

Research methodology in Computer Science (AI800)

Lecture 1

Introduction to Research methodology

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Outlines

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Overview

Research is
creating new
knowledge.
Neil Armstrong

meebillie.com



Research can be undertaken in any kind of environment,
as long as you have the interest. I believe that true
education means fostering the ability to be interested
in something.

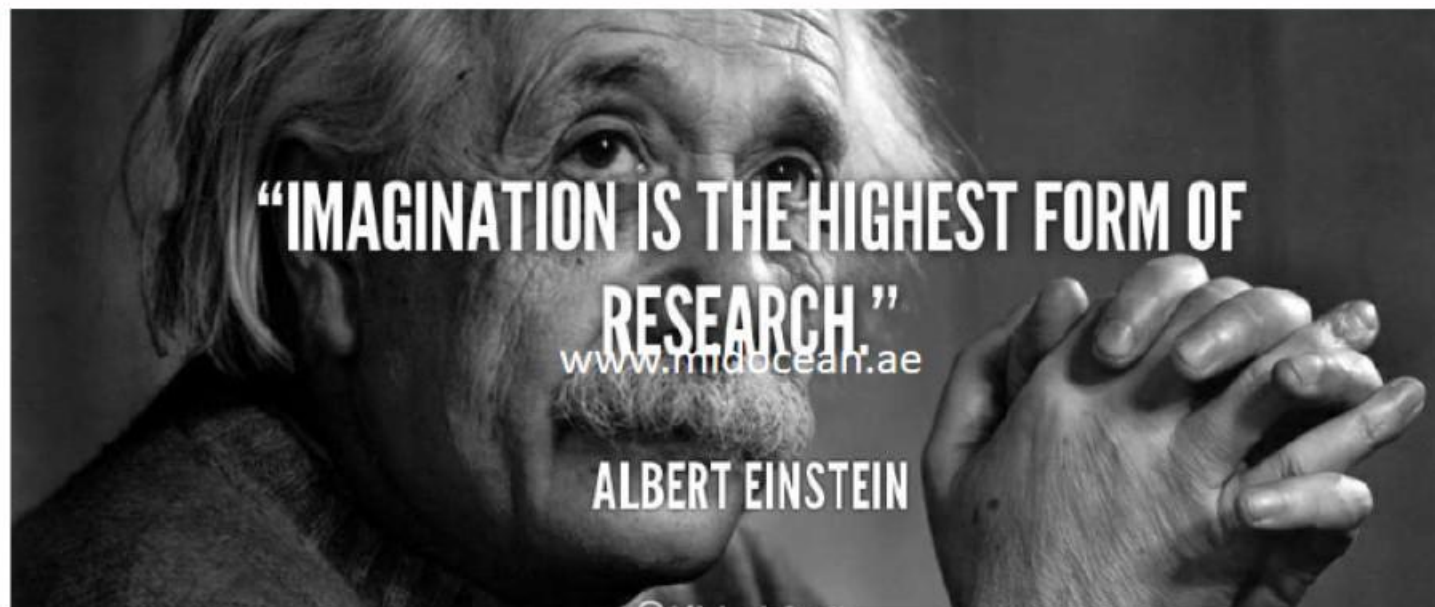
(Sumio Iijima)



Research allows me to ask questions and formulate ways to
answer them.



Overview (cont.)



Research is to see what everybody else has seen, and to think what nobody else has thought



Where to Start From?

1. Decide on a general area of interest

- Why does this area interest you?

2. Answer the questions:

- What is the aim?
- What is the hypothesis?
- Does my work have novelty?
- Why does it matter?

3. Discuss your ideas with others

- Supervisors.
- Co-Supervisors.
- Close Colleague working in your domain.

4. Other issues to consider

- Collaboration with Senior Researchers.
- Get your research proposal peer reviewed at every stage from your Supervisor/Co-Supervisor.





What is research?

- ❖ Research is an art of scientific investigation.
- ❖ Research is “Search of knowledge”- It is a scientific and systematic search for relevant information on specific topic.
- ❖ Research is an academic activity which consists of defining and redefining problems, formulating hypothesis or suggested solutions, collecting, organizing and evaluating data, making deductions and reaching conclusions and at last carefully testing the conclusions to determine whether they fit the formulating hypothesis.
- ❖ Research is an organized set of activities to study and develop a model of procedure technique to find the result of a realistic problem supported by literature and data.





Research Questions

- A research question is a clear, concise, and specific inquiry that a researcher seeks to answer through their research study or investigation.
- These questions are designed to guide the research process and help focus the study on a particular topic or issue.
- Research questions typically address what the researcher wants to explore, understand, or investigate within their study.

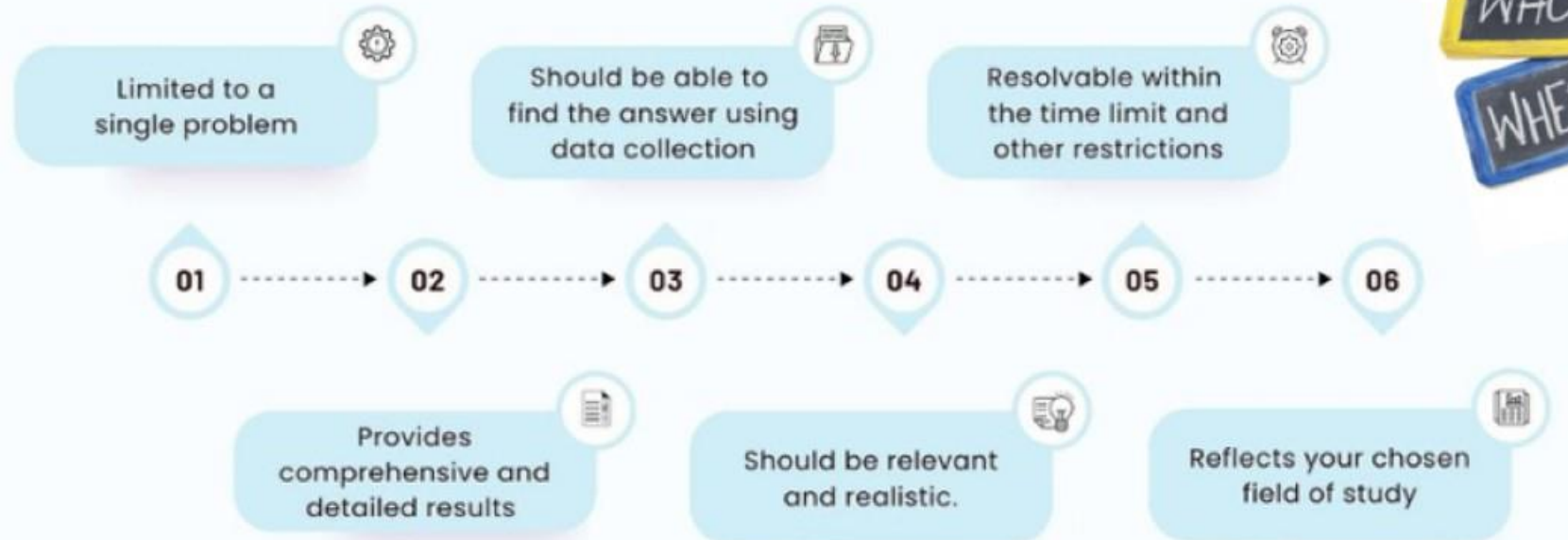


Research Questions example

- How can machine learning algorithms improve the accuracy of natural language processing tasks?
- What are the security vulnerabilities associated with Internet of Things (IoT) devices, and how can they be mitigated?
- What factors influence the adoption of new technology in healthcare settings?



Research Questions Characteristics





What is Computer Science Research?

Computer Science is a 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;
- ☐ knowledge representation and implementation.



What is Computer Science Research? (cont.)

Computer Science Research is a human activity based on the intellectual investigation of aspects of the world related to the discipline of Computer Science to discover new knowledge, interpret existing knowledge, or revise erroneous or incomplete knowledge.

Normally based on the “Scientific Method”



The Scientific Method





Research Methods

Research involves inductive and deductive methods:

- ☐ **Inductive** methods analyzes the observation of phenomenon and identify the underlying principles, structures, or processes.
- ☐ **Deductive** methods verify the assumed principles through observations.

The purposes are different: one is to develop explanations, and the other is to test the validity of the explanations. i.e., Validation of Simulation work with Experimental work



Objectives of Research

- ❑ The purpose of research is to discover answers through the application of scientific procedures.
- ❑ The objectives are:
 - To gain familiarity with a phenomenon or to achieve new insights into it- **Formulative Research.**
 - To portray accurately the characteristics of a particular individual, situation or a group -**Descriptive Research.**
 - To determine the frequency with which something occurs or with which it is associated with something else- **Diagnostic Research.**
 - To test a hypothesis of a causal relationship between variables -**Hypothesis-Testing Research.**



Attributes of Good Research Study

OBJECTIVE: A good research must answer the research question.

CONTROL: A good research must be able to control all variables.

GENERALISABILITY: Generate similar result when used other method.

BIAS FREE: Research should be free from personal bias. It should be based on objective and not on subjective matter.

SYSTEMATIC: A good research study must have various well-planned steps, i.e. all steps must be interrelated, and one step should lead to another step.



Criteria of A Good Research

1. Purpose **clearly defined**.
2. Research **process detailed**.
3. Research **design thoroughly planned**.
4. High ethical **standards applied**.
5. Limitations **frankly revealed**.
6. Suitable analysis for **decision maker's needs**.
7. Findings presented **unambiguously**.
8. Conclusions **justified**.
9. Researcher's **experience reflected**.



Types Of Research Studies

- ❑ **Descriptive research:** includes surveys and fact-finding enquiries of different kinds. It uses descriptive studies in which researcher seeks to measure characteristics like, shopping behavior, preferences, etc. Generally, survey methods are used for descriptive research.
- ❑ **Analytical research:** includes use of facts and information already available and analyze these to make a critical evaluation of the material.
- ❑ **Applied research** aims at finding a solution for an immediate problem facing a society or business organization. Marketing research, trend analysis are examples of applied research.
- ❑ **Fundamental research** is concerned with generalizations and with the formulation of the theory. Research concerning some natural phenomenon or relating to pure mathematics are examples of fundamental research.



Types Of Research Studies (cont.)

- ❑ **Quantitative research** is based on the measurement of quantity or amount. It is applicable to phenomena that can be expressed in terms of quantity. For example, questionnaire survey result.
- ❑ **Qualitative research** is concerned with qualitative phenomenon like relating to or involving the reasons or motives for human behavior. For example, word association, tests, sentence completion tests, story completion, etc.
- ❑ **Conceptual research** is that related to some abstract ideas or theory. It is generally used by philosophers and thinkers to develop new concepts or to reinterpret the existing one.
- ❑ **Empirical research** relies on experience or observation, often with some data-based research. It is necessary to get all facts and information at first hand.



Some other types of research

- ❑ **One-time Research** – Research confined to a single time.
- ❑ **Longitudinal Research** – Research carried on over several time periods.
- ❑ **Diagnostic Research** – It is also called clinical research which aims at identifying the causes of a problem, frequency with which it occurs and the possible solutions for it.
- ❑ **Exploratory Research** – It is aimed to gain familiarity with the problem, to generate new ideas or to make a precise formulation of the problem. Hence it is also known as formulative research.
- ❑ **Experimental Research** – It is designed to assess the effect of one variable on a phenomenon by keeping the other variables constant or controlled.



Research Methods and Methodology

Research Methods

Research methods may be understood as all those methods/techniques that are used for conduction of research. It refers to the methods the researcher uses in performing research operations. **Research methods** can be put into following three groups:

- ☐ Concerned with data collection
- ☐ Concerned with statistical Techniques
- ☐ Concerned with methods of evaluating the accuracy of the results obtained.

Research Methodology

Research Methodology is a way to systematically solve the research problem.

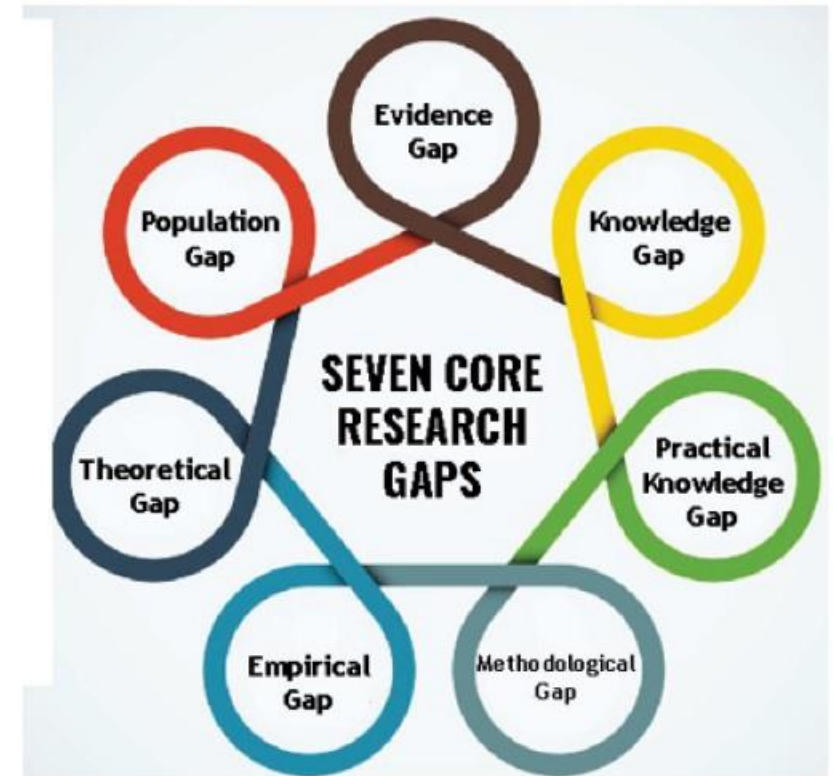
It may be understood as a science of studying how research is done scientifically. When we talk of research methodology, we do not only talk of the research methods but also the logic behind the methods we use in the context of our research.

Research Methodology has many dimensions and research methods do constitute a part of it.



Research Gap

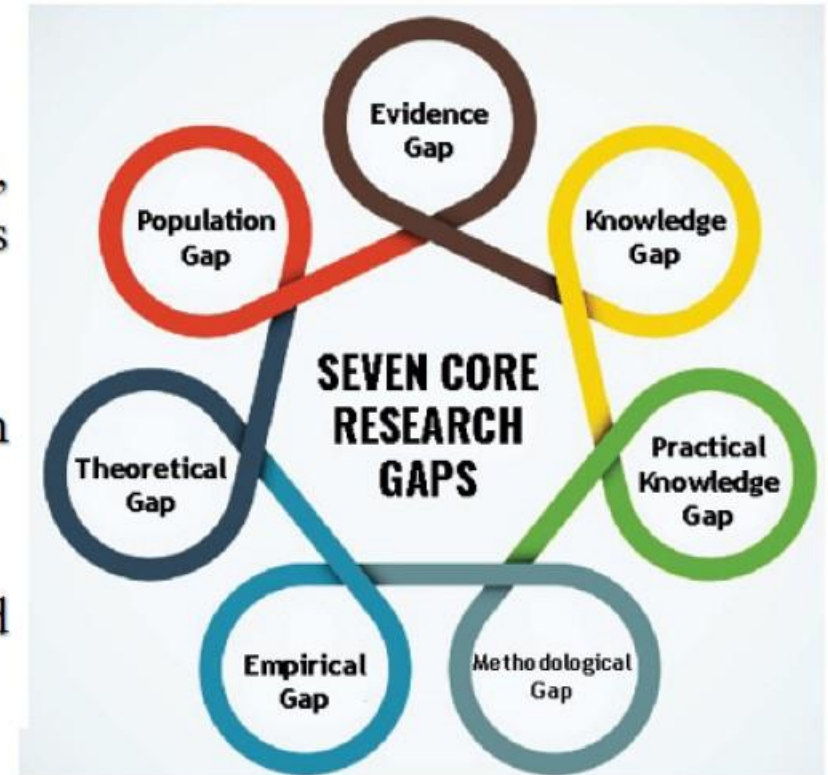
- ❑ Evidence Gap: When a new study contradicts widely accepted beliefs.
- ❑ Knowledge Gap: Two main reasons—lack of awareness about related theories and literature in the real-world context, and the possibility of survey findings deviating from expectations.
- ❑ Practical-Knowledge Gap: This type of gap sparks new research when experts' real-world behavior differs from their recommended behavior.





Research Gap (cont.)

- ❑ **Methodological Gap:** Concerns the conflict arising from the influence of research methods on study outcomes.
- ❑ **Empirical Gap:** Focuses on shortages in prior research, emphasizing the need for empirical evaluation of research results or proposals.
- ❑ **Theoretical Gap:** Involves addressing theoretical shortages in previous research.
- ❑ **Population Gap:** Highlights the recurring issue of underserved and under-researched communities in the field of research.





Problems in Research

- ☐ Uncontrollable variables
- ☐ Time and money
- ☐ Lack of computerization
- ☐ Lack of scientific training in the methodology of research
- ☐ Insufficient interaction between university research departments and business establishments
- ☐ Lack of confidence on the part of business units to give information
- ☐ Lack of code of conduct



Problems in Research(cont.)

- ☐ Difficulty of adequate and timely secretarial assistance
- ☐ Poor library management and functioning
- ☐ Difficulty of timely availability of published data.
- ☐ Ignorance



Role of Research in Decision Making

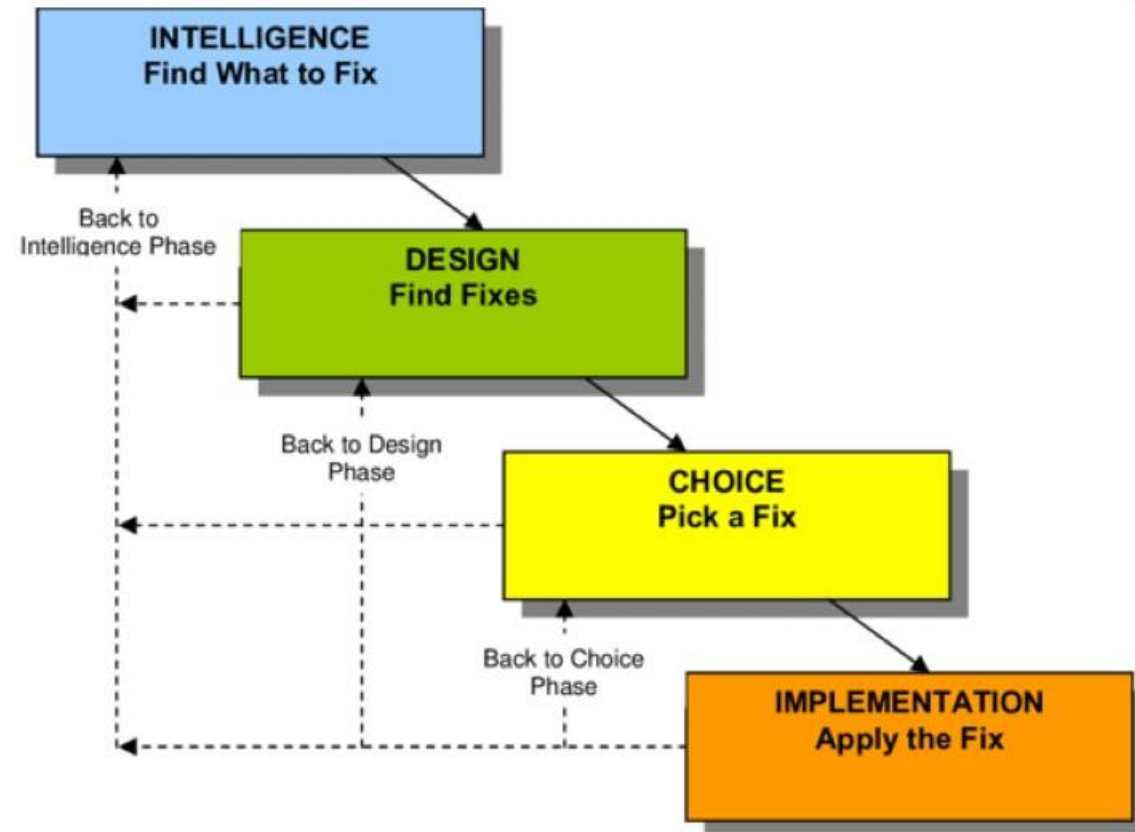
- ☐ Decision-making is the process of selecting the best alternative from the available set of alternatives.
- ☐ Management is mainly concerned with decision making and its implementation.
- ☐ These decisions should be based on appropriate studies, evaluations and observations.
- ☐ Research provides us with knowledge and skills needed to solve the problems and to meet the challenges of a fast-paced decision-making environment.



Role of Research in Decision Making (cont.)

According to Herbert A Simon, decision making involves three activities:

- ❑ **Intelligence Activity** - scanning the environment for identifying conditions necessary for the decision.
- ❑ **Designing Activity** - identifying, developing and analyzing the alternative courses of action.
- ❑ **Choice Activity** - choosing the best course of action from among the alternatives.





Research 'Musts'

- ☐ Problem must be clearly recognized
- ☐ Determine information already available and what further information is required, as well as the best approach for obtaining it
- ☐ Obtain and assess information objectively to help inform the decision



Research Process

- ☐ The research process is a systematic and organized series of steps or activities undertaken by researchers to investigate, gather information, analyze data, and generate new knowledge or insights about a specific topic or research question.
- ☐ It is a structured approach that helps researchers plan, conduct, and report their research effectively.



Research Process Steps

1. Problem Identification and Formulation
2. Reviewing of Literature
3. Research Questions, Objectives, and Hypotheses Formulations
4. Research Design
5. Deciding on the Sample Design
6. Collecting Data From The Research Sample
7. Process and Analyze the Collected Research Data
8. Writing Research Report – Developing Research Proposal, Writing Report, Disseminating and Utilizing Results





Research Process Steps (cont.)

Problem Identification and Formulation

- ❑ Finding a research problem is the first and most important step in the entire scientific research process. Describe the issue or query that needs research:
 - The problem you wish to solve or the inquiry you want to answer should be stated clearly.
 - Describe your goals and objectives. Describe the goals you have for your research.
- ❑ A clearly defined problem will help the researcher complete crucial steps in the research process, such as setting objectives and choosing the research methodology.
- ❑ Researchable issues are those that might be the subject of a thorough verification investigation that considers data analysis and gathering.



Problem Identification and Formulation(cont.)

Researchers need to identify both;

1. Non-Research Problems that may hinder the progress of their study, such as lack of funding or limited access to data.
2. Research Problem that is the focus of their study, which could be related to a gap in existing knowledge or a specific research question they aim to answer.
 1. Statement of the Problem
 2. Justifying the Problem
 3. Analyzing the Problem

Identifying and defining the research problem is crucial as it sets the foundation for the entire study and helps researchers determine the scope and objectives of their research.



Research Process Steps (cont.)

Reviewing of Literature

- ☐ Reviewing the literature helps researchers avoid duplicating previous work, learn what others have discovered about the issue, and become familiar with pertinent concepts and theories.
- ☐ Reviewing pertinent literature aids in problem formulation, background comprehension, methodology selection, and development of coherence between the study's findings and previous findings.
- ☐ Review relevant papers, articles, books, and other sources to understand the current state of knowledge in interest.
- ☐ Identify areas where existing knowledge is insufficient or where new approaches can be explored.



Literature Review



Research Process Steps (cont.)

Research Questions, Objectives, & Hypotheses

- ❑ An aim will clearly state what should be researched, outline the kinds of data that should be gathered, and offer guidelines for the study's scope. The most effective way to state a study purpose is with a well-developed, tested research hypothesis.
- ❑ A hypothesis is an unverified assertion or claim that can be disproved or confirmed by empirical evidence.
- ❑ Hypothetical claims make an assertion about a potential solution to a research question





Research Process Steps (cont.)

Research Design

- ❑ The research design serves as a guide or framework for *achieving goals* and *responding to research questions*.
- ❑ There are four basic research designs that a researcher can use to conduct their study;
 1. *Experimental design* (if applicable): Define the variables, control groups, treatments, and data collection methods for experiments.
 2. *Observational design* (if applicable): Determine how data will be collected in non-experimental settings.
 3. *Case study design* (if applicable): Specify the case(s) to be studied and the methods for data collection and analysis.
 4. *Survey design* (if applicable).
- ❑ Four *factors* primarily determine the type of research design to be used:
 1. The *type* of problem
 2. The *objectives* of the study,
 3. The *existing state of knowledge* about the problem that is being studied, and
 4. The *resources* are available for the study.

Research Design





Research Process Steps (cont.)

Collecting Data

- ❑ Determine where and how to obtain the necessary data (e.g., experiments, surveys, simulations, existing datasets).
- ❑ There are several methods for collecting data. Some common methods include interviews, questionnaires, and experiments. Additionally, data can also be collected through sources such as existing databases , online platforms and simulators.
- ❑ Take steps to validate and clean the data to minimize errors and biases.
- ❑ The goals of the study, the research design, and the availability of resources, including time, money, and personnel, all influence the data collection strategy.
- ❑ The process for collecting data also varies, depending on whether it will be **qualitative** or **quantitative**.

DATA COLLECTION





Research Process Steps (cont.)

Data Analysis

- ❑ Data Processing: Initially, data are edited and coded for uniformity and completeness.
- ❑ Data Analysis: This phase involves data reduction, summarization, pattern recognition, and the application of statistical methods to answer research questions.
- ❑ Technique Selection: Choose appropriate statistical or computational methods for data processing.
- ❑ Interpretation: Analyze findings and draw meaningful conclusions from the data.
- ❑ Hypothesis Evaluation: Based on the analysis, assess whether the findings align with formulated hypotheses and theories.





Research Process Steps (cont.)

Implementation (if applicable)

- ☐ Implementation refers to the process of putting into practice or executing a plan, idea, concept, or system. It involves taking theoretical or conceptual designs and turning them into tangible, functional realities.
- ☐ In various contexts, implementation can refer to the actual construction or development of a product, system, or solution according to established specifications and requirements.
- ☐ This phase often involves tasks such as coding, building prototypes, testing, and deploying software or hardware. It is a critical step in the project lifecycle as it brings theoretical concepts into the real world, allowing them to be used, evaluated, and refined, as necessary.
- ☐ This phase is crucial in bridging the gap between theoretical knowledge and real-world applications, allowing for the validation and refinement of research findings.



Research Process Steps (cont.)

Writing Research Report

- ❑ A research proposal is a formal document that outlines the objectives, methodology, scope, and potential outcomes of a research project. It serves as a detailed plan or blueprint for conducting research, providing a clear framework for the study.
- ❑ A research proposal must also demonstrate how it will be beneficial. There is always a description of the study's aim (the research objectives) or a statement of the issue.
- ❑ In a research proposal, the specific research methodology is methodically described, along with the steps taken at each stage of the research process.





Research Process Steps (cont.)

Conclusions

- ☐ The end goal of a scientific study is to interpret the results and draw conclusions.
- ☐ After conducting experiments, gathering data, or analyzing information, researchers must carefully interpret their findings and draw meaningful conclusions. This process involves:
 - ☐ Interpreting Results.
 - ☐ Contextualizing Findings.
 - ☐ Analyzing Relationships.
 - ☐ Addressing Limitations.
 - ☐ Drawing Conclusions.
 - ☐ Implications and Applications.
 - ☐ Suggesting Future Research.
 - ☐ Communicating Results.
- ☐ The process of interpreting results and drawing conclusions is crucial for advancing scientific knowledge. It ensures that research is conducted rigorously, and it contributes to the accumulation of reliable, evidence-based information in a given field.



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Thank You



Characteristics of Research

1. Research is **directed towards the solution of a problem.**
2. Research is **based upon observable experience or empirical evidence.**
3. Research demands **accurate observation and description.**
4. Research involves **gathering new data from primary sources or using existing data for a new purpose.**
5. Research activities are **characterized by carefully designed procedures.**
6. Research requires **expertise i.e., skill necessary to carryout investigation, search the related literature and to understand and analyze the data gathered.**
7. Research is **objective and logical – applying every possible test to validate the data collected and conclusions reached.**
8. Research **involves the quest for answers to unsolved problems.**
9. Research **requires courage.**
10. Research is **characterized by patient and unhurried activity.**
11. Research is **carefully recorded and reported.**