

RYERSON UNIVERSITY

Research Methods

Introduction to Research

Department of Computer Science

**Faculty of Engineering,
Architecture and Science**

What is research?

- *Research is a human activity based on intellectual investigation and aimed at discovering, interpreting, and revising human knowledge on different aspects of the world. Research can use the scientific method, but need not do so.*

– *Wikipedia*

Normally based on the “Scientific Method”

What is Science

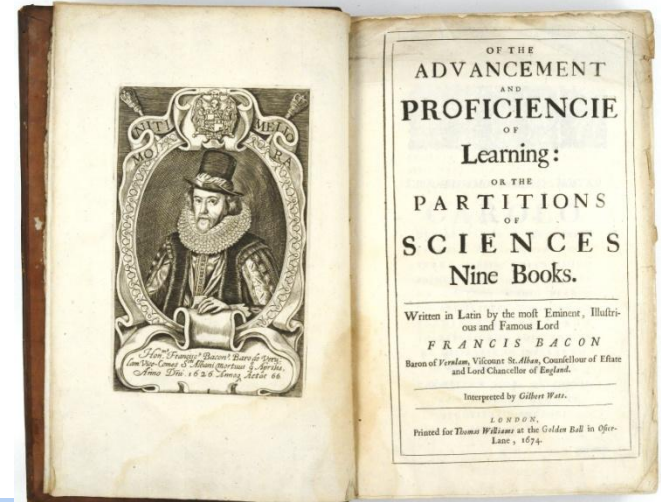
- ¹From Latin
 - scientia, "knowledge"
- Builds and organizes knowledge in the form of testable explanations and predictions about the world we live in.
- Occasionally and interesting and dangerous idea.

1 Wikipedia



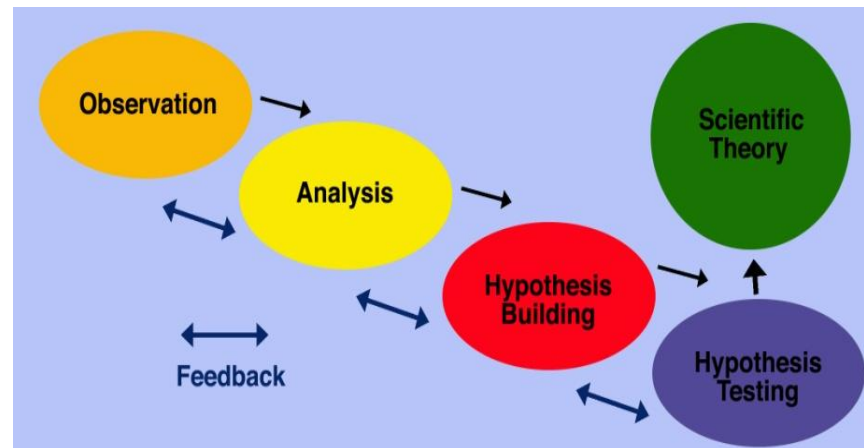
Galileo

Bacon



What is the Scientific Method?

- ¹Formulation, testing, and modification of hypotheses
- Systematic
 - observation,
 - measurement, and
 - experiment,



1 Oxford English Dictionary

2 Indiana University

Research is Destructive

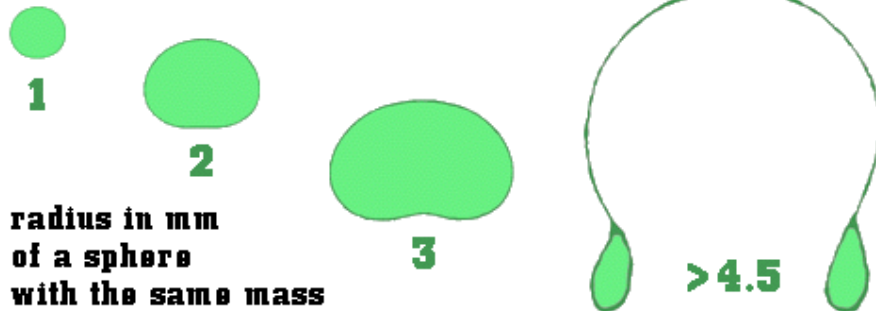
- Science seeks to replace old ideas with measurably better ideas.
- This is not always popular with closed systems.
 - Widget makers (predefined product)
 - Many religions (predefined world)

Things that are not obvious

- Research exposes the world
- Investigate for the purpose of
 - Discovering something new
 - Interpreting something not understood
 - Revising something wrong or incomplete



www.jolyon.co.uk



What is Computer Science Research?

- *A human activity based on the intellectual investigation of aspects of the world related to the discipline of Computer Science for the purpose of discovering new knowledge, interpreting existing knowledge or revising erroneous or incomplete knowledge.*



What is Computer Science?

- The systematic study of computing systems and computation. The body of knowledge resulting from this discipline contains theories for understanding
 - computing systems and methods;
 - design methodology,
 - algorithms, and tools;
 - methods for the testing of concepts;
 - methods of analysis and verification; and
 - knowledge representation and implementation.

This is broad enough to offend
no one!

Is Computer Science a Science?

- Yes but we sometimes go astray
- Sample of 400 computer science papers published before 1995¹
 - 50% of those proposing models or hypotheses did not test them.
 - In other fields of science the fraction of papers with untested hypotheses was about 10%.
- Caution:
 - Our failure to test more allowed many unsound ideas to be tried in practice and lowered the credibility of our field as a science.



1 . Tichy, W. Should computer scientists experiment more. IEEE Computer(May 1998), 32–40.

The processes of research

- not an “exact science”
- can be very messy
 - many important discoveries are made in very unscientific, even improbable ways.
- formal treatment of research
 - prepares you for a result when and if it appears.
 - Be ready to observe the unexpected and unwelcome

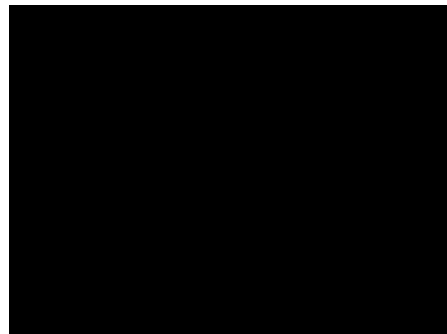
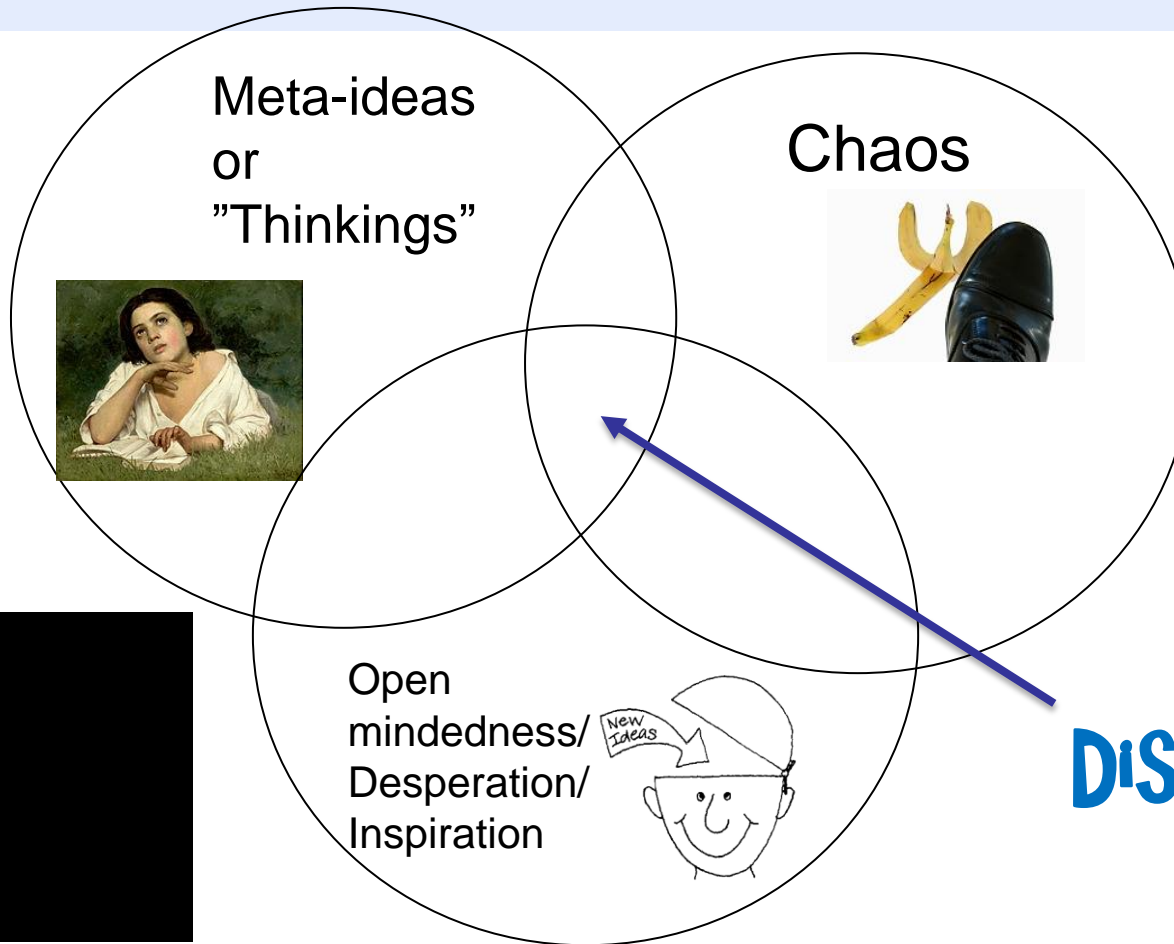
The Serendipity Effect

- Serendipity is the effect of discovering something really interesting, whilst looking for something else entirely¹.
 - A completely unintended but fortunate discovery.
 - X-rays, silly putty and Uranus were all chance discoveries.

1: From “Serendipity on the Web” <http://www.scienceforseo.com/search-engines/serendipity-on-the-web/>

“Chance favors the prepared mind”

Louis Pasteur



Anecdote: Prussian Blue

- The first modern, artificially manufactured colour was Prussian blue.
- Discovered by accident by the colour maker Diesbach of Berlin in about 1704.
- Diesbach accidentally formed the blue pigment when experimenting with the oxidation of iron.
- They were looking for a shade of red



The Research Question

- A question that guides your research
- Characteristics
 - State the main concepts
 - Is neutral (debateable)
 - Clear and specific
- The question should
 - Define the research
 - Guide your inquiries
 - Frame your arguments
 - Be likely to produce your “contributions”

Thinking about the question

- What is the problem you are attempting to address?
- What is the unsolved problem that your research will attempt to resolve?
 - What?
 - Why?
 - Where?
 - When?
 - Who?
 - How?

Is the Question Reasonable?

- What is the context of the question?
- Is the question significant?
- What is everyone else doing?
- Is there a point of attack on the problem?
- Do I like the question?
 - Am I curious about it enough to pursue it?
- Can it be done in the length of time I am willing to spend on it?

Example Proto-Questions

- Is there an algorithm that can solve X?
 - Can something be done at all?
- How can this X be improved...?
 - Can something be made better?
- Why does X work?
 - Why does this give the right answer?
- What is the explanation for the phenomenon demonstrated by X?
 - What are the theoretical underpinnings of this
- Can we apply the technique of Y to X to get Z?
 - Can we nail a number of things together and get something new?

State a goal

- This is a description of the prize!
- Answers the “nature” of the answer to your research question
- does not actually answer the question.
- This statement will let you know when you are done.

Form a plan

- A research plan normally contains
 - Review of how others have addressed it.
 - Sometimes called a *literature review*.
 - Reasoning as to why the question is significant.
 - The methods you intend to apply to the problem.
 - Called the “approach”
 - The resources you will need.
 - The Timetable you intend to follow.
 - The Milestones you will reach.

This is often also a Grant Application

Formulate experiments and hypotheses

- Experiment
 - Set of actions to be performed and observations made
- Hypothesis
 - A statement as to what you think will happen in the experiment
 - The lucky/informed/brilliant/horrible guess
 - Turns into your thesis statement
 - Science is not always this clean

Activities to Follow

- What are your assumptions
- Collect, record and interpret data
 - Sometimes a “black art”
 - What data do I need?
 - What does it mean?
- Avoid the temptation to “avoid interpretation”
- Remember
 - Research doesn’t happen in straight lines
 - The chances of you being right are small for any given experiment/hypothesis pair.

The Thesis Statement

- States your position on a research question once you're working on the question
- This is what you “defend” in your defence
- Characteristics
 - Reference the research question,
 - Unambiguous indication of your view
- “your view” is developed from doing the research to answer the research question.

Contributions

- Your research should produce something new—These are your contributions
- Your contributions flow from the answers to your research question and are (often) encapsulated in your thesis statement
- Contributions are put in the context of existing scientific literature (current practice)

Another Anecdote

- Legged locomotion
 - Is it possible to build artificial walking mechanisms that facilitate movement over unprepared solid surfaces?
 - Can I create such mechanisms?
 - What did everyone else do before I started look at this?
 - Moments of soul searching and despair
 - Is it possible for me to use something else that already knows how to walk to solve my problem?

