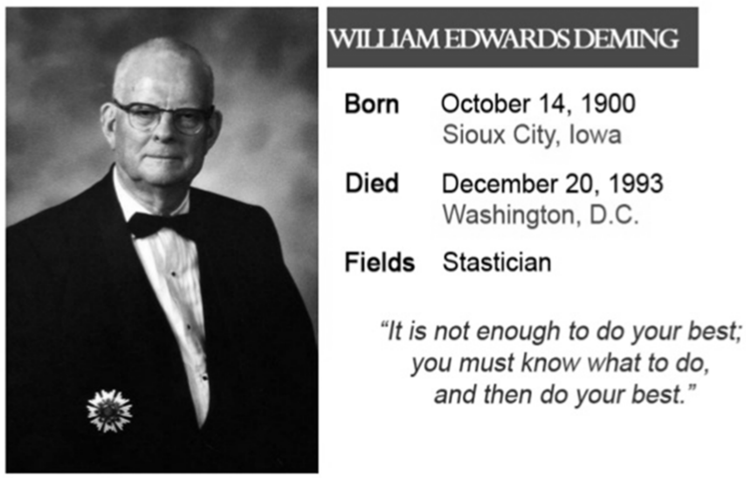
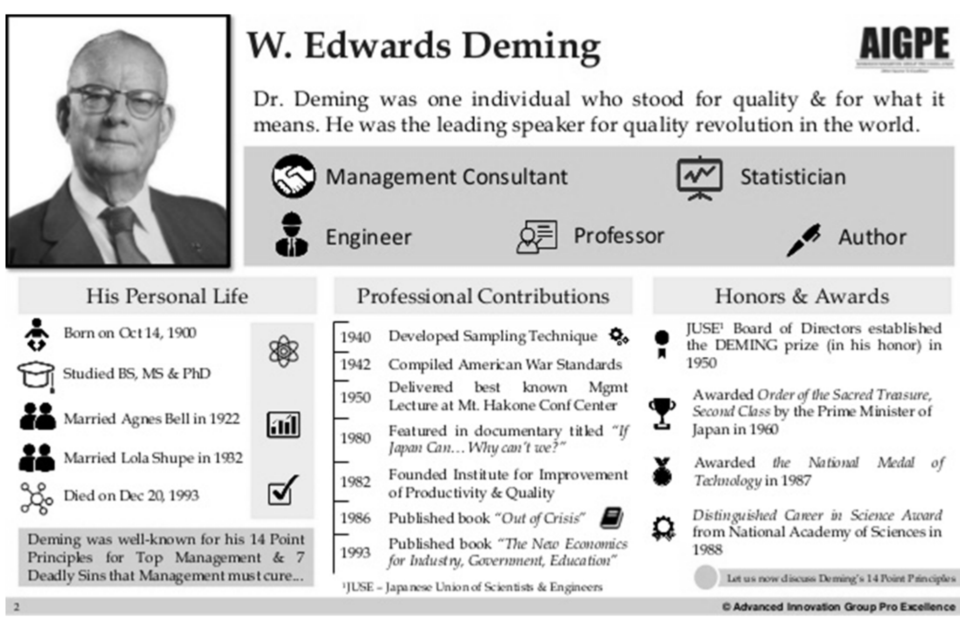
W E Deming



WILLIAM EDWARDS DEMING
Born October 14, 1900
Sioux City, Iowa
Died December 20, 1993
Washington, D.C.
Fields Stastician
"It is not enough to do your best; you must know what to do, and then do your best."



W. Edwards Deming
AIGPE
Dr. Deming was one individual who stood for quality & for what it means. He was the leading speaker for quality revolution in the world.
Management Consultant
Statistician
Engineer
Professor
Author
His Personal Life
Born on Oct 14, 1900
Studied BS, MS & PhD
Married Agnes Bell in 1922
Married Lola Shupe in 1932
Died on Dec 20, 1993
Deming was well-known for his 14 Point Principles for Top Management & 7 Deadly Sins that Management must cure...
Professional Contributions
1940 Developed Sampling Technique
1942 Compiled American War Standards
1950 Delivered best known Mgmt Lecture at Mt. Hakone Conf Center
1980 Featured in documentary titled "If Japan Can… Why can't we?"
1982 Founded Institute for Improvement of Productivity & Quality
1986 Published book "Out of Crisis"
1993 Published book "The New Economics for Industry, Government, Education"
[1]JUSE – Japanese Union of Scientists & Engineers
Honors & Awards
JUSE[1] Board of Directors established the DEMING prize (in his honor) in 1950
Awarded Order of the Sacred Treasure, Second Class by the Prime Minister of Japan in 1960
Awarded the National Medal of Technology in 1987
Distinguished Career in Science Award from National Academy of Sciences in 1988
Let us now discuss Deming's 14 Point Principles
2
© Advanced Innovation Group Pro Excellence

Systems

- Most organizational processes are cross-functional
- Parts of a system must work together
- Every system must have a purpose
- Management must optimize the system as a whole

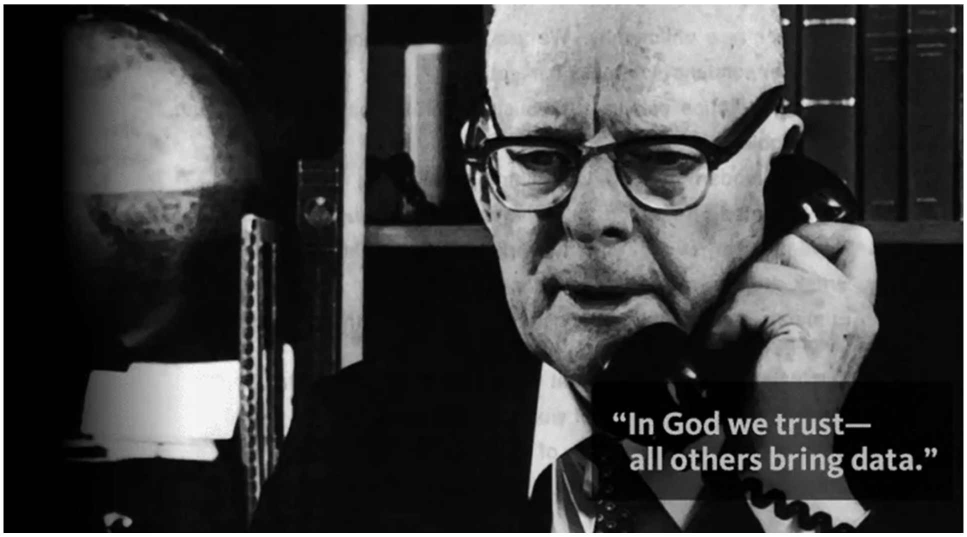
3

Variation

- Many sources of uncontrollable variation exist in any process
- Excessive variation results in product failures, unhappy customers, and unnecessary costs
- Statistical methods can be used to identify and quantify variation to help understand it and lead to improvements

4

W E Deming



Statistics

- The science concerned with "the collection, organization, analysis, interpretation, and presentation of data."
- The use of statistical methods in quality dates back to 1903 at the Bell Telephone system. In the 1920s, Bell Labs thought that statistical tools would have applications in the factory, and began to experiment with statistical sampling, eventually leading to the development of control charts.

6

Probability ~ Statistics

Why do we want to study Probability and Statistics?

Basic Probability Concepts

- An experiment is a process that results in some outcome.
- The outcome of an experiment is a result that we observe
  - E.g.: the number of defective parts in the sample or the length of time until the bulb fails.
- The collection of all possible outcomes of an experiment is called the sample space.
- Probability is the likelihood that an outcome occurs.

9

Categories of Probabilities

- Classical
- Frequency
- Subjective

Probability Properties

- Label the n outcomes in a sample space as O_1, O_2, … O_n, where O_i represents the ith outcome in the sample space.
- The probability associated with any outcome must be between 0 and 1
  - $0 \leq P(O_i) \leq 1$ for each outcome O_i
- The sum of the probabilities over all possible outcomes must be 1.0
  - $P(O_1) + P(O_2) + \ldots + P(O_n) = 1$

11

Events

- An event is a collection of one or more outcomes from a sample space
  - E.g.: finding 2 or fewer defectives in the sample of 10, or having a bulb burn for more than 1000 hours.
- If A is any event, the complement of A, denoted as A^c, consists of all outcomes in the sample space not in A.
- Two events are mutually exclusive if they have no outcomes in common.

12

Calculating Probabilities

- Rule 1: The probability of any event is the sum of the probabilities of the outcomes that compose that event.
- Rule 2: The probability of the complement of any event A is $P(A^c) = 1 - P(A)$.
- Rule 3: If events A and B are mutually exclusive, then $P(A \text{ or } B) = P(A) + P(B)$
- Rule 4: If two events A and B are not mutually exclusive, then $P(A \text{ or } B) = P(A) + P(B) - P(A \text{ and } B)$

13

EXAMPLE 6.1

Using Probability Rules

In testing a new personal computer after assembly, a company discovered that among a sample of 100 units, 3 failed to boot up properly because of a defect in the motherboard, 4 units had a hard drive failure, and 2 units experienced both failures. Let *A* be the event "failure to boot" and *B* be the event "hard drive failure." Then $P(A) = 3/100$ and $P(B) = 4/100$. However, these events are not mutually exclusive because both *A* and *B* occurred together; specifically, $P(A \text{ and } B) = 2/100$. Therefore, the probability that one or the other failure occurred is $P(A \text{ or } B) = P(A) + P(B) - P(A \text{ and } B) = 3/100 + 4/100 - 2/100 = 5/100$.

14

Conditional Probability

- Conditional probability is the probability of occurrence of one event A, given that another event B is known to be true or have already occurred.

$$P(A \mid B) = \frac{P(A \text{ and } B)}{P(B)} \qquad (6.1)$$

- Multiplication rule of probability:

$$P(A \text{ and } B) = P(A \mid B)P(B) = P(B \mid A)P(A) \qquad (6.2)$$

EXAMPLE 6.2

Applying Conditional Probability

Diagnostic tests on products or equipment are often unreliable. For example, if a test indicates a failure, it may be wrong some fraction of the time; similarly, a test that results in a pass may also be wrong. Suppose that if a product that is defective, a diagnostic test indicates that it is defective only 94 percent of the time, and if the product is good, the test incorrectly states that it is defective 2 percent of the time. Assume that the true percentage of product failures is 1 percent. This situation can be illustrated by a tree diagram as shown in Figure 6.1. The probability associated with any branch is conditional on what has happened before. Thus, along the top right branch, 0.94 represents the probability that the test indicates that the product is defective given that the product actually is defective.

Using the multiplication rule, the probability that the product is actually defective *and* the test indicates that it is defective can be found by multiplying the probabilities along the branches of the tree (see Figure 6.2 for the calculation of these joint probabilities). Thus,

$$\begin{aligned}&P(\textit{test indicates defective} \text{ and } \textit{product is defective})\\&= P(\textit{test indicates defective} \mid \textit{product is defective})\, P(\textit{product is defective})\\&= (0.94)(0.01) = 0.0094.\end{aligned}$$

Similarly,

$$\begin{aligned}&P(\textit{test indicates defective} \text{ and } \textit{product is not defective})\\&= P(\textit{test indicates defective} \mid \textit{product is not defective})\, P(\textit{product is not defective})\\&= (0.02)(0.99) = 0.0198.\end{aligned}$$

FIGURE 6.1
Tree Diagram and Probabilities for Diagnostic Testing

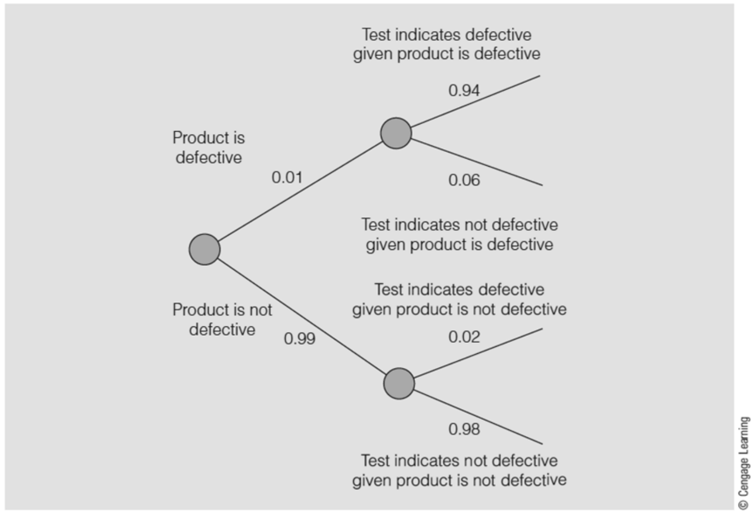
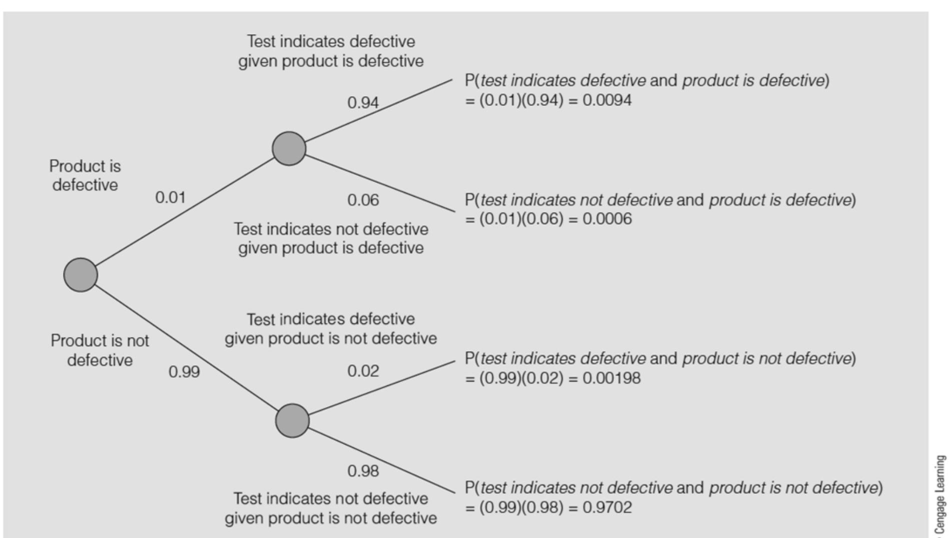


FIGURE 6.2 Calculation of Joint Probabilities



Thus, for any randomly sampled product, the probability that the test will indicate that the product is defective is $0.0094 + 0.0198 = 0.0292$ even though the true probability is 0.01. Similarly, the probability that the test will indicate the product is not defective is $0.0006 + 0.9702 = 0.9708$.

We may also compute the conditional probability that the product is truly defective after knowing the result of the test. For example, using formula (6.1) we have:

$$
\begin{aligned}
&P(\textit{product is defective} \mid \textit{test indicates defective}) \\
&= P(\textit{test indicates defective and product is defective})/P(\textit{test indicates defective}) \\
&= 0.0094/0.0292 = 0.3219.
\end{aligned}
$$

and

$$
\begin{aligned}
&P(\textit{product is not defective} \mid \textit{test indicates defective}) \\
&= P(\textit{test indicates defective and product is not defective})/P(\textit{test indicates defective}) \\
&= 0.0198/0.0292 = 0.6781.
\end{aligned}
$$

You should verify that $P(\textit{product is not defective} \mid \textit{test indicates not defective}) = 0.99938$, and $P(\textit{product is defective} \mid \textit{test indicates not defective}) = 0.00062$.

Independent Events

- Two events A and B are independent if *P(A | B)* = *P(A)*.

EXAMPLE 6.3

Multiplication Rule for Independent Events

Suppose a process consists of two sequential steps, with the probability of a nondefective part produced in the first step (event *A*) being 0.95 and the probability of a nondefective part produced in the second step (event *B*) being 0.98. Clearly the two events are independent, so the probability of producing a nondefective part in the process is $P(A \text{ and } B) = P(A)\,P(B) = (0.95)(0.98) = 0.931$. This means that if we start with 1000 parts, only 931 will be nondefective at the end of the process. In quality control terminology, this is often called the *rolled throughput yield,* which we will formally define in Chapter 8.

Probability Distributions

- A random variable, X, is a numerical description of the outcome of an experiment. Formally, a random variable is a function that assigns a numerical value to every possible outcome in a sample space.
- A probability distribution, f(x), is a characterization of the possible values that a random variable may assume along with the probability of assuming these values.
- The cumulative distribution function, F(x), specifies the probability that the random variable X will assume a value less than or equal to a specified value, x, denoted as P(X ≤ x).

Important Probability Distributions

- Discrete
  - Binomial
  - Poisson
- Continuous
  - Normal
  - Exponential

Binomial Distribution

- The binomial distribution describes the probability of obtaining exactly x "successes" in a sequence of n identical experiments, called trials.

$$
\begin{aligned}
f(x) &= \binom{n}{x} p^x (1-p)^{n-x} \\
&= \frac{n!}{x!(n-x)!} p^x (1-p)^{n-x} \quad x = 0, 1, 2, \ldots, n
\end{aligned}
\tag{6.3}
$$

$$E[X] = \mu = np \tag{6.4}$$

$$\sigma^2 = np(1-p) \tag{6.5}$$

$$\sigma = \sqrt{np(1-p)} \tag{6.6}$$

23

EXAMPLE 6.4

Using the Binomial Distribution

If the probability that a process produces a defective part is 0.2, then the probability distribution that x parts out of a sample of 10 will be defective is described using formula (6.3) with $n = 10$ and $p = 0.2$:

$$f(x) = \begin{cases} \binom{10}{x} (0.2)^x (0.8)^{(10-x)} & \text{for } x = 0, 1, 2, \ldots 10 \\ 0, \textit{otherwise} \end{cases}$$

Thus, to find the probability that 3 parts among a sample of 10 will be defective, we compute

$$
\begin{aligned}
f(3) &= \binom{10}{3} (0.2)^3 (0.8)^{10-3} = \frac{10!}{3!7!}(0.008)(0.2097152) \\
&= 120(0.008)(0.2097152) = 0.20133
\end{aligned}
$$

24