

## Software Engineering Experimentation

### Ways to Acquire Knowledge

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## Measuring and Science

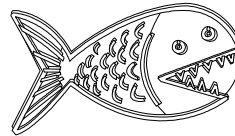
**When you can measure what you are speaking about, and express it in numbers, you know something about it.**

– Lord Kelvin, 1889

<http://zapatopi.net/kelvin/quotes.html>

## What is a Scientific Test

- The Budweiser Test
  - Drinkers of another brand were given a “live” challenge
    - which beer is better?
  - Results?
    - 50% chose Budweiser!!!
  - Conclusion:
    - Budweiser is better !!!
- Hmmm ... something's fishy ...



## Scientific Test

- Test: Live TV, lots of noise and confusion.
- Subjects wouldn't be able to tell any difference, so we should expect each beer to be chosen ...
- Half the time!
- There are three kinds of lies ...

## Lies, Damn Lies, and Statistics



Berkshire Eagle, October 7, 1993 page A3 (An AP story from Boston)

### Guns in the home found to increase risk of death

- People who keep guns at home nearly triple their chances of being murdered, usually by friends or relatives, but fail to protect themselves from intruders ...
- The article goes on to describe how the study was conducted, summarizes aspects of the population cross sections and conclusions of the study, and concludes with a refutation by a representative of the NRA:
- However, Paul Blackman, research coordinator at the National Rifle Association, criticized the study ...
  - "These people were highly susceptible to homicide," he said.
  - "We know that because they were killed."

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## Eating and Talking



- The Japanese eat very little fat and suffer fewer heart attacks than the British or Americans
- On the other hand, the French eat a lot of fat and also suffer fewer heart attacks than the British or Americans

**Conclusion: Eat what you like. It's speaking English that kills you.**

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## Women and Foreigners

- Analysis of results of a final exam

	Female	Male
Did not finish	12	7
Finished early	6 (33%)	9 (55%)
	18	16

- Conclusion: Male students finish earlier than female

- But ... something's fishy ...

	Foreign	US
Did not finish	11	8
Finished early	2 (11%)	13 (65%)
	13	21

- Conclusion: US born students finish earlier ...

	Foreign	US
F	8 (45%)	10
M	5 (33%)	11



**A higher percentage of women are foreign**

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## Be Careful Who You Fool

**The first principle is that you must not fool yourself – and you are the easiest person to fool.**

– Richard Feynman (Nobel Physics, 1965)

## Six Ways to Acquire Knowledge

1. Tenacity
2. Intuition
3. Authority
4. Rationalism
5. Empiricism
6. Science

## 1. Tenacity

### Knowledge based on superstition or habit

- Examples:
  - “Good research can only be done by those in their 20s”
  - “OO design has too many subroutine calls and is too inefficient”
- Exposure: The more we see something, the more we like it
- Tenacity has
  - No guarantee of accuracy
  - No mechanism for error correction

## 2. Intuition

**Guesswork: An approach that is not based on reasoning or inference**

- No mechanism to separate accurate from inaccurate knowledge
- Can be valuable as a way to suggest hypotheses
- Can be very misleading

## 3. Authority

**Accepted because it comes from a respected source**

- Examples:
  - Religion
  - Totalitarian government
  - Rules our parents taught us
- No way to validate or question the knowledge
- Not the same as asking an expert – we can accept, reject, or challenge an expert
  - Teachers are experts, not authorities

## 4. Rationalism (Reasoning)

### Acquisition of knowledge through reasoning

- Logical deduction
- Assume knowledge is correct if the correct reasoning process is used
- Middle ages relied almost exclusively on rationalism
- Important for theory and pure math
  - Theoretical physics ... experimental physics
- Easy to reach incorrect conclusions
- Use rationalism to arrive at a hypothesis, then test with the scientific method

## 5. Empiricism

### Acquiring knowledge through experience

- “I have experienced it, therefore it is true”
- Experience is subjective and hard to control
- “I wrote 3 programs without designing and they worked – designs are worthless!”
  - Who wrote them?
  - What programs?
  - Was the the design present but just unwritten?
- Much of computer “science” is just empiricism

## 6. Science

**Testing ideas empirically according to a specific testing procedure that is open to public inspection**

- Based on reality
- Devoid of personal beliefs, perceptions, biases, attitudes, emotions
- Based on objectively observed evidence

## Scientific Method

1. Identify a problem & form hypothesis
  - Problem must be clear, precise, measurable
  - Hypothesis must be testable and refutable
2. Design the experiment
  - The most creative part
3. Conduct the experiment
4. Perform hypothesis testing
  - Analyze data with appropriate statistics
5. Dissemination
  - Write legible papers and teach classes



## Excellent Scientists

- Lots of decent scientists who are excellent researchers and lousy disseminators
- Lots of decent scientists who are okay researchers and excellent disseminators

**Excellent scientists do both!**

## From a T-Shirt

### The Scientific Method

- It is a capital mistake to theorize before one has data. Insensibly one begins to twist facts to suit theories, instead of theories to suit facts.
  - Sir Arthur Conan Doyle
- It is also a good rule not to put too much confidence in experimental results until they have been confirmed by theory.
  - Sir Arthur Eddington
- First get your facts; then you can distort them at your leisure.
  - Mark Twain

## Be Problem Solvers



- As Computer Science / Software Engineering majors, you have proven yourselves to be good problem solvers
- Much of life is about solving problems
- Education is not about skills, it is about knowledge
- Use your education knowledge to help you:
  - Think rationally
  - Question authority
  - Solve all of life's problems

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