

The Scientific Method

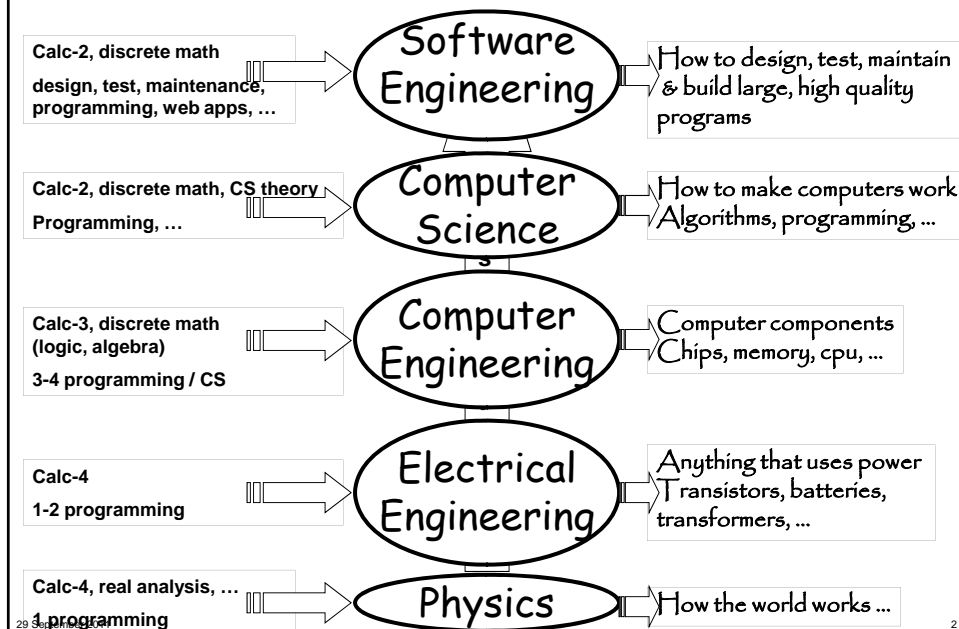
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SWE 432

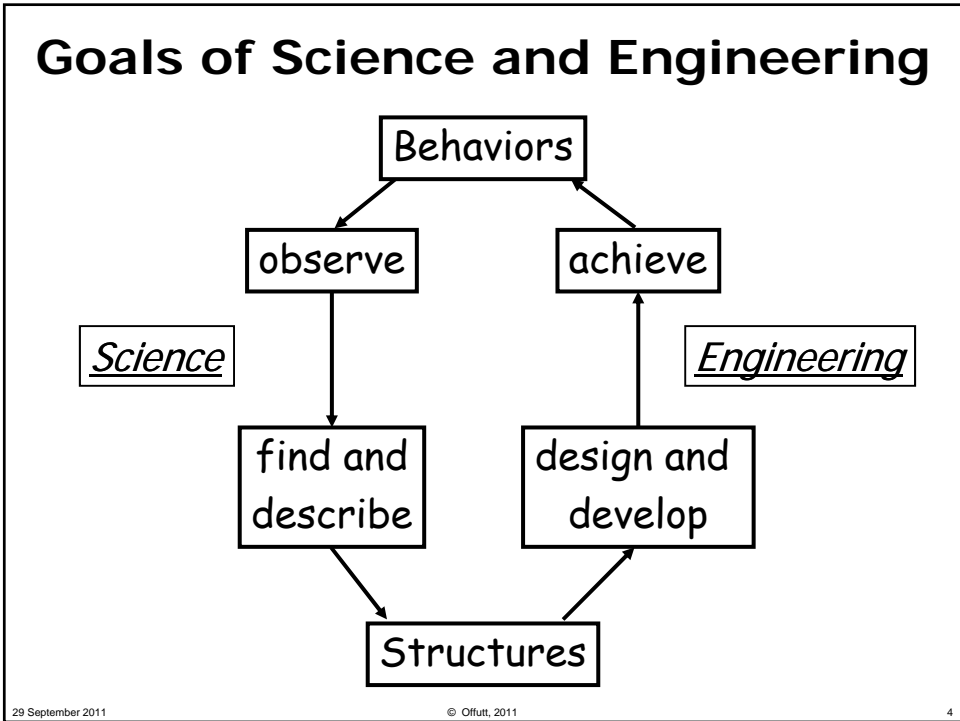
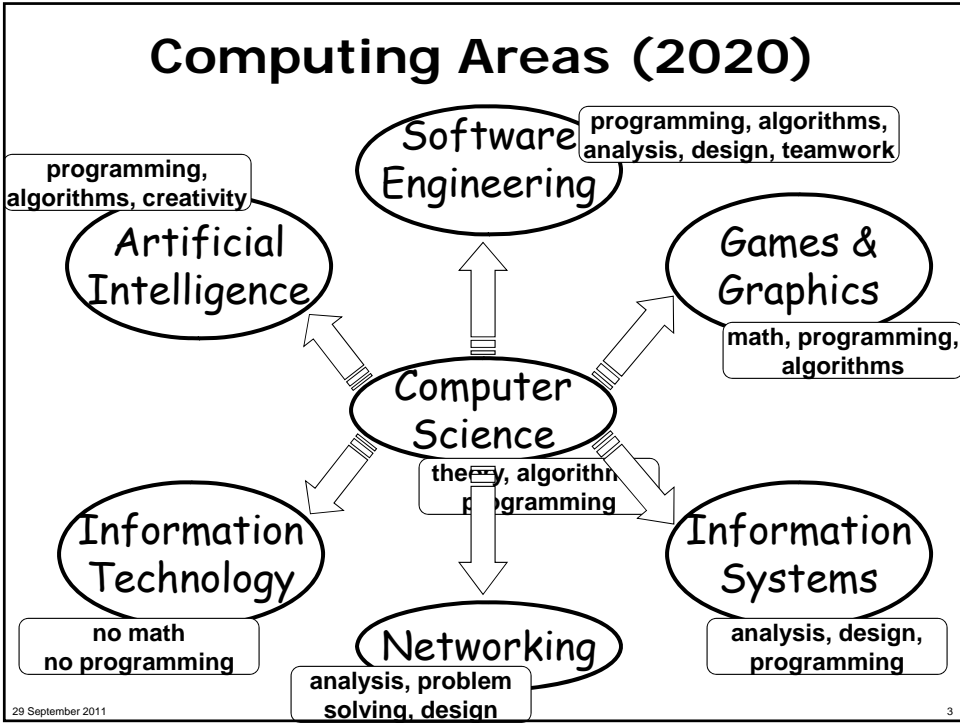
**Design and Implementation of
Software for the Web**

Comparing Computing Fields



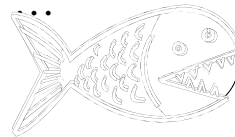
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What is a Scientific Test

- The Budweiser Test
 - In a bar, people who liked another brand best were given a “live” challenge – which beer is better?
 - Results?
 - 50% chose Budweiser over their favorite beer!!!
 - Conclusion:
 - Budweiser is better !!!
- Hmmm ... something's fishy ...



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Scientific Test

- Test: Live TV, lots of noise and confusion, subjects had already been drinking ...
- 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

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Eating and Talking

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

**Conclusion : Eat what you like.
Speaking English kills you.**

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*)

Noone in this world is easier to deceive and mislead than someone who thinks that he is smarter than you are.

– David Eddings (*Author*)

We all think we're smarter than we are.

– Jeff Offutt (*prof*)

Six Ways to Acquire Knowledge

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



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1. Tenacity

Knowledge based on superstition or habit

- **Examples:**
 - “Good research can only be done by scientists under 30”
 - “Gay people are bad”
 - “OO design has too many subroutine calls and is too inefficient”
- **Exposure:** The more we see something, the more we believe
- **Tenacity** has
 - No guarantee of accuracy
 - No mechanism for error correction
- Knowledge from tenacity is prejudism



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2. Intuition

Guessing: An approach that is not based on reasoning or inference

- Examples:
 - I think he is a nice person
 - It's probably going to rain today
- We do not really understand why we believe it
- No way to separate accurate from inaccurate knowledge
- Can be used to form hypotheses
- Can be very misleading



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3. Authority

Accepted because it comes from a person with authority

- Examples:
 - Rules our parents taught us
 - Religion
 - Totalitarian government
- No evidence given
- No way to validate or question the knowledge
- Not the same as asking an expert – we can accept, reject, or challenge an expert
 - In grade school, teachers are treated as authorities
 - In college, teachers are experts



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4. Rationalism (Reasoning)

Acquiring 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
 - A mathematical proof is rationalism at its best
 - Theoretical physics ... experimental physics
- Easy to reach incorrect conclusions
 - False premises
 - Mistakes in the reasoning or steps skipped
- Use rationalism to arrive at a hypothesis, then test with the scientific method



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5. Empiricism

Acquiring knowledge through experience

- “I have experienced it, therefore it is true”
- Experience is subjective and hard to control
- “I drove home 3 times after drinking without having an accident, so drunk driving is safe”
 - Were you lucky ?
 - How severe are the consequences of an accident ?
- Much of computer “science” is just empiricism



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6. Science

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

- Based on reality
 - Scientists have to look at the fire, not the shadows
- Separate personal beliefs, perceptions, biases, attitudes, emotions
 - We all have biases; science helps us ignore them
- Based on objectively observed evidence
- Hypotheses, independent variables, dependent variables, controls, statistical validation



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Experimental Variables

- Independent variable : Changed by the researcher to determine if it causes a change in the dependent variable
- Dependent variable : Measured by the researcher to determine if it is affected by the IV

Does intelligence make people better drivers ?

- Confounding variables : Other explanations for the results
 - Driving skills of parents, amount of time driving, emotional problems
- Measured variable : If the dependent variable cannot be directly measured, we measure a related variable to approximate
 - Accidents, tickets, attempts to pass the driving test, drivers Ed grade

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How Valid are the Results ?

- External validity : Whether the results in the study will be the same in other situations
 - Were the subjects “representative” ?
 - I only looked at CS majors... special kids
- Internal validity : Whether the change in the Dependent Variable was controlled by the Independent Variables
 - Did we miss a confounding variable ?

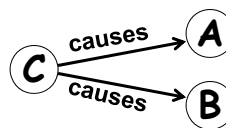
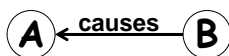
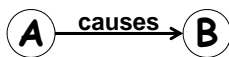
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Correlation and Causality

- Correlated : Two things always happen at the same time
 - Brake lights and car slowing down
- Causality : Understanding what causes something to happen
 - Brake light causes the car to slow down ?
- If **A** and **B** are correlated:



Pressing brake activates brake light AND slows car down ...



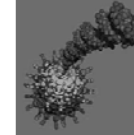
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Confusing Correlation and Causality

- In “*the old days*”, we believed that being cold caused us to get colds



- Colds are caused by viruses, not temperature
- Viruses breed in warm, damp, low-oxygen, carbon-dioxide rich environments
- In cold weather, we close our windows and turn up the heat ... creating ...
- Virginia gets a secondary cold season in *July-August* ... when the weather turns *hot* and *humid* ...

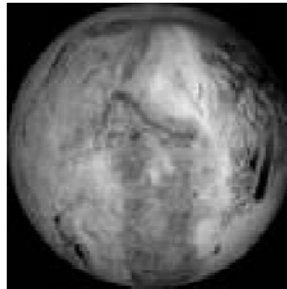
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Cognitive Dissonance

- We feel uncomfortable when new data contradicts our beliefs
- Revising our mental model to accommodate new data is hard
 - We resist new ideas
 - I miss Pluto !!!



Scientists must be open-minded

**Allow facts to replace knowledge gained by
tenacity, intuition and authority**

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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
- Utilize your education knowledge to help you:
 - Think rationally
 - Question authority
 - Solve all of life's problems



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UI Evaluations

- **The purpose of the UI evaluations is to train you to evaluate :**
 - **Objectively**
 - **Rationally**
 - **Quantitatively**
 - **Empirically**

In short, to be scientists

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