Research Methodology

Lecture 1

Dr. Imran Ali
Assistant Professor
School of Computing

Coure Information

- Course Instructor

Dr. Imran Ali
contact: imran.ali@nu.edu.pk

- Office hours

City Campus: Thursday 05:00 PM – 09:00 PM
Main Campus: Monday –Wednesday & Friday
08:00 AM – 04:00 PM

Coure Information

- Google Classroom

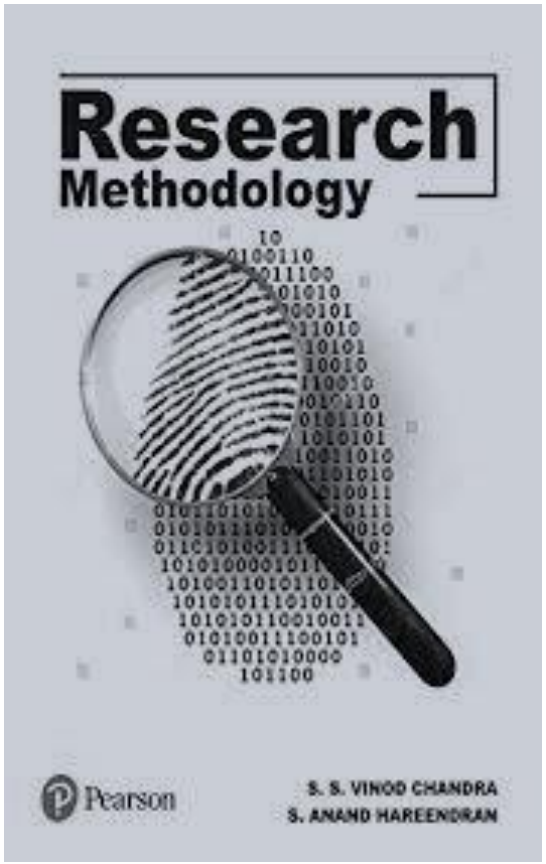
GCR Code: 3l5y6tl

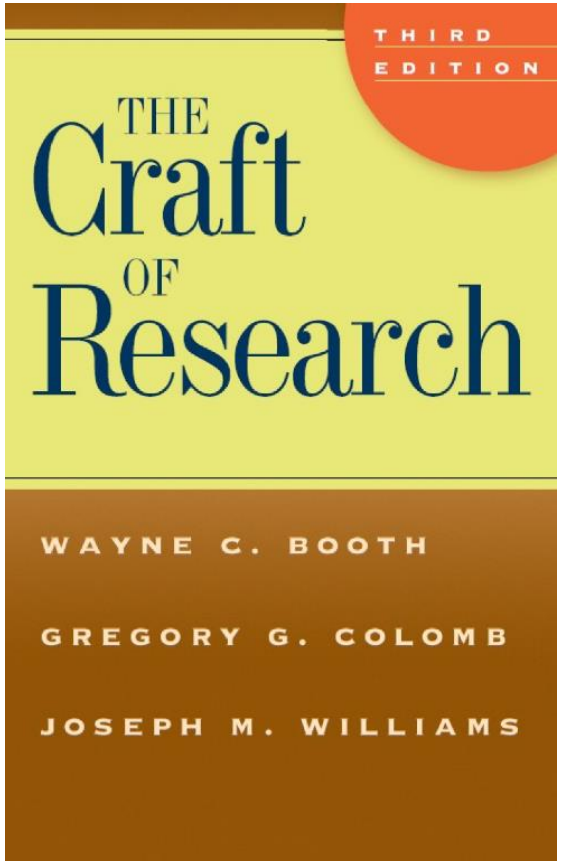
Coure Information

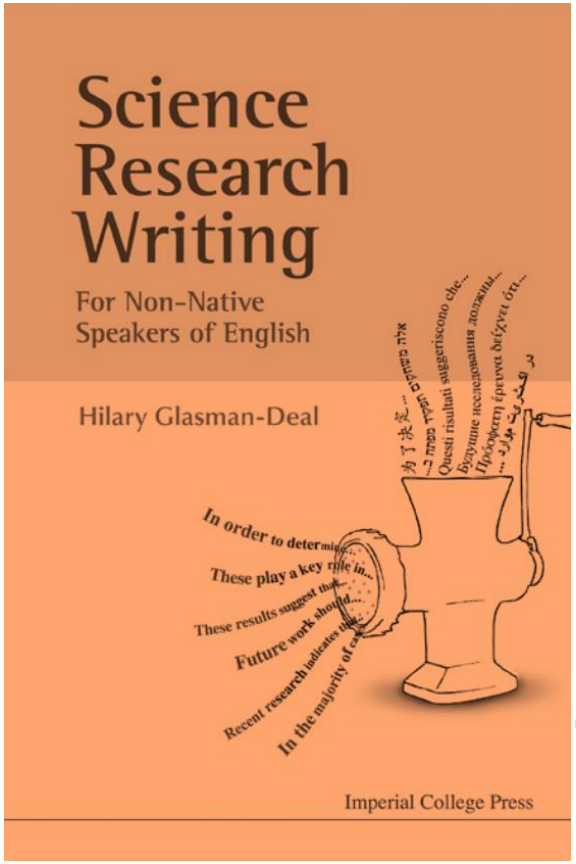
- Pre-requisite
  - None
- Course meeting times
  - Lectures: 1 session/week (Thursday)
- Course Resources
  - Lectures slides, assignments (computer/written), solutions to problems, projects, and announcements will be uploaded on google classroom (GCR).

Coure Information

- Books



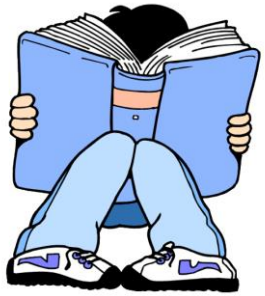




Coure Information

- Class Composition

Lectures



Readings

Term Project

Quizzes

Assignments

Course Information

- Assignments
  - Must be on time
  - Late submission: -25%
  - No Copying

Course outline

- Introduction to scientific research process - Classification of research methods
- Choosing a research problem – choosing a supervisor
- Research methods: Choosing a suitable research methodology
- How to carry out research
  - *Formulation – Problem statement, Literature Review*
  - *Design - Methodology*
  - *Analysis - Data analysis and interpretation*
- Ethics of research
  - *Plagiarism*
  - *Intellectual property rights*
- Presenting your research
  - *Writing a research paper*
  - *Writing your thesis/dissertation*
  - *Planning/delivering a scientific presentation*
- Organizing conference/workshop
- Reviewing papers

Grading policy

Assignments: 10%
Midterm: 30%
Project + Project Presentation: 10%
Final Exam: 50%

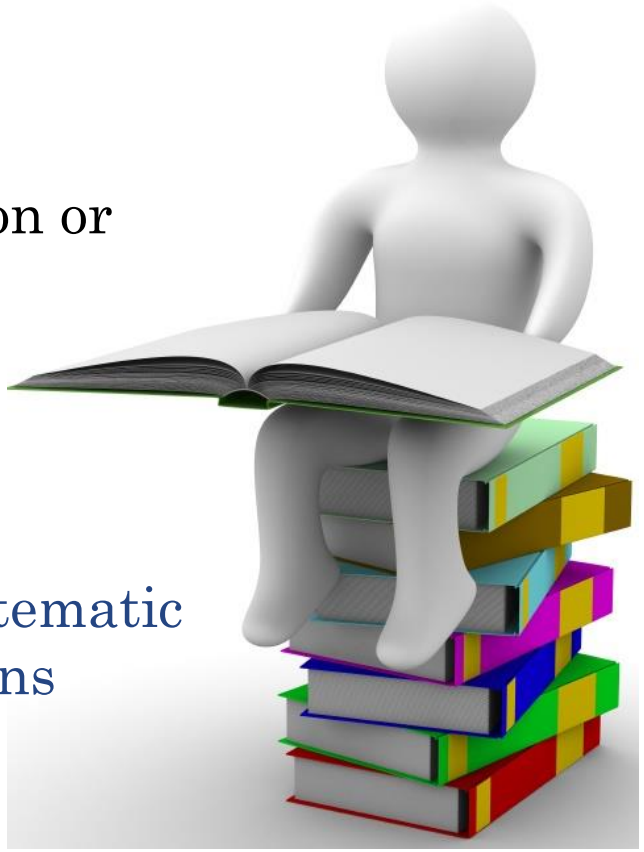
Contents

- Introduction
- Basic Definition and Concept
- Classification of research
- Research Process
  - Scientific Method

What is research?

- Dictionary
  - Scholarly or scientific investigation or inquiry
  - Close, careful study

- Basic Definition
  - Research is an organized and systematic way of finding answers to questions



What is research

- The word research derives from the French word ***recerchier*** meaning travel through, investigate thoroughly, or survey.

*The **systematic** process of collecting and analyzing data in order to discover new knowledge or expand and verify the existing one*

What is research

Research is an attempt to increase the sum of what is known, usually referred to as ‘a body of knowledge’, by the discovery of new facts or relationships through a process of systematic inquiry, the research process.

(Macleod Clark and Hockey 1989 cited by Cormack 1991 p4)

What research is NOT

- Research isn't information gathering:
  - Gathering information from resources such books or magazines isn't research.
  - No contribution to new knowledge.

- Research isn't the transportation of facts:
  - Merely transporting facts from one resource to another doesn't constitute research.
  - No contribution to new knowledge although this might make existing knowledge more accessible.

Discovery vs Invention

- There are two main ways of practicing science : discovery vs. invention
- Biologists, physicists, chemists, researchers in psychology… are discoverers
- Computer scientists, researchers in nanotech or researchers in engineering … are inventors

Discovering

- Understanding the world : what are atoms constituted of, why a disease is inherited, why do people have dreams, etc.
- Understanding means: first asking questions, then observing, inquiring, modeling, evaluating
- At the end of the research process, one has an *answer* to the initial question
- An answer is the most often not definitive. It is an explanation of a small piece of the natural world under some hypotheses

Inventing

- Software computer science produces *inventions*
- Computers do not exist by themselves. They have been created by human beings => there is nothing to *discover* in a computer or in a software
- The objective of research in CS is "just" to make computers and computer networks more efficient more easy to use, more reliable, more powerful… i.e. more useable/useful

Purpose of research

- Review and synthesize existing knowledge
- Investigate some existing situation or problem
- Provide solutions to a problem
- Explore and analyze general issues
- Construct a new procedure or system
- Explain a phenomenon
- Generate new knowledge or enhance the existing
- Combination of above

Research vs Reasoning & Experience

Research distinguishes itself from the two other basic means – experience and reasoning

Experience

- Experience results in knowledge and understanding gained either individually or as a group or society, or shared by experts or leaders, through day-to-day living.

- Examples
  - A child learns to walk by trial and error
  - An adult gets adept at decorating jobs in the house after renovating several rooms

Experience

- Learning from experience can be rather haphazard and uncontrolled.
- Conclusions are often quickly drawn and not exhaustively tested
- Despite these shortcomings, experience can be a valuable starting point for systematic research

Reasoning

- Reasoning is a method of coming to conclusions by the use of logical argument.
- Using the knowledge we have to draw conclusion or infer something new about the domain of interest
- Two basic forms
  - Deductive reasoning
  - Inductive reasoning

Deductive reasoning

- Derive logically necessary conclusion from given premises
- An argument based on deduction begins with *general statements* and, through *logical argument*, comes to a *specific conclusion*.
- Example

If it is Friday then she will go to work
It is Friday
Therefore she will go to work.

Inductive reasoning

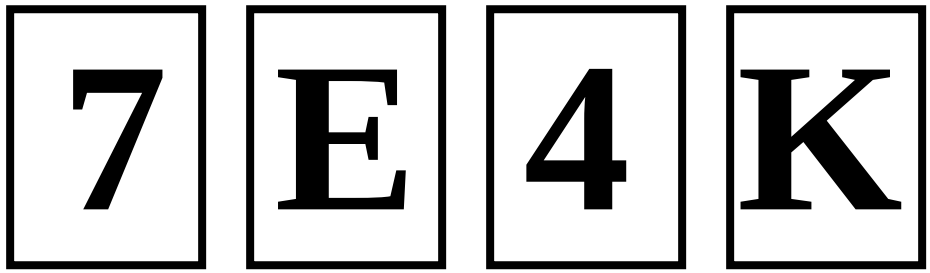
- Induction
  - Generalize from cases seen to cases unseen

    All elephants we have seen have trunks
    therefore all elephants have trunks

- Unreliable
  - Can never prove it true
- … but useful!
- Humans not good at using negative evidence
  - e.g. Wason's cards.

Inductive reasoning

- Wason's Cards



If a card has a vowel on one side it has an even number on the other

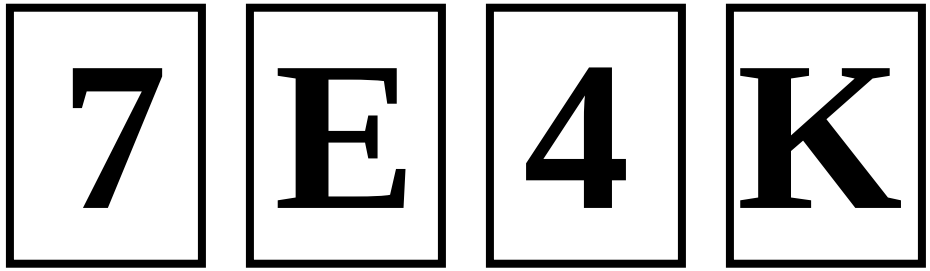
Is this true?

How many cards do you need to turn over to find out?

…. and which cards?

Inductive reasoning

- Wason's Cards
- Common Responses
  - Select E & 4: Positive Evidence
- Check Negative Evidences
  - Select 7



If a card has a vowel on one side it has an even number on the other

Research vs Reasoning & Experience

- It is the combination of experience with deductive and inductive reasoning which is the foundation of modern scientific research.

Research is a combination of both experience and reasoning and must be regarded as the most successful approach to the discovery of truth. (Cohen and Manion, 1994, p. 5)

Contents

- Introduction
- Basic Definition and Concept
- Classification of research
- Research Process
  - Scientific Method

Classification of research

- Dimensions (*on which we classify*)
  - The purpose of doing research
  - The intended uses of doing research
  - How it handles time
  - The research (data collection) techniques used in it

The Purpose of Research

The purpose of research

- Why are you doing research?
  - My boss told me to do so
  - It was a class assignment
  - I was curious
  - ….
  - As many reasons as researchers

- Purposes of research may be organized into three groups based on what the researcher is trying to accomplish

The purpose of research

- Three main groups
  - Explore a new topic – Exploratory research
  - Describe a social phenomenon – Descriptive research
  - Explain why something occurs – Explanatory research

- Studies may have multiple purposes (e.g. both to explore and to describe) but one purpose usually dominates.

Exploratory research

- Exploring a new topic
- Initial research conducted to clarify the nature of the problem
- Formulate more precise questions that future research can answer
- Addresses the "what" question
- Difficult to conduct because there are few guidelines to follow.

Descriptive research

- *Descriptive research* presents a picture of the specific details of a situation, social setting, or relationship
- Characteristics of a population or phenomenon
- Answers to *who, what, when, where*, and *how* questions
- Examples
  - Labor Force Surveys, Population Census, and Educational Census
  - Most of the social research is descriptive

EXAPLANATORY RESEARCH

- The desire to know "why"
- Builds on exploratory and descriptive research and goes on to identify the reasons for something that occurs.
- Looks for causes and reasons - Determine which of several explanations is best
- Determine the accuracy of the theory; test a theory's predictions or principle.
- Example
  - *Descriptive research may discover that 10 percent of the parents abuse their children, whereas the explanatory researcher is more interested in learning why parents abuse their children.*

What about Computer Science/Engineering?

Constructive research

- Develops solutions to a problem
- The most common computer science research method
- “Construct” is often used to refer to the new contribution being developed
- Construct can be a new theory, algorithm, model, software, or a framework

The Uses of Research

The uses of research

- Some researchers focus on using research to advance the knowledge, whereas others use it to solve specific problems

- Basic and applied research

Basic vs Applied Research

- Basic research
  - Type of research that may have limited direct applications and is mostly conducted for the purpose of acquiring knowledge
  - Also known as *fundamental* or *pure* research
  - Driven by a scientist's *curiosity* or interest in a scientific question.
  - The main motivation is to *expand man's knowledge*, not to create or invent something.
  - There is no direct commercial value to the discoveries that result from basic research.
  - Can be exploratory, descriptive, or explanatory; however, explanatory research is the most common.

Basic vs Applied Research

- Generates new ideas, principles and theories, which may not be immediately utilized; though are the foundations of modern progress and development in different fields.

- Today's computers could not exist without the pure research in mathematics conducted over a century ago, for which there was no known practical application at that time.

- Examples of Basic research
  - *How did the universe begin?*
  - *What are protons, neutrons, and electrons composed of?*
  - *What is the specific genetic code of the fruit fly?*
  - *How does the memory system work?*
  - *How are language skills developed?*

Basic vs Applied Research

- Applied research
  - Designed to solve *practical problems* of the modern world, rather than to acquire knowledge for knowledge's sake.
  - Intended to bring about some direct benefit to humankind
- Examples
  - Improve agricultural crop production
  - Treat or cure a specific disease
  - Improve the energy efficiency of homes, offices, or modes of transportation

The gray zone

- The distinction between basic and applied research isn't always clear
- It sometimes depends on your perspective or point of view
- One way:

How long will it be before some practical application results from the research ?

Ashok Gadgil

The gray zone

- If a practical use is only **a few years** away, then the work can be defined as strictly **applied** research.
- If a practical use is still 20-50 years away, then the work is somewhat applied and somewhat basic in nature.
- If a practical use **cannot be envisioned** in the foreseeable future, then the work can be described as purely **basic** research.

The gray zone

- Example
  - A fair amount of research has been underway on developing fusion reactors to provide a controlled energy source for cities
  - There is a clear applied goal to this work, yet there are so many technical obstacles to overcome that it may be another 30 to 50 years before we see a functional fusion reactor in use.
  - The development of fusion energy could be regarded as both basic and applied research.

Time Handling

Time

- Some research neglects the element of time, other research focuses heavily on time

- Two broad categories
  - Cross-sectional research
  - Longitudinal research

Cross sectional research

- Researchers observe at one point in time
- Generally the simplest and least costly
- Cannot capture the changing processes
- Can be exploratory, descriptive, or explanatory, but it is most consistent with a descriptive approach to research

Longitudinal research

- Examine features of people or other units at more than one time
- Much more expensive and time-consuming than cross-sectional but powerful

- Three types
  - Time Series
  - Panel
  - Cohort

LONGITUDINAL RESEARCH

- *Time series research*
  - The same type of information is collected on a group of people or other units across multiple time periods
  - Stability or change in the features of the units or can track conditions overtime.
  - Example
    - One could track the characteristics of students registering in the course on Research Methods over a period of four years
    - The characteristics may include total students, age characteristics, gender distribution, subject distribution, and geographic distribution etc.
    - Such an analysis could tell us the trends in the characteristic over the four years.

Longitudinal research

- *Panel study*
  - Observes exactly the same people, group, or organization across time periods
  - Difficult to carry out
  - Tracking people over time is often difficult – some people die or cannot be located.

- *Cohort Analysis*
  - Similar to the panel study, but rather than observing the exact same people, a category of people who share a similar life experience in a specified time period is studied
  - Examples - all people hired at the same time, all people retire on one or two year time frame, and all people who graduate in a given year.

Research Data

Research (data collection) technique

- Qualitative vs Quantitative research
- Quantitative
  - Data that can be expressed numerically and subjected to statistical analysis
  - Experiments, Surveys, Using Existing Statistics
- Qualitative
  - Data typically in the form of words or pictures and can be analyzed through informed judgement
  - Field Research, Case Study, Focus Group Discussion

Example

- A study in a health care facility
- A standardised item on a questionnaire:

Accountability as practices in our primary health care system creates an undesirable atmosphere of anxiety among nurses.

_____ 1. strongly agree
_____ 2. agree
_____ 3. disagree
_____ 4. strongly disagree

- Responses can be easily aggregated for analysis
- Standardised and easily presented in a short space.

Example

- An open-ended question:

Question: Please add any personal comments you'd like to make in your own words about any part of the primary health care system's accountability approach.

Response: 'Fear' is the word for 'accountability' as applied in our system. Accountability is a political ploy to maintain power and control us. The disappointment in our system is incredible. You wouldn't believe the new layers of administration that have been created just to keep this system going. Come down and visit in hell sometime.

- Qualitative responses are longer, more detailed and analysis is difficult because responses are neither systematic nor standardised.

Qualitative vs Quantitative

- Most research topics can be studied both quantitatively or qualitatively

- However, most research questions are best suited to one or the other

Qualitative vs Quantitative

- Qualitative Research Questions:
  - What motivates people to participate in STIC?
  - How do Vietnamese women view domestic violence?
  - Why do teenagers join street gangs?

- Quantitative Research Questions:
  - How frequently do kindergarten children engage in aggressive acts on the playground?
  - What is the relationship between amount of time studied and the grades students make?
  - Does parental educational level predict students' propensity to drop out of high school?

Which type do you do?

- Depends on your research question
- The process of focusing your research question often helps you determine the use, purpose and structure of your study
- Other elements like time availability, resources and skills must also be considered
- There is usually not one right way to study anything

Summary so far

- Purpose:
  - Exploratory: uncover new elements
  - Descriptive: detailed picture
  - Explanatory: examines causal relationships
- Use:
  - Basic: produces new knowledge
  - Applied: produces answers and solutions
- Time
  - Cross-Sectional: observations at one time point
  - Longitudinal: observations across time points
- Data
  - Qualitative: open questions and verbal data
  - Quantitative: specific questions and numeric data

Summary so far

- Purpose:
  - Exploratory: uncover new elements
  - Descriptive: detailed picture
  - Explanatory: examines causal relationships
- Use:
  - Basic: produces new knowledge
  - Applied: produces answers and solutions
- Time
  - Cross-Sectional: observations at one time point
  - Longitudinal: observations across time points
- Data
  - Qualitative: open questions and verbal data
  - Quantitative: specific questions and numeric data

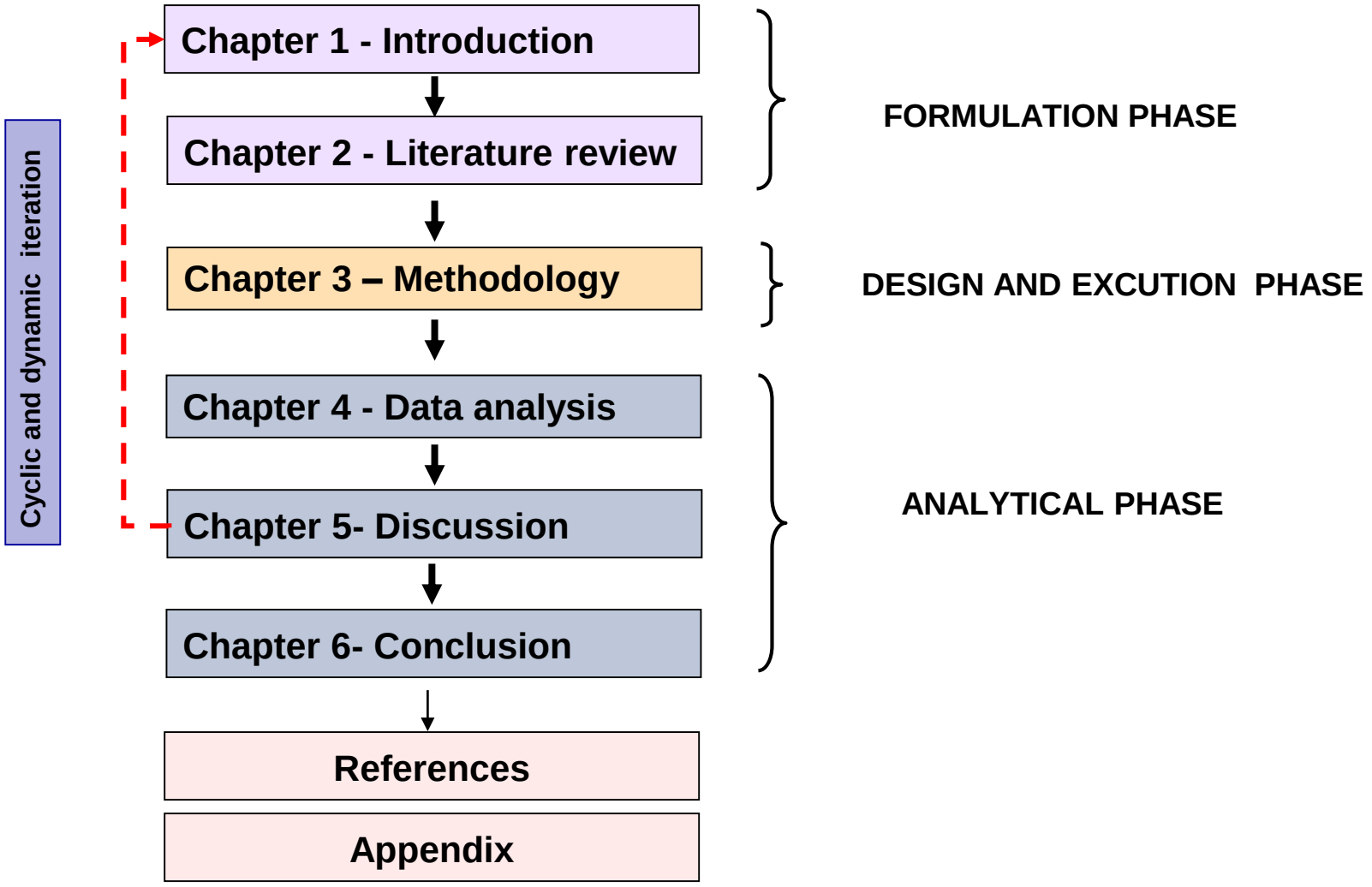
Choices are guided by your question and resources

Contents

- Introduction
- Basic Definition and Concept
- Classification of research
- Research Process
  - Scientific Method

Research Process

THE RSEARCH PROCESS



Research process

- Research is an extremely *cyclic* process.
  - Later stages might necessitate a review of earlier work.
- This isn't a weakness of the process but is part of the built-in error correction machinery.
- Because of the cyclic nature of research, it can be difficult to determine where to start and when to stop.

Non scientific ways

- Non-scientific research based on experience and intuition

- Non-Scientific ways of obtaining knowledge

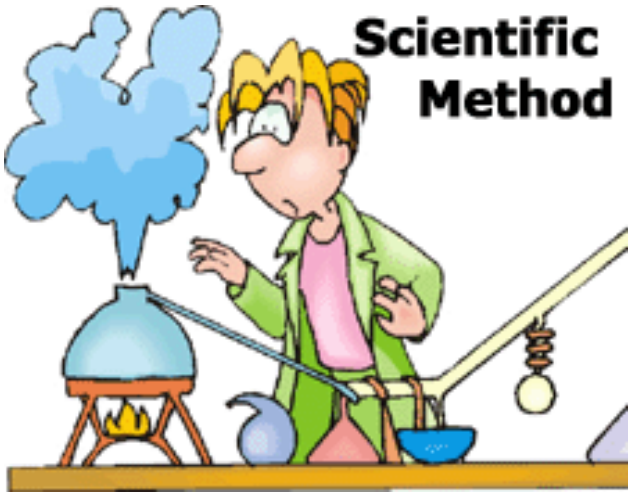
  - Common Sense: *That which is self-evident*

  - Tenacity: *what we have known to be true in the past — holds firmly to beliefs because "it has always been so"*

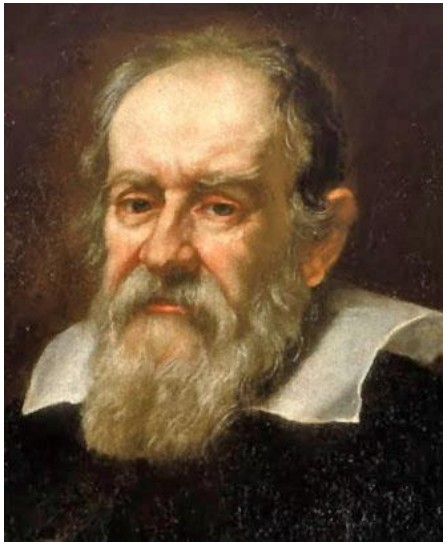
  - Authority: *established belief based on prominence or importance of source*

Non scientific ways

Scientific Method



Scientific method



- Galileo Galilei – (1564 - 1642)
- Italian physicist, mathematician, astronomer, and philosopher
- The scientific method is popularly attributed to **Galileo** who, in 1590, dropped iron balls of two different weights off **the Leaning Tower of Pisa**.

Scientific method

- He wanted to test his hypothesis that the forces acting on a falling object were independent of the object's weight.

- He was correct and so refuted the previously held belief that heavier objects would fall faster than light objects.

Scientific method

- The steps he took:
  - Observation,
  - Hypothesis generation,
  - Testing of the hypothesis
  - and Refutation or Acceptance of the original hypothesis

Scientific method

The Scientific Method is a logical and systematic approach or process to problem solving.

It involves a series of steps that are used to investigate a research question.

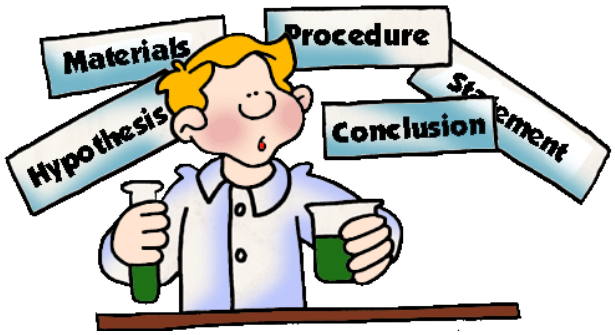
Scientific methods - Steps

- Define the research question
- Research the problem
- State the hypothesis
- Experiment to test Hypothesis
- Collect and Record Data
- Analyze Data
- Draw Conclusions
- Determine Limitations
- Communicate/Report Results

If needed, Do more investigation

Scientific Method

An Overview



First → **Question** — What does the scientist want to learn more about?

Then → **Research** — Gathering of information

Next → **Hypothesis** — An "Educated" guess of an answer to the question

Then → **Procedure/ Experiment** — Written and carefully followed step-by-step experiment designed to test the hypothesis

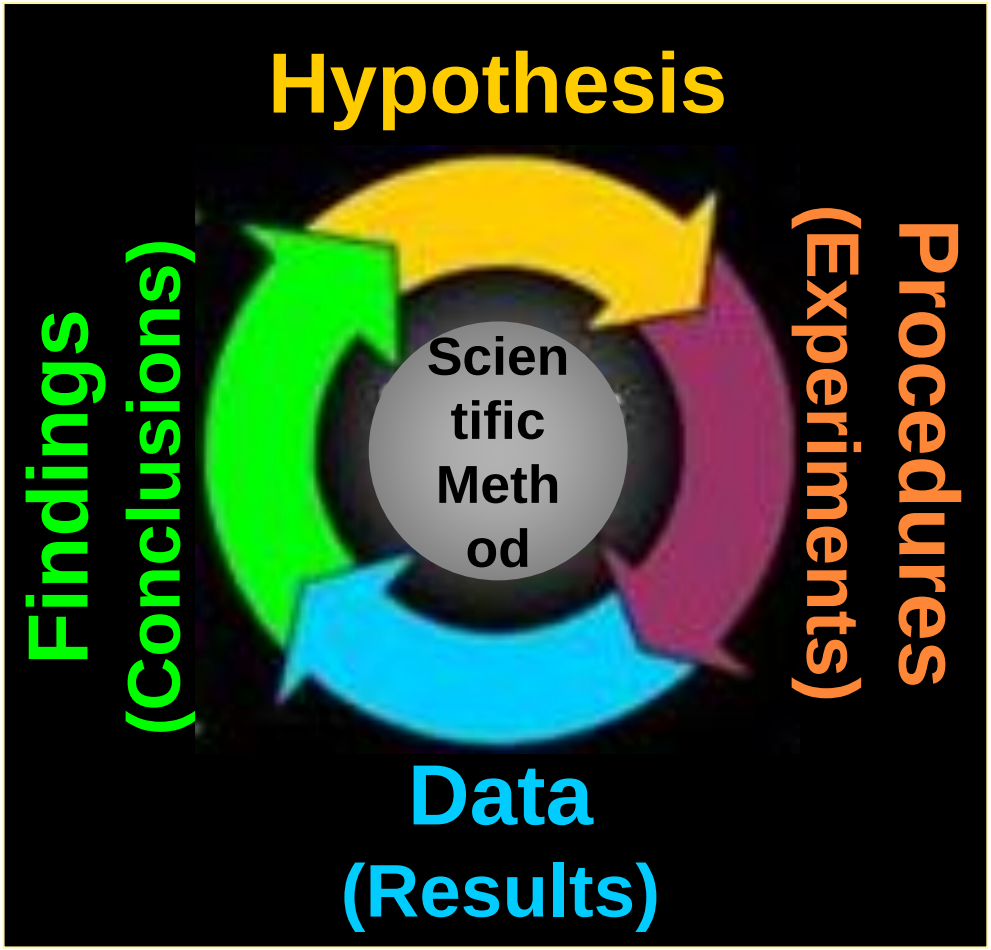
Next → **Data** — Information collected during the experiment

And → **Analysis** — Written description of what was noticed during the experiment

And

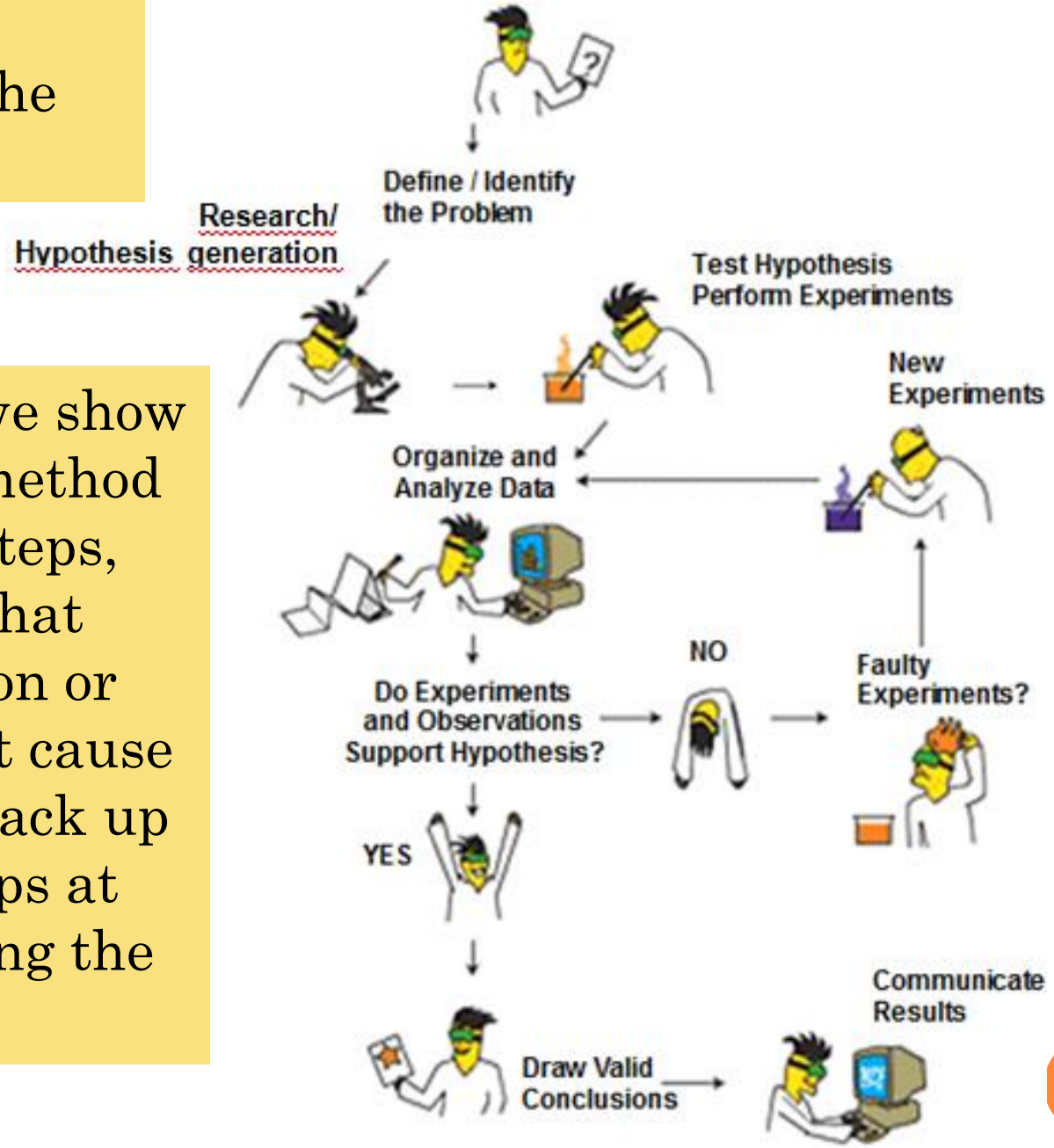
Finally → **Conclusion** — Was the hypothesis correct or incorrect?

Scientific method – other representations



Here is another example of how the steps may go….

Even though we show the scientific method as a series of steps, keep in mind that new information or thinking might cause a scientist to back up and repeat steps at any point during the process.



Step 1 – Problem/Question

- Define the research question

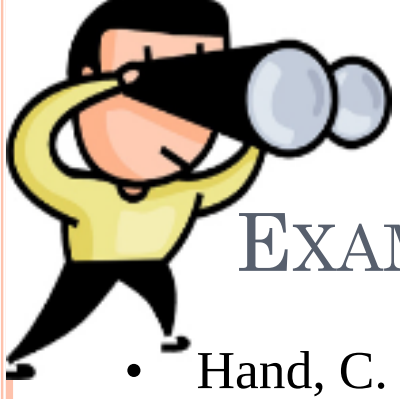
- A question occurs to or is posed to the researcher for which that researcher has no answer.
  - This doesn't mean that someone else doesn't already have an answer.

- The question needs to be converted to an appropriate problem statement like that documented in a research proposal.

- Research question can also arise from observation

Step 2 – Research/review

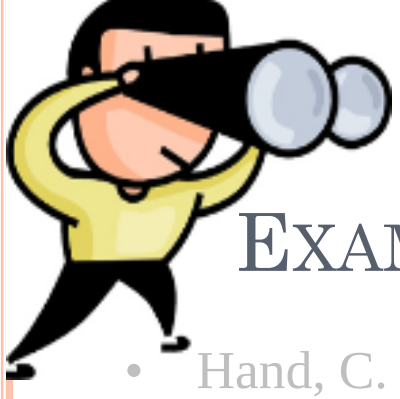
- Gather information related to the problem
- Read, observe, measure, take samples, etc
- Perform literature review
  - The available literature is reviewed to determine if there is already a solution to the problem.
    - Existing solutions do not always explain new observations.
    - The existing solution might require some revision or even be discarded.



Example of a literature review

- Hand, C. "A Survey of 3D Interaction Techniques". Computer Graphics Forum, 16(5): 269-281. (Dec 1997)

- Recent gains in the performance of 3D graphics hardware and rendering systems have not been matched by a corresponding improvement in our knowledge of how to interact with the virtual environments we create; therefore there is a need to examine these further if we are to improve the overall quality of our interactive 3D systems. This paper examines some of the interaction techniques which have been developed for object manipulation, navigation and application control in 3D virtual environments. The use of both mouse-based techniques and 3D input devices is considered, along with the role of feedback and some aspects of tools and widgets.

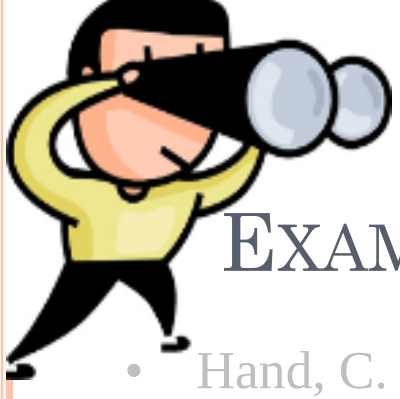


Example of a literature review

- Hand, C. "A Survey of 3D Interaction Techniques". Computer Graphics Forum, 16(5): 269-281. (Dec 1997)

rationale

- Recent gains in the performance of 3D graphics hardware and rendering systems have not been matched by a corresponding improvement in our knowledge of how to interact with the virtual environments we create; therefore there is a need to examine these further if we are to improve the overall quality of our interactive 3D systems. This paper examines some of the interaction techniques which have been developed for object manipulation, navigation and application control in 3D virtual environments. The use of both mouse-based techniques and 3D input devices is considered, along with the role of feedback and some aspects of tools and widgets.

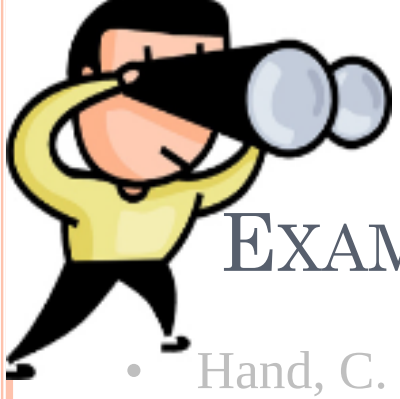


Example of a literature review

- Hand, C. "A Survey of 3D Interaction Techniques". Computer Graphics Forum, 16(5): 269-281. (Dec 1997)

Scope

- Recent gains in the performance of 3D graphics hardware and rendering systems have not been matched by a corresponding improvement in our knowledge of how to interact with the virtual environments we create; therefore there is a need to examine these further if we are to improve the overall quality of our interactive 3D systems. This paper examines some of the interaction techniques which have been developed for object manipulation, navigation and application control in 3D virtual environments. The use of both mouse-based techniques and 3D input devices is considered, along with the role of feedback and some aspects of tools and widgets.



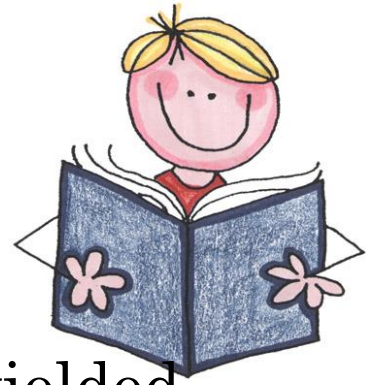
Example of a literature review

- Hand, C. "A Survey of 3D Interaction Techniques". Computer Graphics Forum, 16(5): 269-281. (Dec 1997)

Indication of taxonomy

- Recent gains in the performance of 3D graphics hardware and rendering systems have not been matched by a corresponding improvement in our knowledge of how to interact with the virtual environments we create; therefore there is a need to examine these further if we are to improve the overall quality of our interactive 3D systems. This paper examines some of the interaction techniques which have been developed for object manipulation, navigation and application control in 3D virtual environments. The use of both mouse-based techniques and 3D input devices is considered, along with the role of feedback and some aspects of tools and widgets.

Step 2 – Research/review

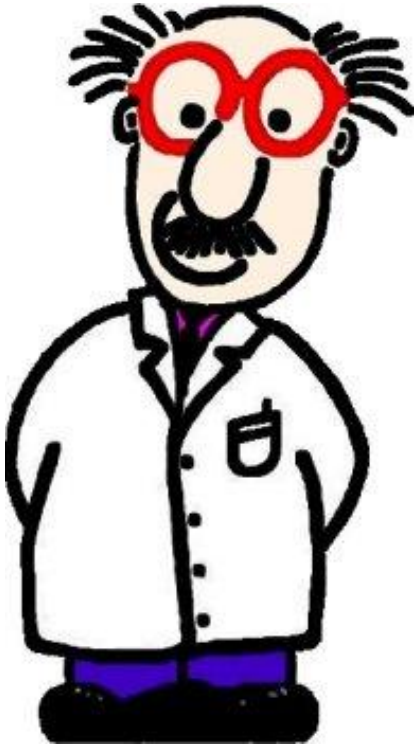


- It's possible that the literature review has yielded a solution to the proposed problem.
  - This means that you haven't really done research.

- On the other hand, if the literature review turns up nothing, then additional research activities are justified.

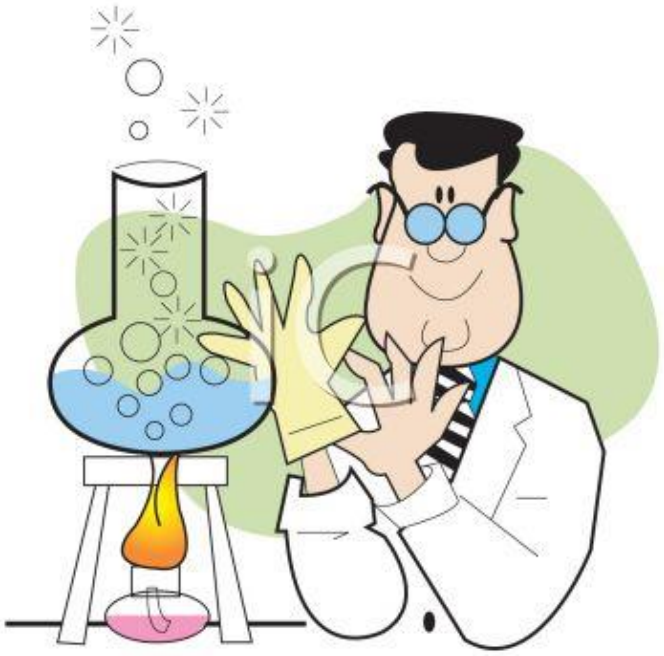
STEP 3 -HYPOTHESIS

- Predict a possible answer to the problem or question.
- The researcher generates intermediate hypotheses to describe a solution to the problem.
- This is at best a temporary solution since there is as yet no evidence to support either the acceptance or rejection of these hypotheses.
- *Example: If soil temperatures rise, then plant growth will increase.*



Step 4 – Experiment

- Testing the hypothesis
- Design experiments
- Control and Experimental groups
  - Control group – used as a standard of comparison
  - Experimental group - the group containing the factor (variable) that has been changed



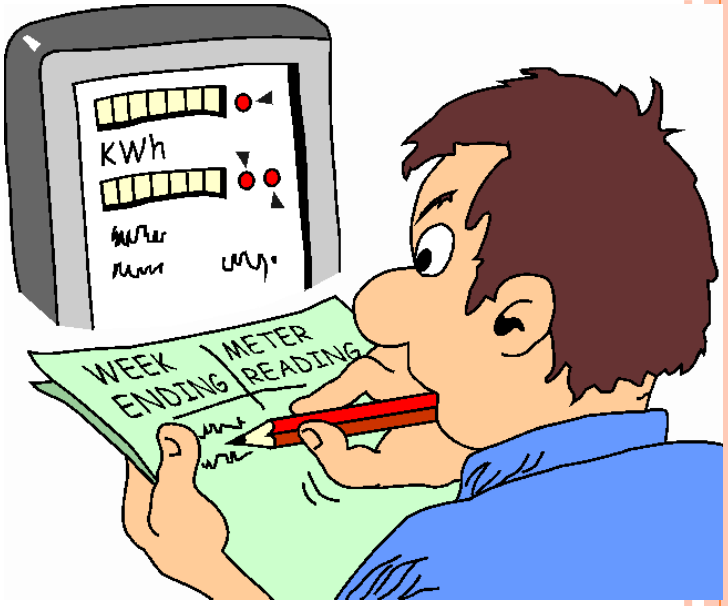
Step 4 - Experiment

- Variables - Factors that can be changed
- Controlled Variables - all the variables that remain constant
- Manipulated Variable - (also called the Independent Variable) - factor in an experiment that a scientist purposely changes
- Responding Variable- (also called the Dependent Variable) - the outcome or results, factor in an experiment that may change because of the manipulated variable….what a scientist wants to observe

Step 4 - Experiment

- Example?
  - We want to find out whether people complete operations faster with a colored or a black and white user interface.
  - Do experiments and note time of operation – What are different variables?
    - Independent Variable – Interface type: colored or black and white
    - Dependent Variable – Time to complete operation
    - Controlled Variables – Text or icons on the interface, the font size etc.

Step 5 – Data collection



- Data - observations and measurements made in an experiment

- Type of recorderd data
  - **Quantitative -** observations that involve measurements/numbers; i.e. 3 days, 4 g, 13 sec, 8 liters

  - **Qualitative -** observations that do not involve numbers, are of a descriptive nature i.e. white maggots covered the meat, leaves were all drying

Step 6 – Data Analysis

- Examine data tables, charts, and graphs
- Look for trends, patterns, and averages
- What does the data show?
- Put your data into words

Step 7 - Conclusion

- The data will either support the hypotheses or they won't.
- Include a statement that accepts or rejects the hypothesis.
  - This may lead the researcher to cycle back to an earlier step in the process and begin again with a new hypothesis.
  - This is one of the self-correcting mechanisms associated with the scientific method.

Step 8 - Limitations

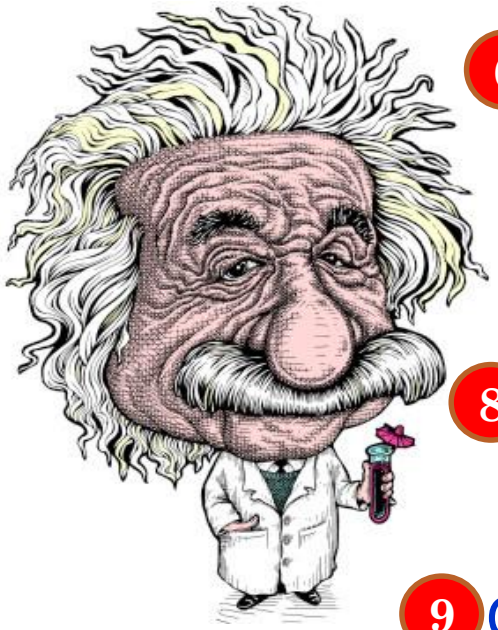
- Scientists look for possible flaws in their research
- They look for faulty (inaccurate) data
- They look for experimental error
- They decide on the validity of their results
- They make suggestions for improvement or raise new questions
- Make recommendations for further study

Step 9 – communicate findings

- Communication is an essential part of science
- Scientists report their results in journals, on the internet, or at conferences
- This allows their experiments to be evaluated and repeated
- Scientists can build on previous work of other scientists

Think you can name all the steps?

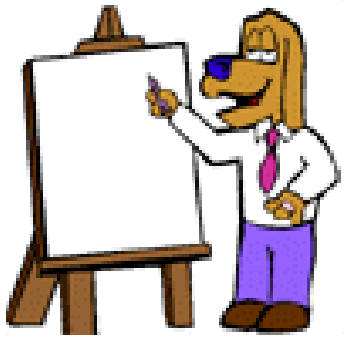
1. Problem/Question
2. Research/ Review
3. Formulate a Hypothesis
4. Experiment
5. Collect Data
6. Analyze Data
7. Conclusion
8. Limitations
9. Communicate the Results



Can you put these steps in order?

Define the Problem

Analyze Data



Report Results

Make an Observation

State the Hypothesis

Determine Limitations

the Problem

Steps of scientific method in order

1

Make an Observation

2

Define the Problem

3

the Problem

4

State the Hypothesis

5

6

7

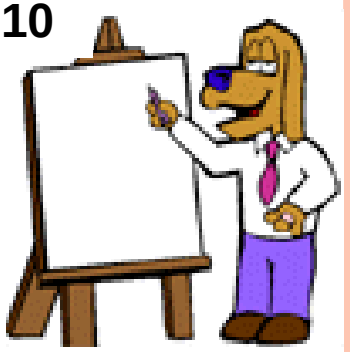
Analyze Data

8

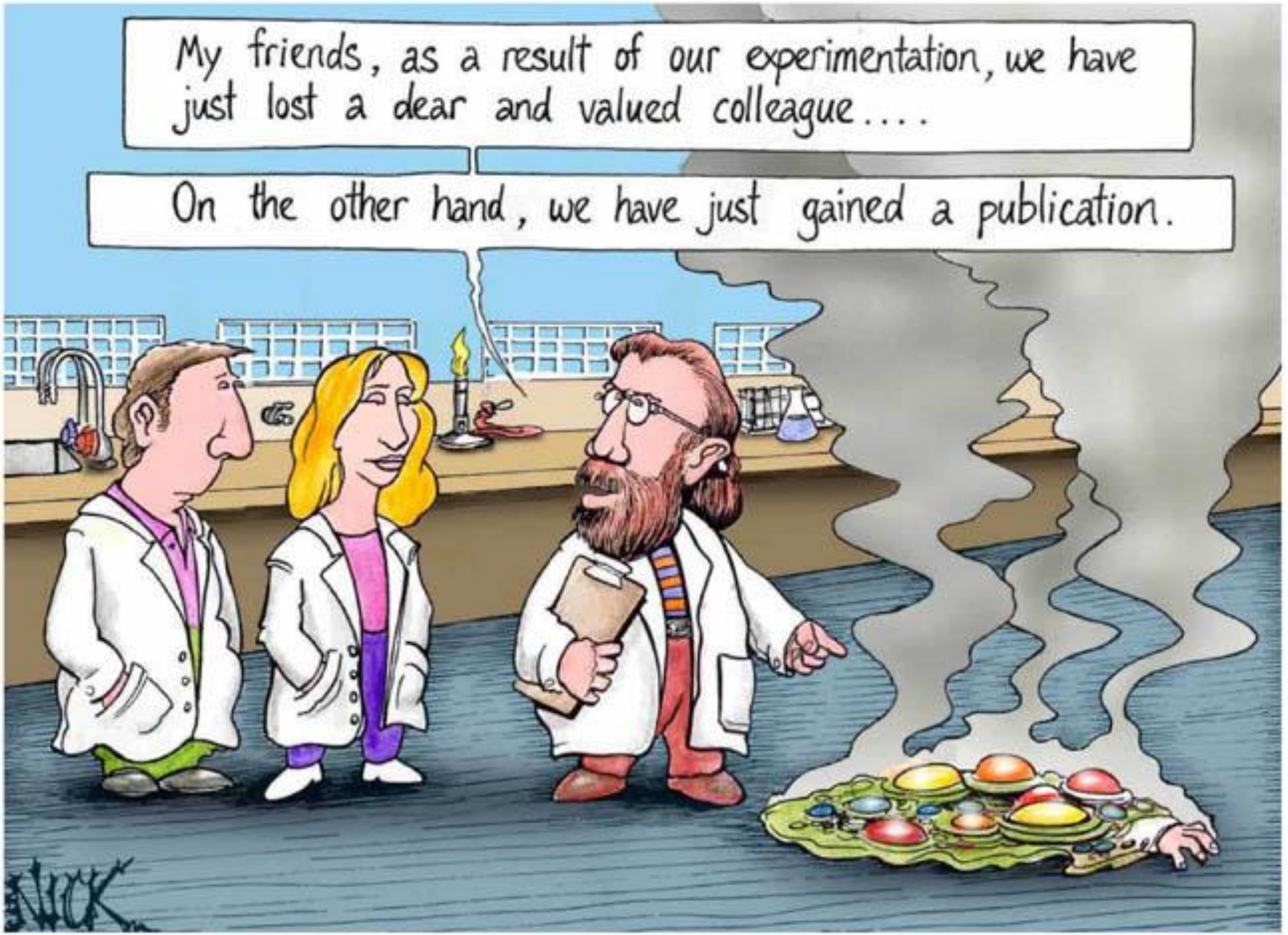
9

Determine Limitations

10



Report Results


My friends, as a result of our experimentation, we have just lost a dear and valued colleague....
On the other hand, we have just gained a publication.

REFERENCES

- Methodologies for research in computer science, Lionel Brunie, LIRIS – INSA, Lyon, France
- Introduction to research process, Dr Muhammad Hanif, Workshop on research methodologies, MCS-NUST
- Scientific Research in Computer Science and Computer Engineering, Doctoral Seminar, Nayda G. Santiago
- Basic vs Applied research – Retrieved August 2011 from http://www.lbl.gov/Education/ELSI/research-main.html
- Labuschagne, A. (2003, March). Qualitative research - Airy fairy or fundamental? *The Qualitative Report, 8*(1). Retrieved August 2011, from http://www.nova.edu