

Scientific Research Methods

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Based on the online course materials prepared

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Objectives

- Understand different research methods
- Critically read and evaluate scientific papers
- Logically and contextually present your arguments



Outlines

- ▶ Scientific Research and Hypothesis
- ▶ Scientific Research Process
- ▶ Qualitative vs. Quantitative researches
- ▶ The Structure of a Scientific Paper
- ▶ Sources of Literature



Definition

- Research is the *systematic collection, analysis* and *interpretation of data* to answer a certain question or solve a problem
- **Scientific research**
 - Scientific research is the systematic investigation of scientific theories and hypotheses.
 - **Goal of research**

Discover and disseminate new knowledge

Objectives of Scientific Research

The ultimate aims of research are to generate measurable and testable data, gradually adding to the accumulation of human knowledge.

- **Observe and Describe:**

- ▶ The first stage of any research is to observe the world around us and to ask questions about why things are happening.

- **Predict:**

- ▶ develop a strong hypothesis

- **Determination of the Causes**

- ▶ Providing numerical data to prove or disprove the hypothesis.

- **Explain**

- ▶ try to find possible explanations of 'Why?' and 'How?' things are happening.



Types of Research

Exploratory research structures and identifies new problems.

Constructive research develops solutions to an existing well defined problem
Common in Computer science: framework, algorithm, theory, model, software, etc.

Needs cautious validation with pre-existing findings and criteria or benchmarks and convincing conclusions.

Empirical research tests the feasibility of a solution using empirical evidence

Use direct observation and experience

Observe → Induce → Deduce → Test → Evaluate

Need be analyzed both quantitatively and qualitatively to provide evidences

Research method

It is the way in which we conduct research

Research methodology

The study of the research method

Research technique

The tools we are using to collect and infer data

Research techniques and tools

Field study

Surveys

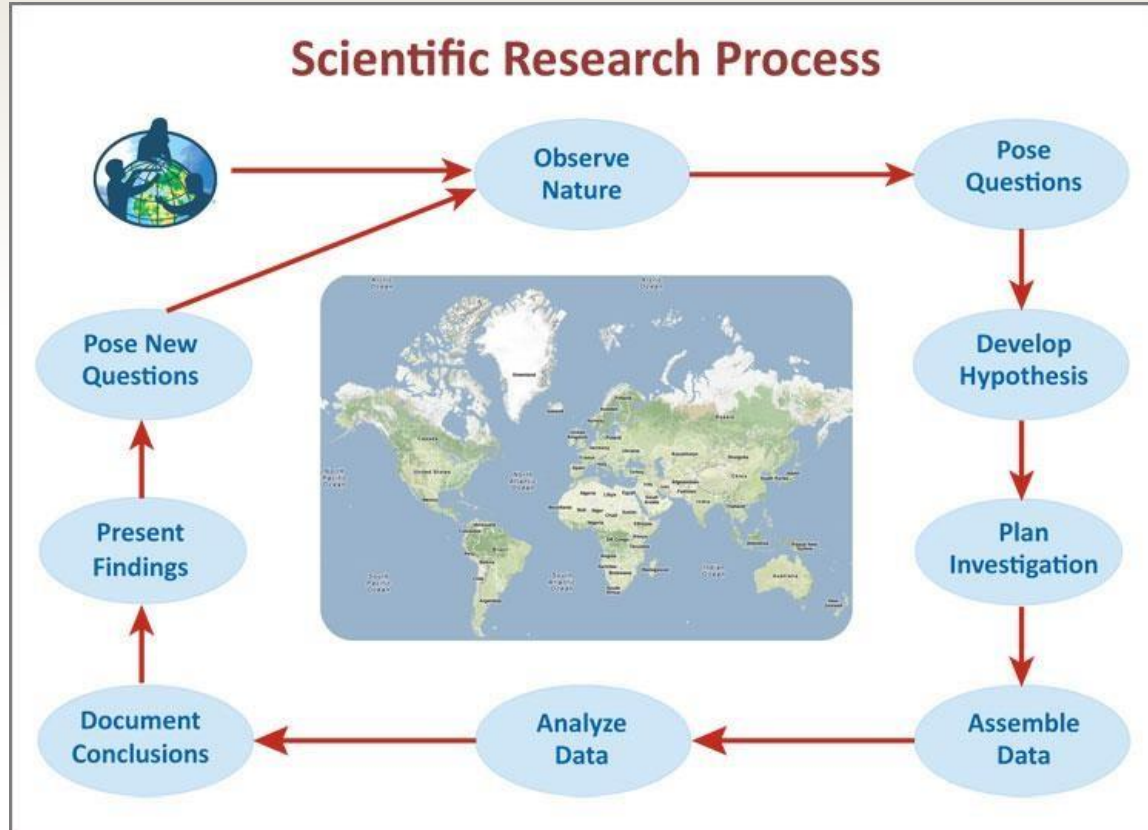
Case study

Secondary research

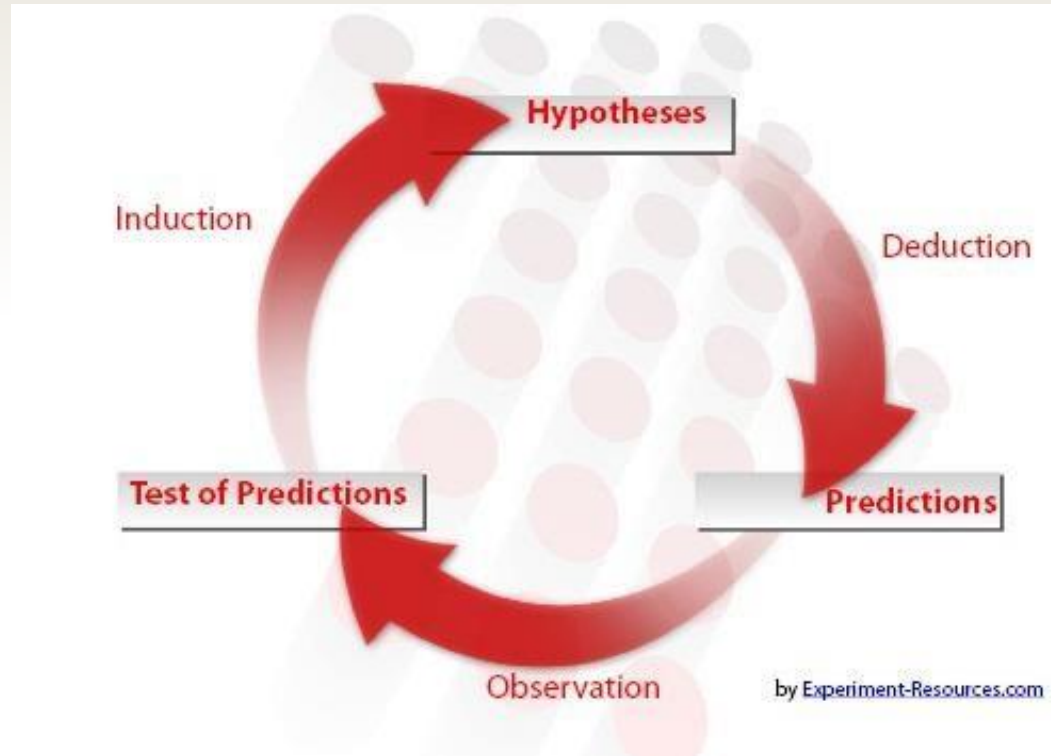
Computing and Engineering

Building a concept, design and
prototyping

The Process of Scientific Research



The Process of Scientific Research (2)



What is Hypothesis ?

➤ Hypothesis

- ▶ A clear and testable proposition or predictive statement to answer a research question
- Null hypothesis (needed when we have statistical hypothesis testing
 - No association between variables



What is Computer science?

- Algorithmic study, investigation and development of computer-related phenomena
- Other definitions
 - The study of phenomena related to computers, Newell, Perlis and Simon, 1967
 - The systematic study of algorithmic processes that describe and transform information: their theory, analysis, design, efficiency, implementation, and application (ACM-2001)
 - The study of algorithms, Knuth, 1968
 - The study of information structures (Wegner, 1968)
 - Computer Science is the study and management of complexity, Dijkstra, 1969.
 - The mechanization of abstraction, Aho and Ullman 1992



Computer Science Research

- We generate data
- We collect data
- We interpreted data
- We search for better way of doing that!

Types of data

Observational

- Human observation,
- sensors and monitors
- surveys

Derived/compiled

From existing data points or equations

Experimental

Produced through experiments

Reproducible

Casual relations

Simulation

Computer algorithm-generated

Test model prediction

Computer Science Research methods

- **Formal** → prove facts about algorithms and systems
- **Experimental**: Two phases → exploration + evaluation
- **Build** → a new system or new features
- **Process** → understand computing tasks
- **Model and simulate**

A 14-step Process:

1. Choose a problem
2. Review the literature
3. Evaluate the literature
4. Be aware of all ethical issues
5. Be aware of all cultural issues
6. State the research question or hypothesis
7. Select the research approach
8. Determine how the variables are going to be measured
9. Select a sample
10. Select a data collection method
11. Collect and code the data
12. Analyze and interpret the data
13. Write the report
14. Disseminate the report



See more : <http://www.humankinetics.com/excerpts/excerpts/steps-of-the-research-process>

Qualitative vs. Quantitative research

Qualitative

- ▶ The aim of qualitative analysis is a complete detailed description.
- ▶ The design emerges as the study unfolds
- ▶ Researcher is the data gathering instrument.
- ▶ Data is in the form of words (interviews), pictures (videos), or objects (artifacts).
- ▶ Qualitative data is more rich, time consuming, and less able to be generalized.


Quantitative

- ▶ In quantitative research we classify features, count them, and construct statistical models in an attempt to explain what is observed.
- ▶ All aspects of the study are carefully designed before data is collected.
- ▶ Researcher uses tools (questionnaires or equipment) to collect data.
- ▶ Data is in the form of numbers and statistics.
- ▶ Quantitative data is more efficient, able to test hypotheses, but may miss contextual data.



Part II

Scientific Writing

- 
- A scientific experiment is not complete until the results have been published and understood.
 - A scientific paper is a written and published report describing *original research results*.



What is Scientific Writing

- The purpose of scientific writing is to communicate new scientific findings
- Thus it has to be **clear, simple** and **well ordered** communication to transmit new scientific findings
- Scientific writing must use *proper English which gives the sense in the fewest short words*



What is the structure of a scientific paper?

- All scientific papers have the same general format. They are divided into distinct sections and each section contains a specific type of information.
- The number and the headings of sections may vary among journals, but for the most part a basic structure is maintained.
- Because scientific papers are organized in this way, a reader knows what to expect from each part of the paper, and they can quickly locate a specific type of information.



What is the structure of a scientific paper?

Typically, scientific papers are comprised of the following parts:

- Title
- Abstract
- Introduction
- Methods
- Results
- Discussion & Conclusion
- Acknowledgments
- References





TITLE

- The title will help you to determine if an article is **interesting** or **relevant** for your project.
- Well-written titles give a reasonably complete description of the study that was conducted, and sometimes even foreshadow the findings. Included in a title are the species studied, the kinds of experiments performed, and perhaps a brief indication of the results obtained.



ABSTRACT

- Abstracts provide you with a complete, but very succinct **summary** of the paper.
- An abstract contains brief statements of the **purpose**, **methods**, **results**, and **conclusions** of a study.
- **Abstracts** are often included in article databases, and are usually *free to a large audience*.
- Thus, they may be the **most widely read portions** of scientific papers.



INTRODUCTION

- You will find **background** information and a statement of the author's **hypothesis** in the introduction.
- An introduction usually describes the **theoretical background**, indicates **why the work is important**, states a specific **research question**, and poses a specific **hypothesis to be tested**.





METHODS

- The methods section will help you determine exactly **how** the authors performed the experiment.
- The methods describes both specific techniques and the overall experimental strategy used by the scientists.
- Generally, the methods section does not need to be read in detail. Refer to this section if you have a specific question about the experimental design.





RESULTS

- The results section contains the **data** collected during experimentation.
- The results section is the heart of a scientific paper.
- In this section, much of the important information may be in the form of tables or graphs.
- When reading this section, do not readily accept an author's statements about the results.
- Rather, carefully analyze the raw data in tables and figures to draw your own conclusions.



DISCUSSION & CONCLUSION

- The discussion section will explain the authors interpret their data and how they connect it to other work.
- Authors often use the discussion to describe what their work suggests and how it relates to other studies.
- In this section, authors can anticipate and address any possible objections to their work.
- The discussion section is also a place where authors can suggest areas of improvement for future research.





ACKNOWLEDGMENTS

- The acknowledgments tell you what people or institutions (in addition to the authors) **contributed** to the work.
- In reading the acknowledgments, you can see what sources provided financial support for the study. You might want to know an industry group or the federal government funded the study.



Essential Parts of a Scientific paper

- **Title:** Describe **concisely** the core contents of the paper
- **Abstract:** **Summarize** the **major elements** of the paper
- **Introduction:** provide **context and rationale** for the study
- **Literature review:** **surveys scientific** articles, books, journals, dissertations & other **sources relevant to the research question**.
- **Materials:** Describe the **experimental design** so it is **reproducible**
- **Methods:** Describe the **experimental procedures**
- **Results:** Summarize the **findings without interpretation**
- **Discussion:** **Interpret the findings** of the study
- **Summary (Conclusion):** **Summarize** the findings
- **Acknowledgement:** Give **credit** to those who helped you
- **References:** **List** all scientific papers, books and websites that you cited



LITERATURE CITED (References)

- This section provides the **sources** cited throughout the paper.
- This section offers information on the range of other studies cited.
- The literature cited section is also helpful for generating a list of background reading on the topic under study.



1. WHAT IS A literature review(LR)?

- The **literature** represents an on-going scholarly conversation
- A literature **review** “reviews” –looks again –at what others have said, done and found in a particular area
- In fact, a literature review is performed on many rounds.



Sources of Literature (1)

1) Journal articles:

- these are good sources, especially for up-to-date information.
- They are frequently used in literature reviews because they offer a relatively concise, up-to-date format for research.
- Depending on the publication, these materials may be refereed materials.



Sources of Literature (2)

What about Non-refereed Journals?

- ▶ **Non-refereed materials** such as **Trade Journals**, or **magazines** use less precise standards of screening prior to publication.
- ▶ Non-refereed materials may not be checked as intensely as refereed materials, but many can still be considered useful, although not for scientific literature and research.



Sources of Literature (cont.)

2) Books:

- remember that books tend to be less up-to-date, as it takes longer for a book to be published than for a journal article.
- They are still likely to be useful for including in your literature review as they offer a good starting point from which to find more detailed and up-to-date sources of information.



Sources of Literature (cont.)

3) Conference proceedings:

- these can be useful in providing the latest research, or research that has not been published.
- They are also helpful in providing information about people in different research areas, and so can be helpful in tracking down other work by the same researchers.



Sources of Literature (cont.)

4) Government/corporate reports:

- Many government departments and corporations commission carry out research.
- Their published findings can provide a useful source of information, depending on your field of study.



Sources of Literature (cont.)

5) Thesis and dissertations: can be useful sources of information.

However there are disadvantages:

- they can be difficult to obtain since they are not published, but are generally only available from the library or interlibrary systems
- the student who carried out the research **may not be an experienced researcher** and therefore you might have to treat their findings with more caution than published research.



Sources of Literature (cont.)

5) Thesis and dissertations:

- A PhD thesis in the science **is supposed to present the candidate's original research** i.e. it is a scientific paper
- Unlike the scientific paper, the thesis may **describe more than one topic**, and it may present **more than one approach to some topics**.
- The thesis may present all or most of the data obtained in the student's thesis related research.
- Thus it is more involved and **longer than a scientific paper**.



Sources of Literature (cont.)

- 6) **Internet:** the **fastest-growing** source of information is on the Internet.
- bear in mind that anyone can post information on the Internet so the quality may not be reliable
 - the information you find may be intended for a general audience and so not be suitable for inclusion in your literature review (information for a general audience is usually less detailed).



Assignment



What is the quality of the papers I have collected?



Template- Title evaluation of my papers

	Title	Length	No Redundancy	Specificity	Syntax	Keywords	Total
1							
2							
3							
4							
5							



Template- Abstract evaluation of my papers

#	Title	Single Paragraph	Fewer than 250 words	No Citations	Abbreviations	Consistency	Past Tense	Total
1								
2								
3								
4								
5								



General Criteria:

Paper #	Hypothesis	Aim	Why is this paper important?	Not too many details	Method of investigation	State the results	Final score
1	0	0	1	1	0	1	3
2	1	1	1	0	1	1	5
3	1	1	1	1	0	0	4
4	1	1	1	1	1	1	6
5	0	1	1	1	1	1	5
6	0	1	1	1	1	1	5
7	0	1	1	1	1	1	5
8	0	1	1	1	1	1	5
9	0	1	1	0	1	1	4
10	1	0	1	1	1	1	5
11	0	1	1	0	1	1	4
12	1	1	1	0	1	1	5

Title of my term paper-Example

Student #1

- 5G Wireless Communication and Health Effects
- Big data privacy issues
- Ethical hacking ethics

Student #2

- 5G Networks and IoT
- Importance of network security cryptography encryption
- Ethical artificial intelligence and machine learning

Student #3

- Home networking environment
- Research on how AI and deep learning are changing the healthcare industry
- ETHICAL HACKING TECHNIQUES WITH PENETRATION TESTING

Accuracy	No abbreviations	Informativ e	Good length	F S
1	1	1	1	4
1	1	1	0	3
1	0	0	0	1
1	1	1	0	3
1	0	1	1	3
1	1	0	0	2
1	0	1	0	2
1	1	0	0	2
1	1	1	1	4

Final topic: ETHICAL HACKING TECHNIQUES WITH PENETRATION TESTING



Scoring the abstracts

Paper	Less than 250	1 paragraph	Past tense for own work	long words abbreviations	No citations	Final score
1	1	1	0	1	1	4
2	1	1	0	0	0	2
3	1	1	1	1	1	5
4	1	1	0	0	1	3
5	1	1	0	1	1	4
6	1	1	0	0	0	2
7	1	1	1	1	0	4
8	0	1	0	1	0	2
9	1	1	1	1	0	4



To be
continued