

Research Methodology for Engineering

Center for Computational Engineering and Networking

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Disclaimer

This content is intended solely for educational purposes and is developed with due respect and attribution to the original speakers. The material will not be used for commercial purposes, and any references to the content will properly acknowledge the contributions of the esteemed professors mentioned above. The purpose of this material is to support the academic and ethical growth of research scholars at Amrita Vishwa Vidyapeetham.

Preface

This course, developed by the Amrita School of Artificial Intelligence, supports research scholars at Amrita Campus by providing a comprehensive approach to conducting high-quality research. The course consists of four core units, guiding students from research conceptualization to ethical considerations in scholarly work.



Unit 1: The Research Process

- Introduces the research process, including formulating research questions, research design, and selecting appropriate approaches (Quantitative vs. Qualitative, Exploratory vs. Confirmatory, Experimental vs. Theoretical).
- Emphasizes the importance of reasoning and model validation in research.

Unit 2: Literature Survey

- Focuses on the importance of literature surveys, planning literature searches, identifying key concepts, and evaluating source reliability.
- Equips scholars with strategies for locating relevant literature to contextualize their research.

Unit 3: Problem Formulation and Data Analysis

- Covers experimental research, hypothesis development, causality, error analysis, and statistical design of experiments.
- Includes hands-on training with R software for statistical analysis, sampling, surveys, and interpretation of results.

Unit 4: Philosophy and Ethics in Research

- Introduces philosophy and ethics, focusing on moral philosophy, intellectual honesty, research integrity, and scientific misconduct (e.g., plagiarism, falsification).
- Discusses publication ethics, conflicts of interest, and best practices for ensuring ethical conduct in research.

By the end of the course, scholars will be equipped with both the practical skills and ethical principles necessary for conducting impactful, responsible research.

1 Fundamentals of Research

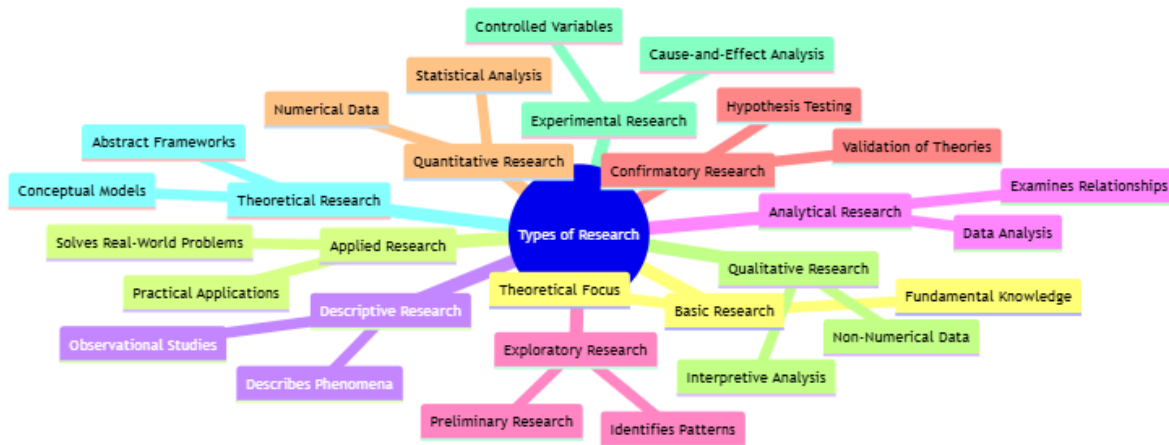
1.1 Introduction

This module introduces foundational concepts in research, including different types of research, the research process, framing research questions, research design, and reasoning approaches. By the end of this module, students will understand the essentials of conducting ethical and effective research, including the differentiation of methodologies and the appropriate contexts for each.

1.2 Types of Research

1.2.1 Approved Types of Research

In academia, research is categorized based on purpose, methods, and goals. Understanding these categories helps researchers select an appropriate methodology. A mind map of approved types of research is given below.



1. **Basic (Fundamental) Research:** Aims to expand general knowledge without immediate practical application. Often theoretical, basic research seeks to increase understanding of fundamental principles.

Example: A theoretical physics study on string theory aims to enhance understanding of the universe's structure without immediate practical application.

2. **Applied Research:** Seeks to solve practical, real-world problems by applying existing knowledge.

Case Study: A research project aiming to optimize renewable energy sources (e.g., solar or wind) for urban settings, providing solutions to real-world energy challenges.

3. **Descriptive Research:** Focuses on describing phenomena as they exist without manipulating variables. Common in fields like psychology, sociology, and market research.

Example: A study analyzing consumer preferences in online shopping behavior, collecting data on demographics, shopping frequency, and preferences without altering the environment.

4. **Analytical Research:** Uses existing data to explore new relationships and insights, typically involving statistical analysis.

Case Study: An analysis of existing health data to identify patterns in the spread of a disease, like examining historical data from past flu outbreaks to predict future trends.

5. **Exploratory Research:** Conducted to gain insight into an area with limited existing knowledge. Often serves as a preliminary step to more structured research.

Example: Interviews with social media influencers to explore how they perceive their role in modern advertising could serve as the basis for more in-depth studies on social influence.

6. **Confirmatory Research:** Conducted to confirm hypotheses or theories by testing specific predictions, often using statistical tests to validate results.

Case Study: A psychology study tests whether a new therapeutic approach reduces anxiety levels in a specific demographic, using structured methods to confirm initial hypotheses.

7. **Quantitative Research:** Involves the collection and analysis of numerical data to find patterns, test hypotheses, or make predictions. It often uses structured tools like surveys or experiments.

8. **Qualitative Research:** Focuses on exploring ideas, understanding experiences, and interpreting non-numerical data, typically collected through interviews, observations, and open-ended surveys.

1.3 Research Process

A mind map of the steps involved in a systematic research is given below.



1.3.1 Steps in the Research Process

The research process is systematic and includes multiple stages:

1. **Identify the Research Problem:** Define a clear, researchable problem based on gaps in current knowledge or specific needs.
2. **Review Literature:** Conduct a comprehensive review of existing literature to understand what is already known and identify gaps.
3. **Formulate Research Questions/Hypotheses:** Develop questions that the research will address, often leading to specific hypotheses in quantitative research.
4. **Select Research Design and Methods:** Choose the design (e.g., experimental, descriptive) and methods (e.g., surveys, experiments) that best fit the research goals.
5. **Collect Data:** Gather data according to the chosen methods, ensuring ethical standards and reliability in data collection.
6. **Analyze Data:** Use appropriate analysis tools to interpret data, drawing conclusions based on evidence.
7. **Report Findings:** Share results through publications, presentations, or reports, adhering to publication ethics.

8. **Reflect and Conclude:** Conclude with implications, limitations, and recommendations for future research.
-

1.4 Research Questions

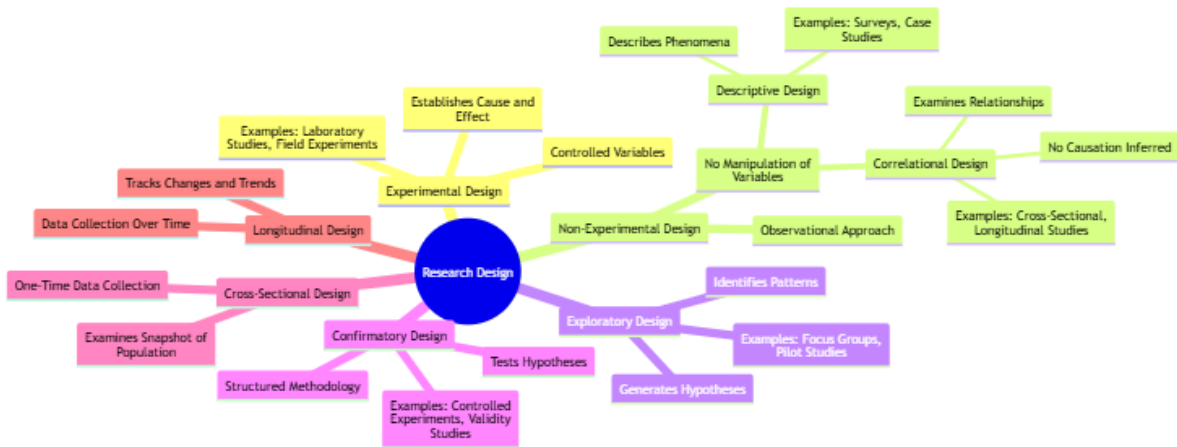
1.4.1 Importance of Research Questions

Research questions provide direction, structure, and focus to a study. Good research questions are clear, concise, and researchable. They help narrow down the study's scope and guide the choice of methodology.

Example: A study on the impact of remote work on productivity may have research questions like: - "How has remote work affected productivity in software development teams?" - "What factors contribute to productivity challenges in remote work setups?"

1.5 Research Design

A detailed mindmap of different types of research designs used in scientific research is given below.



1.5.1 Defining Research Design

Research design refers to the framework or strategy used to answer research questions. It includes decisions on data collection, analysis methods, and sampling.

Types of Research Design: - **Experimental Design:** Involves manipulation of variables to establish cause-and-effect relationships. - **Non-Experimental Design:** Includes observational studies without manipulating variables, like correlational or descriptive research.

Example: An experiment testing a new medication would assign participants to control and treatment groups to compare outcomes and establish causality.

1.6 Approaches to Research: Quantitative vs. Qualitative

1.6.1 Quantitative Approach

The quantitative approach involves collecting and analyzing numerical data. It's ideal for studies needing measurable, objective results.

Example: A survey collecting data on student test scores to examine the correlation between study time and performance.

1.6.2 Qualitative Approach

The qualitative approach focuses on non-numerical data, emphasizing understanding experiences, behaviors, and cultural contexts.

Case Study: Interviews with teachers to explore their perceptions of online teaching's challenges, analyzing responses for recurring themes and insights.

1.7 Building and Validating Theoretical Models

1.7.1 Importance of Theoretical Models

Theoretical models provide a framework for understanding phenomena and guiding research. Building and validating models ensure that the research's assumptions are grounded in reality.

Example: A climate change model predicting temperature rises based on carbon emissions, validated by comparing predictions with observed data over time.

1.7.2 Steps in Model Building and Validation

1. **Develop a Model:** Create a theoretical framework based on known principles and assumptions.
 2. **Collect Data:** Gather relevant data to test the model's assumptions.
 3. **Validate Model:** Compare model predictions with real-world data, adjusting as needed to increase accuracy.
-

1.8 Exploratory vs. Confirmatory Research

1.8.1 Exploratory Research

Exploratory research seeks to understand phenomena in a new area, often preceding more structured research.

Example: Observational research on a new social trend, such as the rise of “digital nomad” lifestyles, to identify potential areas for in-depth study.

1.8.2 Confirmatory Research

Confirmatory research tests specific hypotheses or theories, using structured methodologies to validate or refute predictions.

Case Study: Testing a hypothesis on the relationship between exercise frequency and mental health improvements in a controlled study.

1.9 Experimental vs. Theoretical Research

1.9.1 Experimental Research

Experimental research involves controlled testing of hypotheses, manipulating variables to observe effects. It's ideal for studies requiring cause-and-effect conclusions.

Example: A lab study examining the impact of a specific nutrient on plant growth by controlling conditions like sunlight and water levels.

1.9.2 Theoretical Research

Theoretical research is often abstract, focusing on concepts and frameworks without direct experimentation. It aims to build or refine models or theories.

Case Study: Research in theoretical physics, such as developing string theory, is primarily conceptual and aims to explain fundamental aspects of the universe without immediate experimentation.

1.10 Importance of Reasoning in Research

1.10.1 Types of Reasoning in Research

1. **Deductive Reasoning:** Begins with a theory or hypothesis and tests it through data collection and analysis. Common in confirmatory research.

Example: Hypothesizing that “increased exercise reduces stress,” then gathering data to confirm or refute this claim.

2. **Inductive Reasoning:** Begins with observations and patterns to develop a theory. Often used in exploratory research.

Example: Observing a trend in data suggesting that social media use increases in urban areas, then theorizing about its causes.

3. **Abductive Reasoning:** Combines both deductive and inductive approaches, focusing on forming plausible explanations based on incomplete information.

Case Study: A health researcher finds a link between dietary habits and disease rates, theorizing that lifestyle factors influence the correlation, though not all evidence is available.

1.10.2 Role of Reasoning in Validating Research Findings

Effective reasoning supports valid conclusions and ensures that findings are robust and generalizable. The choice of reasoning method should align with the research goals and design.

1.11 Summary

This module provided a foundation in research fundamentals, including understanding types of research, the research process, forming research questions, and distinguishing between quantitative and qualitative approaches. Additionally, it outlined the importance of reasoning and various research designs, guiding researchers in making ethical, well-informed decisions.

The next module will delve into more specific ethical considerations in research practices, emphasizing integrity, transparency, and accountability in the research process.

2 Literature Survey Process

2.1 Introduction

Literature review is the second step in any series research work. In scientific research, a literature review, also known as a relevant review of the literature (RRL), is an objective and critical summary of scholarly sources related to a specific research topic. It acts as a survey of current knowledge, contextualizing the research problem within the existing body of research and identifying gaps that future studies can address. Within the introduction section of a research paper, the literature review serves several key purposes:

1. Introduces the topic and establishes its significance:

It captures the reader's interest and highlights the importance of the research area.

2. Provides an overview of relevant literature:

It summarizes existing research findings and theories related to the topic.

3. Identifies knowledge gaps:

It pinpoints areas where existing research is lacking or contradictory, paving the way for new research questions.

4. Positions the study within the field:

It establishes the context for the study and demonstrates how it builds upon or challenges existing knowledge.

5. Illustrates how the study will advance knowledge:

It explains how the proposed research will address the identified gaps and contribute to the field.

i What is a literature review?

A Literature Review is a systematic and comprehensive analysis of books, scholarly articles, and other sources relevant to a specific topic providing a base of knowledge on a topic. Literature reviews are designed to identify and critique the existing literature on

a topic to justify your research by exposing gaps in current research. This investigation should provide a description, summary, and critical evaluation of works related to the research problem and should also add to the overall knowledge of the topic as well as demonstrating how your research will fit within a larger field of study. A literature review should offer a critical analysis of the current research on a topic and that analysis should direct your research objective. This should not be confused with a book review or an annotated bibliography both research tools but very different in purpose and scope. A Literature Review can be a stand-alone element or part of a larger end product, know your assignment. The key to a good Literature Review is to document your process.

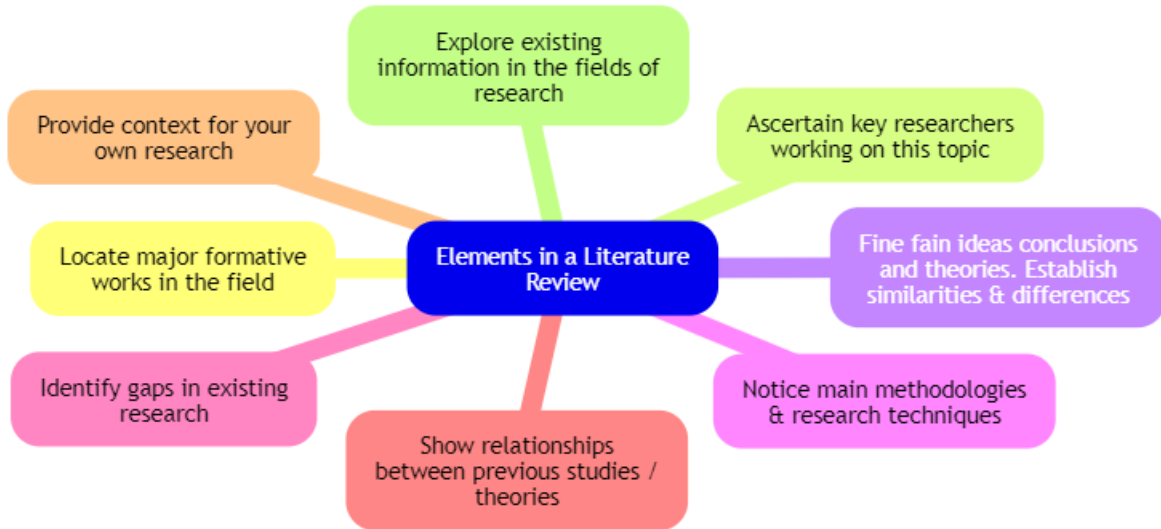
2.2 Elements of Literature review

A literature review is a critical analysis of existing research on a specific topic. To conduct a thorough and effective review, it's essential to consider the following components:

1. *Locate major formative works in the field:* Identify the seminal studies that have significantly shaped the current understanding of your topic. These foundational works provide a historical context and establish the key concepts and theories.
2. *Ascertain key researchers working on this topic:* Identify the leading experts in the field and their contributions. Their work can offer valuable insights, methodologies, and perspectives.
3. *Fine tune ideas conclusions and theories. Establish similarities & differences:* Analyze the key concepts, theories, and findings presented in the literature. Compare and contrast different perspectives to identify similarities, differences, and potential contradictions.
4. *Notice main methodologies & research techniques:* Examine the research methods used in the studies, such as quantitative or qualitative approaches, data collection techniques, and analysis methods. This will help you understand the strengths and limitations of different research designs.
5. *Identify gaps in existing research:* Analyze the literature to identify areas where research is lacking or inconsistent. These gaps can highlight potential avenues for your own research.
6. *Show relationships between previous studies / theories:* Examine how different studies and theories connect to each other. This will help you understand the broader context of your research and identify potential areas for synthesis or integration.
7. *Provide context for your own research:* Position your own research within the broader context of the existing literature. Explain how your study contributes to the field and addresses any identified gaps.

8. *Explore existing information in the fields of research:* Delve deeper into the specific areas of research related to your topic. This will help you gain a comprehensive understanding of the current state of knowledge and identify potential collaborators or resources.

These eight elements of an effective literature survey is shown in the following mind map.



2.3 Key points to be taken care while planning a literature survey

A literature survey is a critical analysis of existing research on a particular topic. It provides a foundation for understanding the current state of knowledge, identifying research gaps, and establishing the context for your own research.

2.4 Key Points

2.4.1 Define the Scope

Clearly outline the specific topic, timeframe, and geographical area you want to focus on.

2.4.2 Develop a Search Strategy

Identify relevant keywords, databases, and search operators to locate relevant literature.

2.4.3 Establish Inclusion and Exclusion Criteria

Determine the specific criteria that studies must meet to be included or excluded from your review.

2.4.4 Consider the Quality of Sources

Prioritize peer-reviewed articles from reputable journals. Consider the publication date and research methodologies used in the studies.

2.4.5 Organize Your Findings

Group similar studies or findings together, identify overarching themes, and compare and contrast different studies.

2.4.6 Evaluate the Evidence

Critically analyze each study, assess its strengths and weaknesses, and identify potential biases or limitations.

2.4.7 Identify Gaps in the Literature

Pinpoint areas where existing research is lacking or inconsistent, and suggest potential avenues for future research.

2.4.8 Write a Clear and Concise Summary

Highlight the most important conclusions from your survey and discuss their implications for the field.

A mindmap to keep as a ready-reckener for future research planing is shown below.



Figure 2.1: Mindmap of Research Planning

i Layers of Knowledge

It is important to think of knowledge in a given field as consisting of three layers.

- First, there are the primary studies that researchers conduct and publish.
- Second, are the reviews of those studies that summarize and offer new interpretations built from and often extending beyond the original studies.
- Third, there are the perceptions, conclusions, opinions, and interpretations that are shared informally that become part of the lore of the field.

In composing a literature review, it is important to note that it is often this third layer of knowledge that is cited as “true” even though it often has only a loose relationship to the primary studies and secondary literature reviews.

while literature reviews are designed to provide an overview and synthesis of pertinent sources you have explored, there are several approaches to how they can be done, depending upon the type of analysis underpinning your study. Listed below are definitions of types of literature reviews:

2.5 Types of Literature Reviews

A mindmap of types of Literature reviews with characteristics is shown in the following figure and the explanation follows.



Figure 2.2: Mindmap of Types of Literature Review

1. **Argumentative Review:** This form examines literature selectively in order to support or refute an argument, deeply embedded assumption, or philosophical problem already established in the literature. The purpose is to develop a body of literature that establishes a contrarian viewpoint. Given the value-laden nature of some social science research [e.g., educational reform; immigration control], argumentative approaches to analyzing the literature can be a legitimate and important form of discourse. However, note that they can also introduce problems of bias when they are used to make summary claims of the sort found in systematic reviews.
2. **Integrative Review:** Considered a form of research that reviews, critiques, and synthesizes representative literature on a topic in an integrated way such that new frameworks and perspectives on the topic are generated. The body of literature includes all studies that address related or identical hypotheses. A well-done integrative review meets the same standards as primary research in regard to clarity, rigor, and replication.
3. **Historical Review:** Few things rest in isolation from historical precedent. Historical reviews are focused on examining research throughout a period of time, often starting

with the first time an issue, concept, theory, phenomenon emerged in the literature, then tracing its evolution within the scholarship of a discipline. The purpose is to place research in a historical context to show familiarity with state-of-the-art developments and to identify the likely directions for future research.

4. **Methodological Review:** A review does not always focus on what someone said [content], but how they said it [method of analysis]. This approach provides a framework of understanding at different levels (i.e. those of theory, substantive fields, research approaches, and data collection and analysis techniques), enables researchers to draw on a wide variety of knowledge ranging from the conceptual level to practical documents for use in fieldwork in the areas of ontological and epistemological consideration, quantitative and qualitative integration, sampling, interviewing, data collection and data analysis, and helps highlight many ethical issues which we should be aware of and consider as we go through our study.
5. **Systematic Review:** This form consists of an overview of existing evidence pertinent to a clearly formulated research question, which uses pre-specified and standardized methods to identify and critically appraise relevant research, and to collect, report, and analyze data from the studies that are included in the review. Typically it focuses on a very specific empirical question, often posed in a cause-and-effect form, such as “To what extent does A contribute to B?”
6. **Theoretical Review:** The purpose of this form is to concretely examine the corpus of theory that has accumulated in regard to an issue, concept, theory, phenomenon. The theoretical literature review help establish what theories already exist, the relationships between them, to what degree the existing theories have been investigated, and to develop new hypotheses to be tested. Often this form is used to help establish a lack of appropriate theories or reveal that current theories are inadequate for explaining new or emerging research problems. The unit of analysis can focus on a theoretical concept or a whole theory or framework.

2.6 Identifying Key Concepts and Keywords for Literature Review

One of the first tasks when conducting a literature review is to *clearly identify the research topic or question*. This step involves a comprehensive understanding of the topic, breaking it down into smaller components, and identifying key concepts that will form the foundation of the literature search.

To begin with, the researcher needs to understand the broader research field and the specific problem they intend to solve. For example, a study focused on improving solar panel efficiency using advanced materials requires an understanding of both solar technology and material science. These broad topics provide the groundwork for narrowing down the scope

and identifying the key concepts such as solar efficiency, material properties, and energy conversion. A well-defined topic enables the researcher to break down the research question into its component parts, identifying the main ideas that will guide the literature search.

Once the research question has been clarified, it should be *broken down into its fundamental components*. Typically, these components are the essential nouns or noun phrases that represent the focus of the research. This step ensures that every relevant aspect of the question is examined. For instance, in a study asking, “What is the effect of renewable energy integration on grid stability?”, the main components would be renewable energy (the broad area), power grid (the context), and grid stability (the outcome). By dissecting the research question, the researcher can form a more targeted approach to their literature search, ensuring that no critical areas are overlooked.

The next step involves *identifying the key concepts*, which are the cornerstone ideas directly related to the research problem. These key concepts are central to the research and should reflect the primary focus areas. For example, in a study on predictive maintenance using machine learning in industrial robots, the key concepts might be predictive maintenance, machine learning, and industrial robots. These concepts guide the researcher in identifying the most relevant literature, theories, and models that apply to their area of study.

Synonyms and alternative phrases for each key concept must also be considered to capture a broader range of literature. Different researchers may use varied terminology for similar concepts, so it’s essential to consider all possible variations. Taking renewable energy as an example, synonyms such as green energy, clean energy, sustainable energy, and alternative energy sources should be used to ensure a comprehensive search. Similarly, the term machine learning might also be represented by terms like artificial intelligence, predictive algorithms, or neural networks. Using a variety of synonyms and alternative phrases in the literature search increases the likelihood of retrieving relevant studies that might otherwise be missed.

Boolean operators play a crucial role in refining the literature search. These operators — AND, OR, and NOT — *are used to combine or exclude specific keywords in a search*, helping to narrow down or broaden the results. For instance, using AND in the query “renewable energy AND grid stability” will retrieve studies that discuss both renewable energy and grid stability together, while using OR in “renewable energy OR alternative energy sources” will provide results for either term. Excluding unrelated topics can also be done using NOT, as in “renewable energy NOT fossil fuels,” which will eliminate studies focused on fossil fuels. Effectively utilizing Boolean operators allows researchers to fine-tune their search and yield more focused and relevant results.

In addition to Boolean operators, *truncation and wildcards* are powerful tools in literature searching. Truncation involves using a symbol, usually an asterisk (*), to search for multiple word forms. For example, searching for “optim” will return results for optimize, optimization, and optimizing. Wildcards, on the other hand, allow the researcher to search for words with various spellings, such as “colo*r” to capture both color and colour. This technique ensures that different word forms and spellings do not lead to missed relevant studies.

Building a keyword list is another essential step in organizing a literature search. After identifying key concepts and their synonyms, the researcher should create a list of keywords. This list must cover the primary terms and their variations to ensure that the search is thorough and inclusive. For instance, for a study on data privacy in cloud computing systems, the keyword list might include terms like data privacy, cloud security, encryption, cloud storage, confidential computing, and GDPR (General Data Protection Regulation). Having a well-structured keyword list allows the researcher to run an organized and efficient literature search across databases.

It's also crucial to *search in specialized databases* relevant to the field of study. Different disciplines have dedicated databases that house specialized research. For example, engineering research may require the use of IEEE Xplore, while medical research might rely on PubMed or Medline. These databases focus on high-quality, field-specific studies and can provide more accurate and reliable information for the literature review. For example, a mechanical engineering researcher might use IEEE Xplore to search for studies related to robotics or automation, while a medical researcher investigating clinical trials may turn to PubMed or the Cochrane Library. Choosing the appropriate database is key to finding relevant and valuable studies.

After conducting the initial search, the results need to be *carefully reviewed* to determine their relevance to the research question. Titles, abstracts, and keywords should be examined to assess whether the articles align with the research objectives. If the results are not as relevant as expected, the researcher may need to refine their search strategy by adjusting keywords, adding Boolean operators, or excluding certain topics. For instance, if a search for machine learning AND predictive maintenance returns too many general results on machine learning, refining the search with a more specific term, such as in industrial robots, can help narrow the focus. This process of reviewing and refining the search ensures that the literature review is focused and that the most relevant studies are included.

2.7 Open Source Tools for Literature Review

When conducting a literature review, it's crucial to use the right tools to help streamline the process of gathering, organizing, and analyzing literature. Below are some excellent open-source tools that assist researchers in identifying key concepts, building keyword lists, conducting comprehensive searches, and managing literature.

2.7.1 Zotero

Zotero is an open-source reference management tool that helps researchers collect, organize, cite, and share research sources. Its ability to recognize content from databases, websites, and journals allows for automatic extraction of metadata, making it easier to organize literature. Researchers can create collections of articles, add tags, and categorize references according to

key concepts or research themes. Zotero's integrated search and tagging features help with keyword organization and identifying related sources.

2.7.1.1 Key Features

- Automatic bibliography creation in various citation formats.
- Customizable tagging and search functionality for organizing literature.
- Browser extensions for easy collection of articles from the web.
- Integration with word processors for seamless referencing.

2.7.2 JabRef

JabRef is a BibTeX reference manager that helps researchers organize and manage their references in an open-source environment. It is especially useful for L^AT_EX users but supports other formats. JabRef's search feature can be used to find literature based on key concepts and keywords. It also allows researchers to attach keywords and annotations to each reference for better organization and tracking.

2.7.2.1 Key Features

- Integration with various scientific databases like Google Scholar, Springer, and IEEE.
- Organization of references using custom fields and keyword annotations.
- Cross-platform and suitable for L^AT_EX users.
- Import and export capabilities for various citation formats.

2.7.3 Publish or Perish

Publish or Perish is an open-source software that retrieves and analyzes academic citations. It uses Google Scholar, Crossref, PubMed, and other databases to extract citation data for research papers. This tool is useful for conducting keyword-based searches and evaluating the impact of literature using citation metrics, helping identify key studies that align with research concepts.

2.7.3.1 Key Features

- Searches across databases like Google Scholar, Microsoft Academic, PubMed, and more.
- Comprehensive citation analysis, including metrics like h-index and g-index.
- Helps identify the most cited and relevant literature related to key concepts.

2.7.4 Connected Papers

Connected Papers is an open-source tool designed to help researchers discover relevant papers in their field. By inputting a seed paper (based on identified key concepts or keywords), Connected Papers builds a graph of related works, helping researchers visually explore how studies are interconnected. This is particularly useful for identifying additional literature that may not surface during traditional keyword searches.

2.7.4.1 Key Features

- Visual representation of related academic papers in a graph format.
- Discover hidden connections between research papers based on a seed paper.
- Identifies foundational and influential works in a specific research area.

2.7.5 Mendeley

Mendeley is a free reference manager and academic social network that helps organize research papers, collaborate online, and discover the latest research trends. It allows users to annotate PDFs, organize research libraries, and search for relevant literature based on keywords and tags. Mendeley also suggests related articles based on the contents of the library, enhancing the literature search process.

2.7.5.1 Key Features

- PDF reader and annotation tools.
- Automatic extraction of citation details and organizing papers into folders.
- Social networking feature for discovering and sharing papers.
- Browser plugin to capture citations from websites.

2.7.6 Docear

Docear is an open-source academic literature management tool that integrates mind mapping and reference management. It helps researchers organize their literature and notes in a mind map structure, which can be particularly useful for identifying key concepts and tracking related works. Researchers can build a visual representation of their literature and keep track of keywords, concepts, and research themes.

2.7.6.1 Key Features

- Unique mind mapping feature to organize thoughts, literature, and annotations.
- Comprehensive PDF management and annotation.
- Integration with BibTeX for L^AT_EX users.
- Helps organize literature in hierarchical structures based on research questions.

2.7.7 OpenThesaurus

OpenThesaurus is a useful tool for expanding your keyword list. It provides synonyms and related terms for words, helping researchers to enhance their search queries by finding alternative expressions. This is especially helpful when trying to ensure the inclusion of all relevant literature in a keyword-based search.

2.7.7.1 Key Features

- Provides synonyms and alternative terms for keywords.
- Enhances search queries with broader or related terms.
- Open-source and web-based, easy to access.

2.7.8 Voyant Tools

Voyant Tools is an open-source text analysis and visualization tool that helps researchers analyze large volumes of text data. For literature reviews, it can process large collections of research papers to identify frequently occurring terms, key phrases, and trends, providing insights into the main themes within the body of literature.

2.7.8.1 Key Features

- Analyzes large text datasets and identifies frequently occurring keywords.
- Provides visualizations, including word clouds, trends, and topic modeling.
- Helps identify key concepts and terms within a corpus of literature.

A table of popular literature search tools are shown in following table.

Tool	Description	Key Features	Website
Zotero	A free tool for managing and sharing research sources.	Reference management, citation generation, supports multiple formats, collaborative features.	zotero.org

Tool	Description	Key Features	Website
JabRef	A reference manager for BibTeX and BibLaTeX databases.	Citation management, integrates with LaTeX, advanced search and filtering options.	jabref.org
Mendeley	Reference manager and academic social network for organizing research.	Reference management, PDF annotation, citation generation, collaboration tools.	mendeley.com
Docear	An academic literature management tool that includes a mind-mapping feature.	Integrated literature management, mind-mapping, PDF annotation, reference organization.	docear.org
Publish or Perish	Software that retrieves and analyzes academic citations to provide various metrics.	Citation analysis, various metrics (e.g., h-index, g-index), data export capabilities.	harzing.com
Connected Papers	A tool for exploring and visualizing the relationships between research papers.	Graph-based visualization, discovery of related papers, interactive exploration.	connectedpapers.com

In the next section, we will focus on the role of reliability of knowledge sources in research.

2.8 Role of Reliability of a Literature Source

In academic research, the reliability of a literature source plays a crucial role in determining the credibility and validity of the research outcomes. Reliability refers to the trustworthiness of the information, consistency in the presentation of facts, and adherence to scholarly standards. Using unreliable sources can lead to faulty assumptions, misinterpretations, and incorrect conclusions, which may invalidate research efforts.

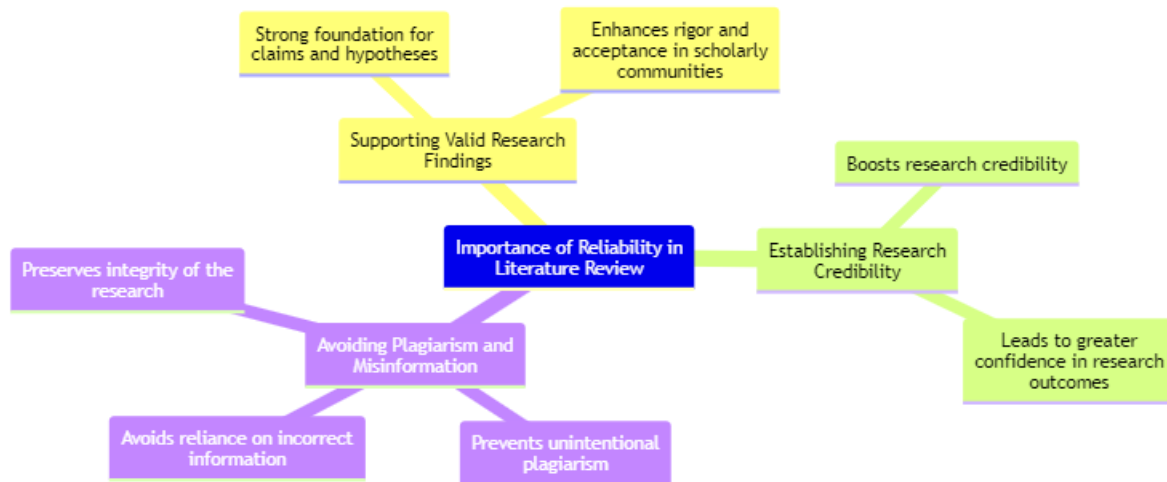
Reliable literature sources often come from established and peer-reviewed journals, respected authors, and well-known publishers. They exhibit consistency across multiple studies, provide transparent data and methodologies, and typically withstand critical scrutiny by the academic community. Conversely, unreliable sources may contain biased, outdated, or inaccurate information, and lack proper references or peer review.

2.8.1 Importance of Reliability in Literature Review

1. **Supporting Valid Research Findings:** Reliable sources provide a strong foundation for supporting the claims and hypotheses of a research project. This enhances the rigor and acceptance of the research in scholarly communities.

2. **Establishing Research Credibility:** Citing reliable sources boosts the credibility of the research, leading to greater confidence in its outcomes.
3. **Avoiding Plagiarism and Misinformation:** Unreliable sources may lead to unintentional plagiarism or reliance on incorrect information, which can severely undermine the integrity of the research.

A mindmap for easy recollection is shown here:



2.8.2 How to Identify Reliable Sources

- **Peer-Reviewed Journals:** Articles published in peer-reviewed journals are often more reliable, as they have undergone rigorous evaluation by experts.
- **Publisher Reputation:** Books or papers published by reputable academic institutions or publishers like Springer, Elsevier, or IEEE are generally considered reliable.
- **Citations and References:** Reliable sources often cite a broad range of previous work, which demonstrates thorough research and knowledge of the field.
- **Updated Information:** Reliable sources contain up-to-date information and address current developments in the field.
- **Author's Credentials:** The credibility and expertise of the author are significant indicators of the reliability of a source. Researchers with strong academic backgrounds are typically more trustworthy.

2.9 Checking the Authenticity of Sources Using Open Source Tools

Open-source tools can help researchers assess the authenticity and credibility of literature. Below are some tools that can be used for this purpose:

2.9.1 Google Scholar Metrics

Google Scholar provides citation counts, which indicate how many other researchers have cited a particular article. Highly cited works tend to be more reliable as they are often scrutinized and used by other researchers.

How to use: - Search for the article in Google Scholar. - Check the citation count and h-index of the journal where it is published. - Higher citations and reputable journal rankings generally indicate reliable sources.

2.9.2 Scite

Scite is an open-source tool that helps verify how research papers have been cited. It provides context for citations, showing whether a paper has been supported, disputed, or mentioned neutrally. This allows researchers to assess whether the findings of a paper are widely accepted or contested.

How to use: - Enter the DOI of a research paper on the Scite platform. - Review how other researchers have cited the paper, including positive or critical evaluations.

Table of popular authenticity checking open source platforms.

Tool	Description	Website
Google Scholar Metrics	Provides citation counts to indicate the number of times an article has been cited by other researchers.	scholar.google.com
Scite	Verifies how research papers have been cited, providing context for whether citations are supportive, disputed, or neutral.	scite.ai
Unpaywall	Provides access to open-access versions of academic articles, ensuring authenticity and accessibility.	unpaywall.org
Dimensions	Offers citation analysis and journal impact information, providing insights into source credibility.	dimensions.ai

Tool	Description	Website
CrossRef	Provides DOI lookup services to verify the legitimacy and publication details of articles and journals.	crossref.org
OpenCitations	Provides citation data from openly available sources to analyze citation networks and influence.	opencitations.net
Plagiarism Checkers	Tools for checking whether sources have been plagiarized or properly cited.	turnitin.com / plagscan.com

2.9.3 Unpaywall

Unpaywall is a tool for accessing open-access versions of academic articles. It ensures that the literature you are citing is authentic and accessible from legitimate sources.

How to use: - Install the Unpaywall browser extension. - When browsing an article on a publisher's page, Unpaywall will show if there's a legal, free-to-read version of the paper available.

2.9.4 Dimensions

Dimensions is a freely available research database offering insights into citation analysis and journal impact. It provides citation counts, journal ranks, and detailed information about the authors, allowing you to assess the credibility of a source.

How to use: - Search for a paper or author on the Dimensions platform. - Review citation metrics, journal impact scores, and other details to verify the reliability of the source.

2.9.5 CrossRef

CrossRef is a non-profit organization that provides DOI (Digital Object Identifier) lookup services. It allows researchers to verify the legitimacy and publication details of articles and journals.

How to use: - Enter the DOI on the CrossRef website to retrieve metadata about the article, including the publication date, journal, and author details. - Ensure the article is linked to a reliable journal or publisher.

2.9.6 OpenCitations

OpenCitations is a tool that provides citation data from openly available sources. Researchers can use it to check the citation network of a particular paper and its influence in the field.

How to use: - Search for the paper or author on OpenCitations. - Analyze the citation network to see how widely the paper has been cited and in what contexts.

2.9.7 Plagiarism Checkers (Turnitin, Plagscan)

While not entirely open-source, some plagiarism checkers have free or open-access features that can help verify whether a source has been plagiarized or if it has been properly cited.

How to use: - Submit a paper or excerpt to the plagiarism checker to identify any issues related to authenticity. - Ensure proper attribution to original sources by reviewing the generated report.

2.10 Unit summary

A **literature review** is a critical part of any research project, ensuring that the researcher builds on a foundation of existing knowledge. It allows the researcher to understand the current state of research, identify gaps, and position their work within the broader academic conversation.

2.10.1 Importance of Literature Survey

A literature survey is essential for establishing a comprehensive understanding of the topic. It helps researchers avoid duplication, build on previous work, and refine research questions by learning from others' successes and mistakes. An effective literature review ensures that research is informed, relevant, and aligned with the current academic discourse.

2.10.2 Planning a Literature Survey

The first step in planning a literature survey involves setting clear objectives. Researchers should begin by identifying their research problem or research question. Understanding the scope of the topic allows for focused exploration of the relevant literature. A well-planned review prevents the researcher from becoming overwhelmed by the vast amount of information available.

2.10.3 Identifying Key Concepts and Keywords

Identifying key concepts and keywords is crucial for a successful literature search. These keywords stem from the research problem and are pivotal in locating relevant sources. By brainstorming, reviewing existing literature, and defining the key variables, researchers can generate a list of terms to use in search databases, increasing the efficiency and relevance of their search.

2.10.4 Locating Relevant Literature

Once keywords are identified, researchers can use various academic databases like Google Scholar, IEEE Xplore, or PubMed to find relevant literature. A systematic approach to searching ensures that researchers locate the most pertinent articles, journals, and books for their work. Using advanced search options, citation networks, and reference lists can help in discovering high-quality sources.

2.10.5 Reliability of Sources in Research

The reliability of literature sources is critical for ensuring credible and trustworthy research findings. Researchers should prioritize peer-reviewed journals, works from reputable authors and publishers, and sources with high citation counts. Open-source tools like **Google Scholar Metrics**, **Scite**, and **Unpaywall** can help verify the credibility and authenticity of sources. These tools offer citation data, access to free versions of papers, and insights into how the research has been received and cited by others in the academic community.

Unit summary flowchart

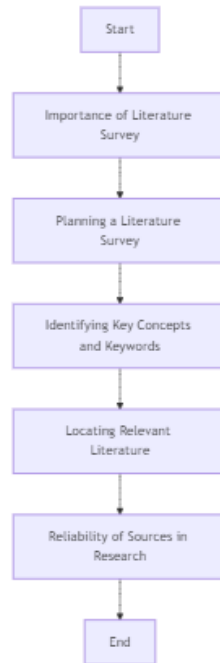


Figure 2.3: Unit Summary

3 Research Design, Data Analysis, and Statistical Modelling

3.1 Introduction

This unit introduces essential concepts for conducting experimental research, with a focus on problem formulation, modeling, simulation, data collection, and statistical analysis using R-software. The content equips engineering students with the knowledge to design and analyze experiments, interpret results, and apply statistical methodologies in real-world engineering projects.

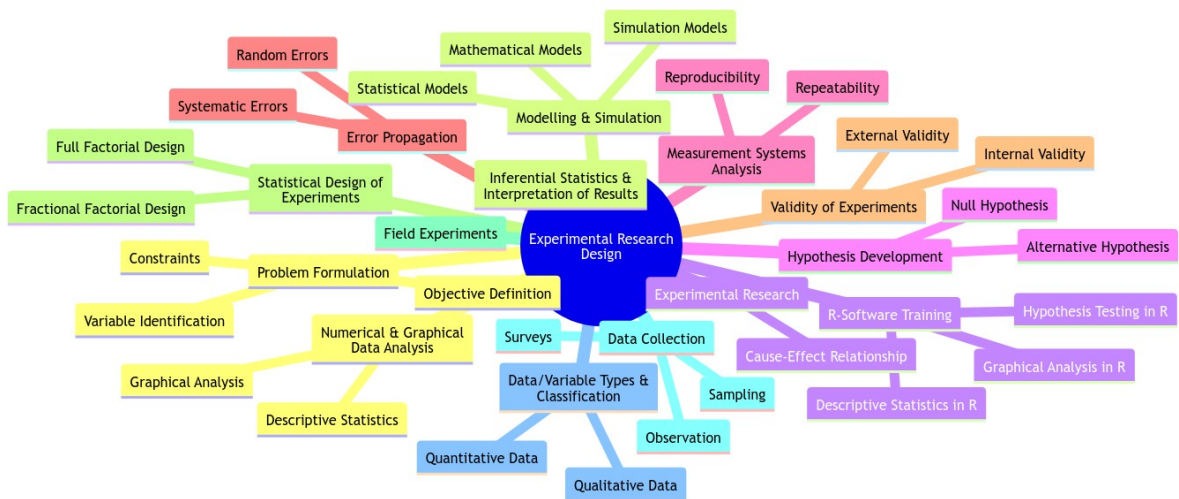


Figure 3.1: Mindmap of the unit

3.1.1 Problem Formulation

In engineering research, problem formulation is the foundation of any experiment or study. It involves defining the research objective, understanding system behavior, and identifying variables and constraints. Well-formulated problems lead to efficient experiment designs and meaningful conclusions.

Steps in Problem Formulation:

1. *Objective Definition*: Clearly state the purpose of the experiment or study.
2. *Variable Identification*: Determine the dependent (response) and independent (input) variables.
3. *Constraints*: List the practical and theoretical limitations (e.g., resources, physical conditions).

3.1.2 Objective Definition

To begin with, the researcher needs to clearly define the objective of their study. A well-defined objective guides the entire research process and ensures that the study addresses specific questions effectively. For instance, consider a study aimed at evaluating the effectiveness of a new medication. The objective could be to determine whether this new medication significantly improves patient outcomes compared to a placebo. By setting a clear objective, researchers establish a focus that will help in setting precise goals, formulating hypotheses, and designing the experiment.

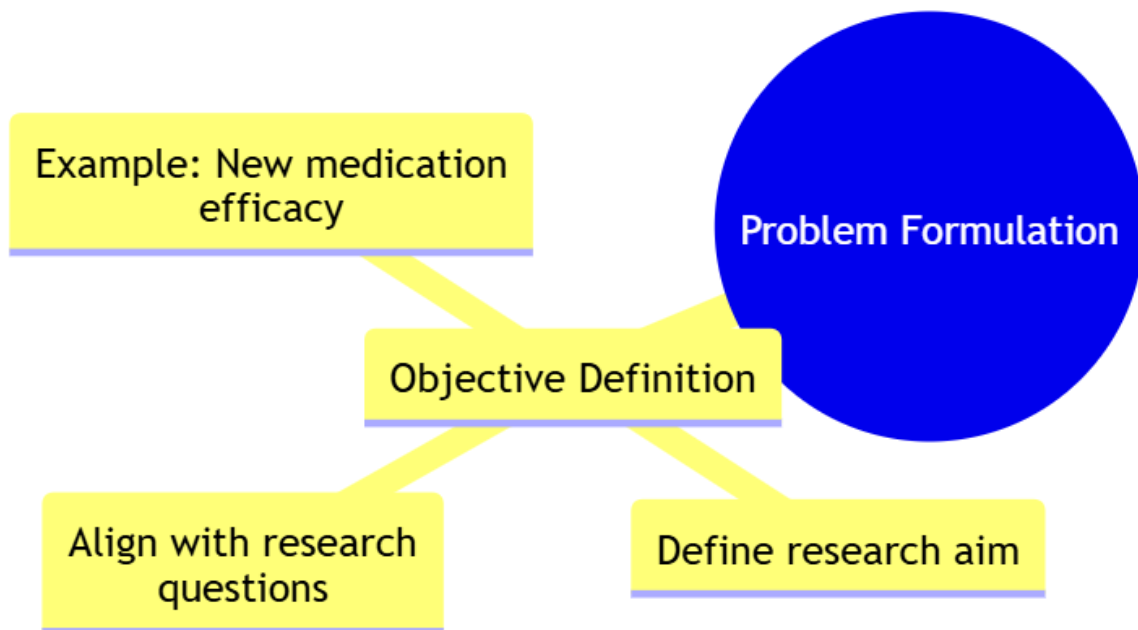


Figure 3.2: Mindmap on problem formulation.

3.1.3 Variable Identification

Identifying variables is crucial for designing an effective experiment. Variables are classified into independent, dependent, and control categories. The independent variables are those that are manipulated by the researcher, while dependent variables are the outcomes measured in response to these manipulations. Control variables are kept constant to ensure that they do not affect the results.

For example, in a clinical trial investigating a new drug, the independent variable could be the dosage of the drug administered, the dependent variable could be the reduction in symptoms, and control variables might include factors like the age and gender of participants. By carefully identifying and controlling these variables, researchers can isolate the effects of the independent variables on the dependent variables.

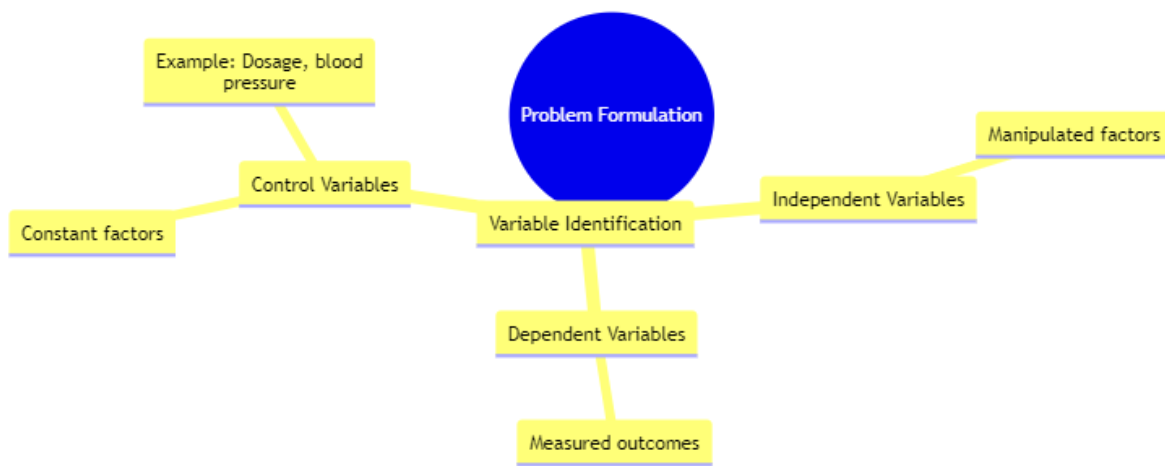


Figure 3.3: Variable Identification Steps

3.1.4 Constraints

Constraints are limitations that affect the research design and implementation. These could be related to budget, time, or resources. Identifying constraints helps researchers plan a feasible study and manage expectations realistically.

For instance, if a research project is constrained by a limited budget, it may be necessary to reduce the number of participants or simplify the experimental design. Similarly, time

constraints might affect the duration of the study or the complexity of the data collection process. Understanding these constraints is essential for developing a practical research plan that can achieve meaningful results within the available resources.

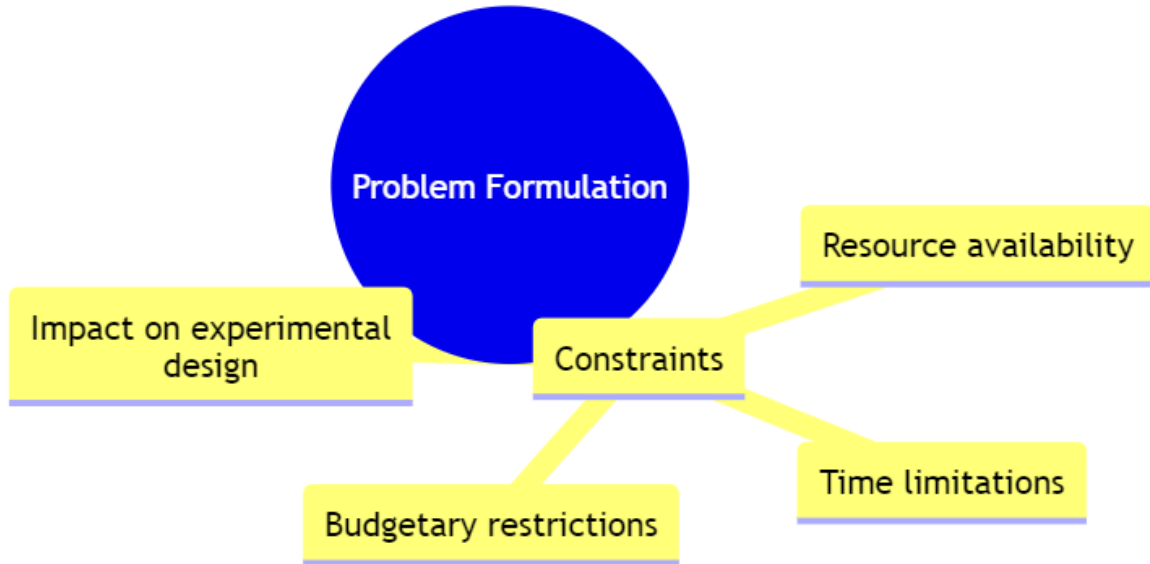


Figure 3.4: Constrains in Research

3.1.5 Modelling & Simulation

3.1.5.1 Mathematical Models

Mathematical models use mathematical equations to represent relationships between variables and predict outcomes. These models help in understanding complex systems and making quantitative predictions.

For example, a linear regression model might be used to study the effect of different drug dosages on blood pressure. In this case, the model would use an equation to describe the relationship between dosage (independent variable) and blood pressure (dependent variable). The results can provide insights into how varying dosages might affect blood pressure, helping researchers optimize treatment protocols.

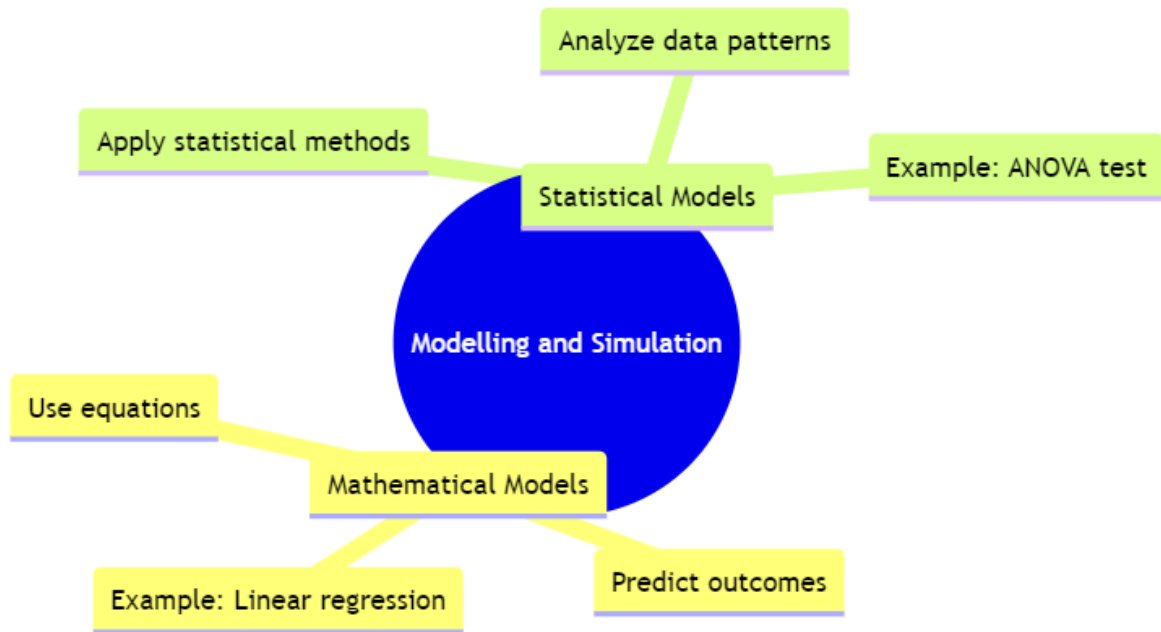


Figure 3.5: Mathematical and Statistical Models

3.1.5.2 Simulation Models

Simulation models replicate real-world processes to predict outcomes under various scenarios. They allow researchers to test different conditions and understand how variables interact in a controlled environment.

For example, a Monte Carlo simulation might be used to assess the risk of different investment strategies. By running simulations with random variables representing market conditions, researchers can estimate the potential risks and returns of various investment options, helping investors make informed decisions based on simulated outcomes.

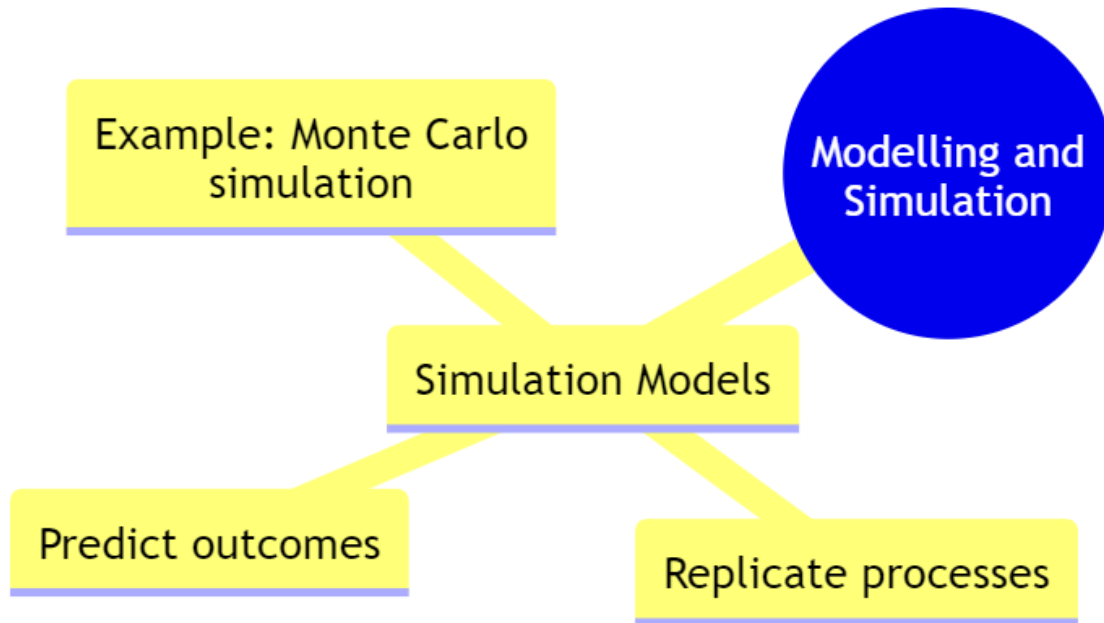


Figure 3.6: Simulation Models

3.2 Experimental Research

3.2.1 Cause-Effect Relationship

Establishing a cause-effect relationship involves demonstrating that changes in one variable directly cause changes in another. This is achieved through controlled experiments where the independent variable is manipulated and the effects on the dependent variable are observed.

For example, in an experiment testing a new drug, researchers might manipulate the dosage of the drug (independent variable) and measure the resulting changes in patient health outcomes (dependent variable). By controlling other factors and observing the direct impact of the dosage on health outcomes, researchers can establish a causal link between the drug dosage and its effects.

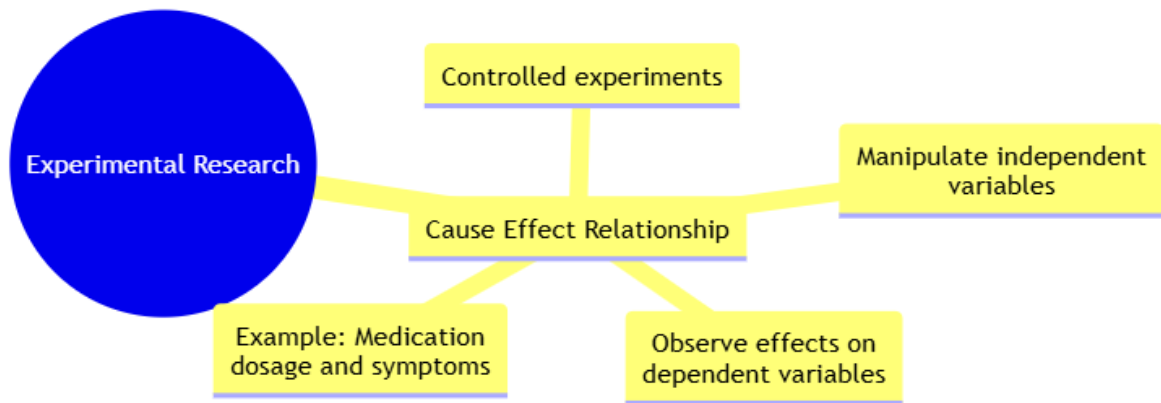


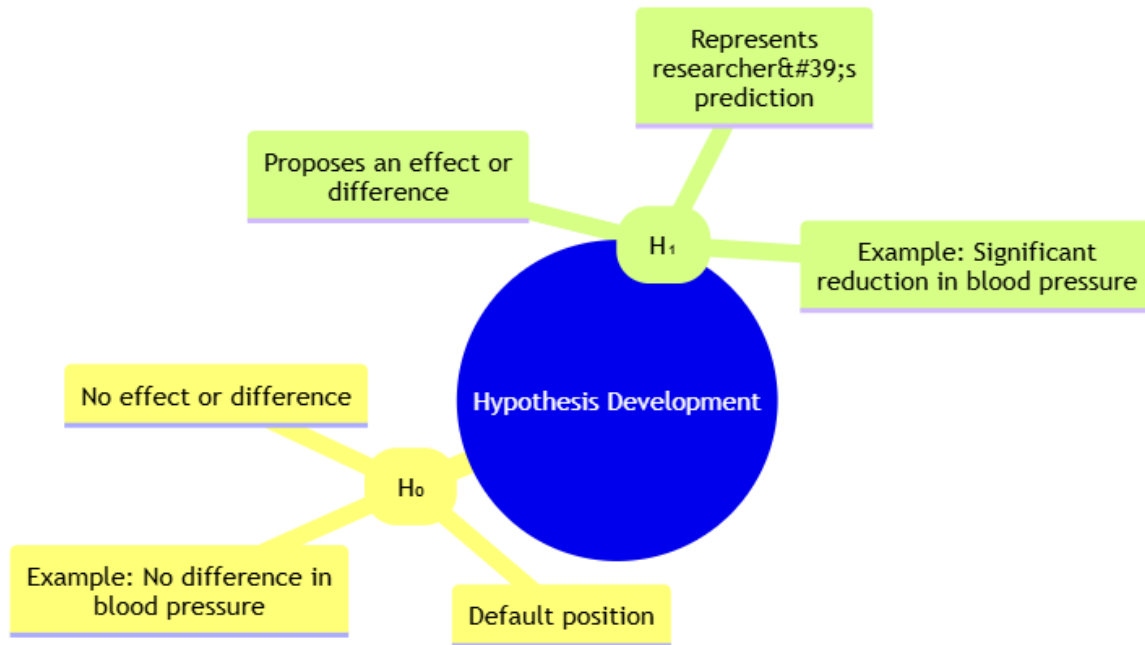
Figure 3.7: Mindmap on Cause-effect relationship.

3.3 Hypothesis Development

3.3.1 Null Hypothesis (H)

The null hypothesis (H) is a statement that assumes no effect or no difference between groups. It serves as the default assumption that researchers aim to test against.

For instance, in a clinical trial comparing two drugs, the null hypothesis might state, "There is no difference in blood pressure reduction between Drug A and Drug B." Researchers then use statistical tests to determine if the observed data provides sufficient evidence to reject this null hypothesis.



3.3.2 Alternative Hypothesis (H₁)

The alternative hypothesis (H₁) proposes that there is an effect or difference between groups. It reflects the researcher's prediction or expectation.

For example, if researchers believe that Drug A will significantly reduce blood pressure more than Drug B, the alternative hypothesis might be, "Patients receiving Drug A will experience a greater reduction in blood pressure compared to those receiving Drug B." This hypothesis is tested against the null hypothesis to evaluate the evidence for the predicted effect.

3.4 Measurement Systems Analysis

3.4.1 Repeatability

Repeatability measures how consistently a measurement can be repeated under the same conditions. It indicates the reliability of the measurement process when performed by the same operator.

For example, if a technician repeatedly measures the weight of the same sample using a scale and obtains nearly identical readings each time, the measurement system demonstrates good repeatability. Ensuring high repeatability is crucial for reliable and consistent data collection.

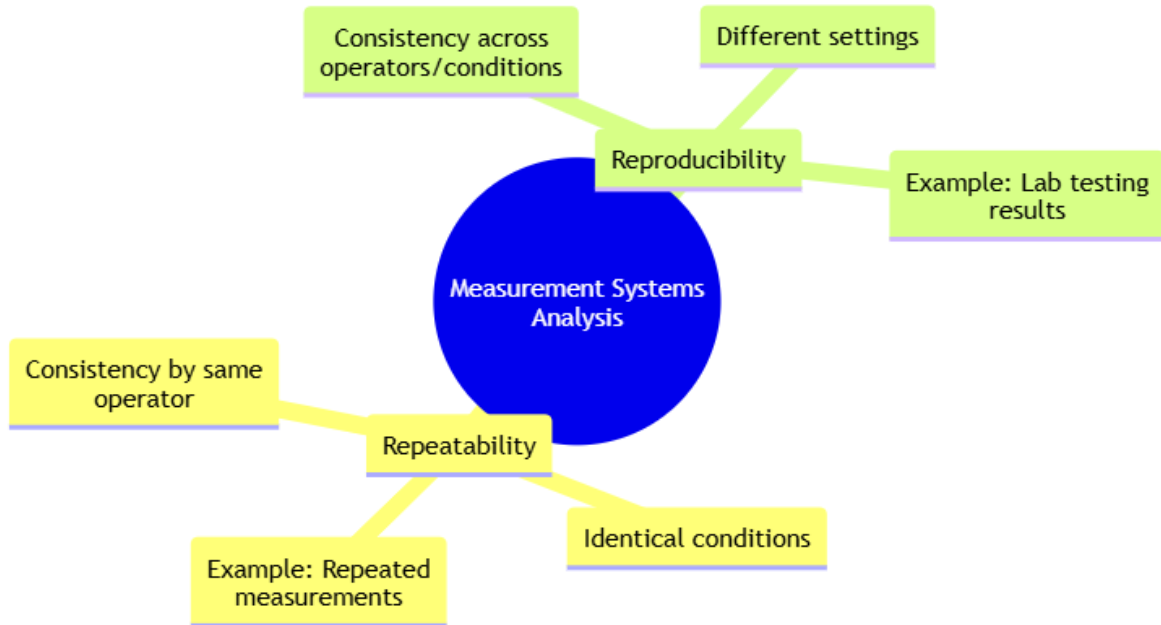


Figure 3.8: Mindmap on Measurement System Analysis.

3.4.2 Reproducibility

Reproducibility assesses how consistently measurements can be obtained across different operators or settings. It evaluates whether different individuals or environments yield similar results.

For example, if different laboratories test the same sample and obtain comparable results, the measurement system shows high reproducibility. Reproducibility is important for validating that results are reliable and can be generalized across different conditions.

3.5 Error Propagation

3.5.1 Systematic Errors

Systematic errors are consistent and repeatable errors that affect the accuracy of measurements. They often stem from calibration issues or inherent biases in the measurement system.

For instance, if a weighing scale consistently reads 2 kg heavier than the actual weight due to a calibration error, all measurements will be affected by this systematic error. Identifying and correcting systematic errors is essential for accurate measurements.

3.5.2 Random Errors

Random errors are unpredictable variations that affect the precision of measurements. These errors can result from environmental fluctuations or human factors and are less consistent than systematic errors.

For example, slight variations in temperature or measurement technique can introduce random errors into the data. While random errors cannot be completely eliminated, they can be minimized through careful measurement practices and statistical analysis.

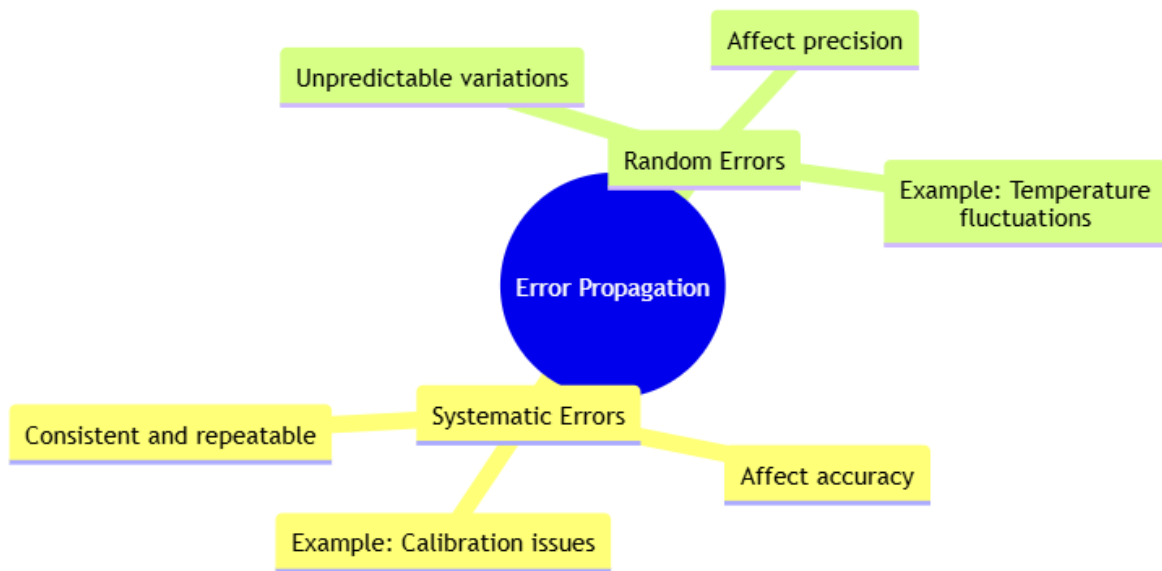


Figure 3.9: Mindmap on error propagation in analysis.

3.6 Validity of Experiments

3.7 Internal Validity

Internal validity refers to the extent to which an experiment accurately measures the effect of the independent variable on the dependent variable, without interference from extraneous factors. High internal validity ensures that the observed effects are due to the manipulated variables alone.

For example, a clinical trial with rigorous control over participant selection and environmental conditions will have high internal validity, as it effectively isolates the effect of the drug from other variables.

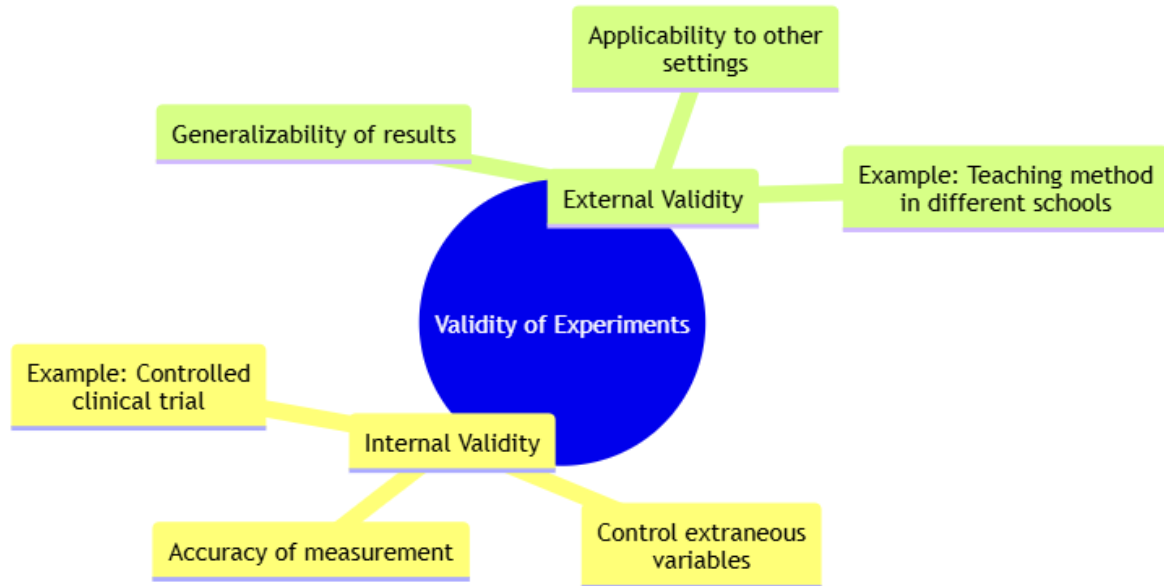


Figure 3.10: Mindmap on Validity check of experiments.

3.7.1 External Validity

External validity is the degree to which the results of an experiment can be generalized to other settings, populations, or times. It assesses whether the findings are applicable beyond the specific conditions of the study.

For example, if a new teaching method is tested in a single school and shows positive results, its external validity would depend on whether similar effects are observed in other schools or educational settings.

3.8 Statistical Design of Experiments

3.8.1 Full Factorial Design

Full factorial design examines all possible combinations of factors and their levels, providing comprehensive insights into the interactions between variables. This design is useful for

understanding how multiple factors simultaneously affect the outcome.

For example, a full factorial design might explore how different levels of temperature and pressure affect the yield of a chemical reaction. By examining all possible combinations of these factors, researchers can determine their individual and interactive effects on the reaction yield.

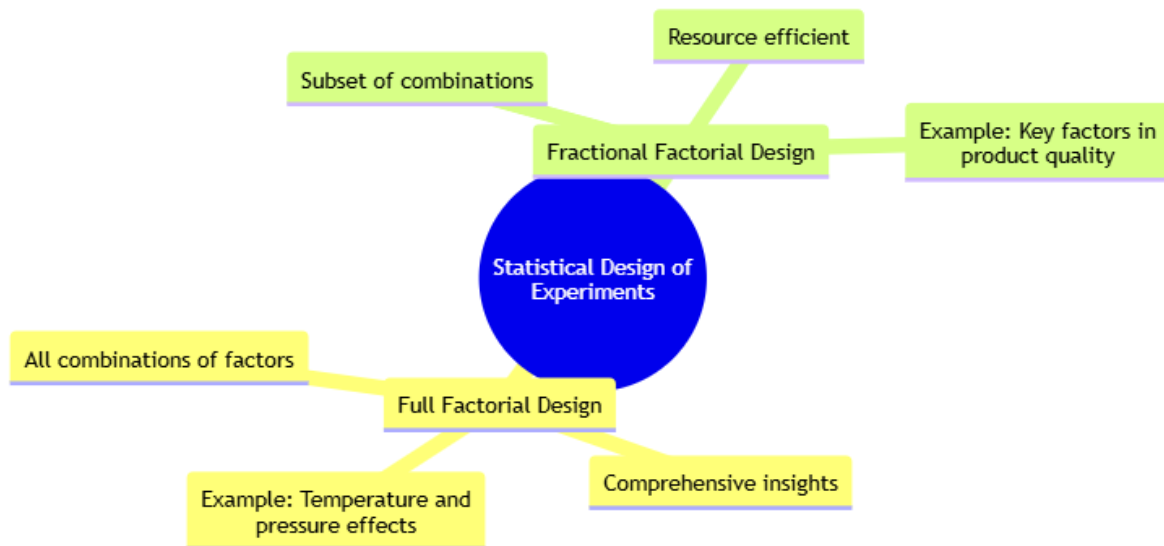


Figure 3.11: Mindmap on Statistical Design.

3.8.2 Fractional Factorial Design

Fractional factorial design involves testing only a subset of all possible combinations of factors. It is resource-efficient and suitable when dealing with a large number of variables, providing valuable information while reducing the number of experiments required.

For example, if studying the effects of five different factors on product quality, a fractional factorial design might select a subset of factor combinations to analyze, thereby saving time and resources while still yielding significant insights.

3.8.3 Field Experiments

Field experiments are conducted in natural settings rather than controlled environments. They provide insights into how variables interact in real-world conditions, offering practical evidence

of effectiveness.

For instance, a field experiment might test the impact of a new teaching method in a classroom setting. Researchers can observe how the method performs under everyday classroom conditions, providing valuable information about its real-world effectiveness.

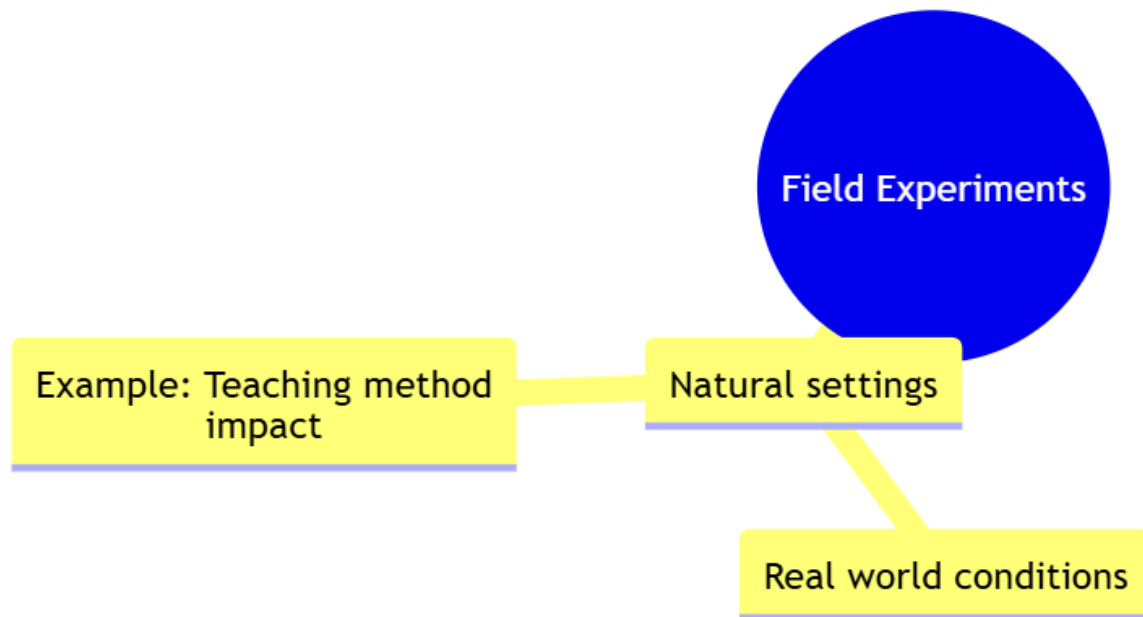


Figure 3.12: Mindmap on field experiments.

3.9 Data Collection

3.9.1 Surveys

Surveys involve gathering data through questionnaires or interviews, enabling researchers to collect information from a large number of participants. They are useful for exploring public opinions or behaviors.

For example, a public opinion survey might be conducted to gauge attitudes towards a new policy. By asking participants about their views and experiences, researchers can obtain a broad understanding of public sentiment and its implications for policy implementation.

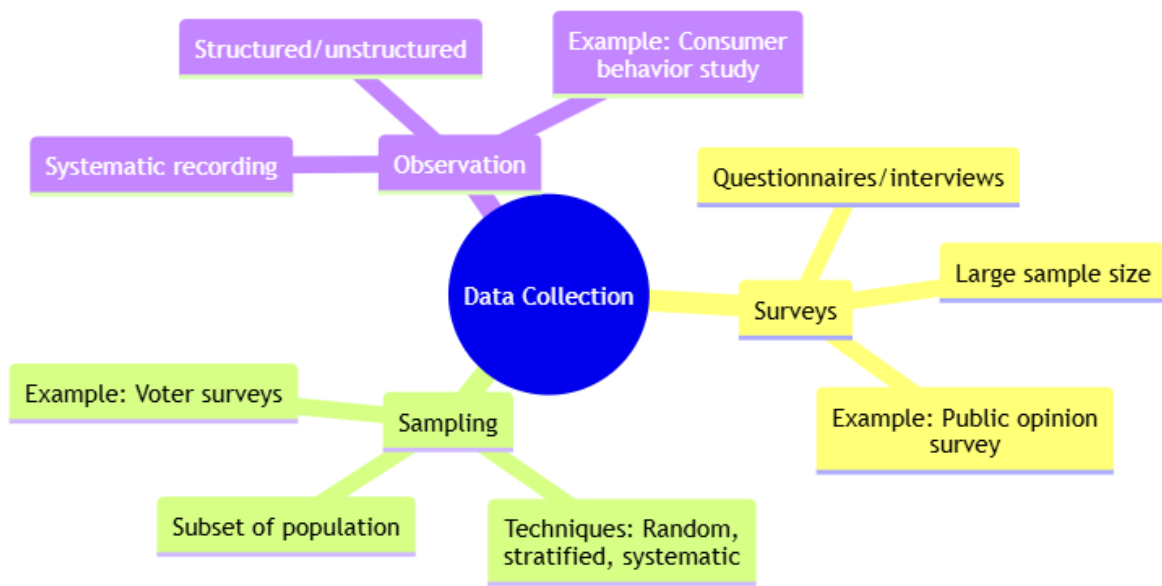


Figure 3.13: Data collection stage.

3.9.2 Sampling

Sampling is the process of selecting a subset of individuals from a larger population to make inferences about the entire group. Techniques include random sampling, stratified sampling, and systematic sampling.

For instance, random sampling might be used in a study to estimate election results. By surveying a randomly selected group of voters, researchers can infer the preferences of the entire voter population and predict the likely outcome of the election.

3.9.3 Observation

Observation involves systematically recording behaviors or phenomena as they occur. It can be structured or unstructured, depending on the research objectives.

For example, an observer might record consumer behavior in a store to understand shopping patterns. By noting the frequency and types of purchases, researchers can gain insights into consumer preferences and purchasing habits.

3.10 Data/Variable Types & Classification

3.10.1 Quantitative Data

Quantitative data consists of numerical values that can be measured and analyzed statistically. This type of data allows for mathematical analysis and comparisons, such as calculating averages or performing regression analysis.

For example, data on student test scores is quantitative. Researchers can use this data to compute the average score, assess the distribution of scores, and analyze correlations between test performance and other factors, such as study habits.

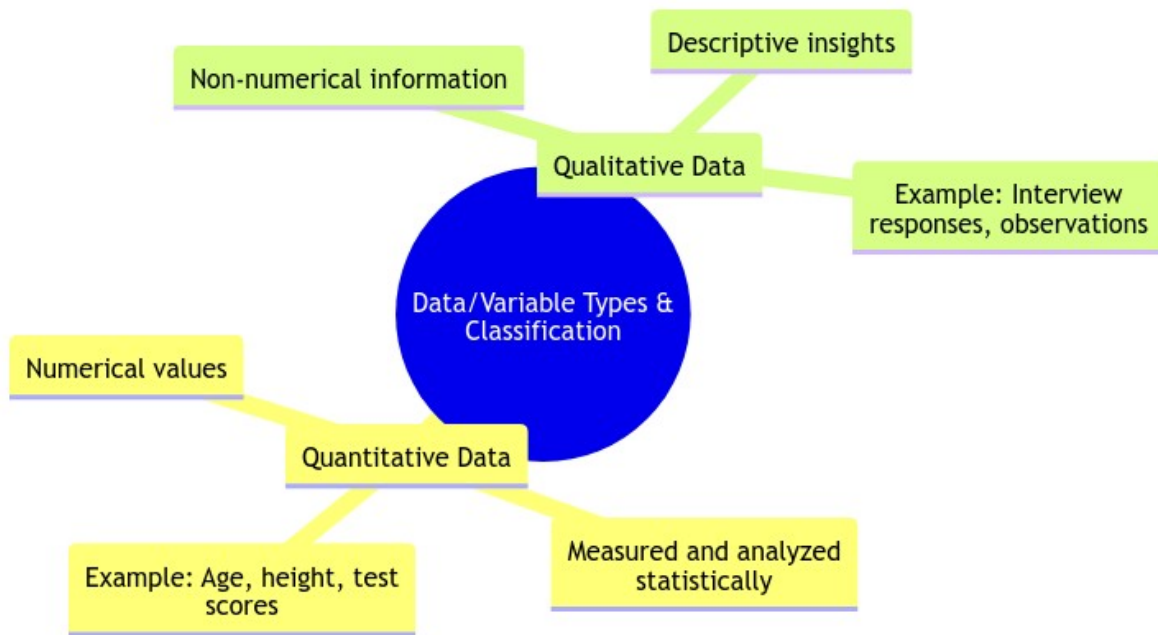


Figure 3.14: Mindmap for Data/ Variable Types and Classification

3.10.2 Qualitative Data

Qualitative data comprises non-numerical information that describes qualities or characteristics. It provides rich, descriptive insights into phenomena that are not easily quantified.

For example, interview responses about job satisfaction are qualitative. Researchers analyze these responses to identify themes and patterns in employees' experiences and opinions, offering a deeper understanding of job satisfaction beyond numerical ratings.

3.11 Numerical & Graphical Data Analysis

3.11.1 Descriptive Statistics

Descriptive statistics summarize and describe the main features of a dataset. Key measures include mean, median, mode, variance, and standard deviation.

For example, descriptive statistics might be used to summarize survey responses on job satisfaction. By calculating the mean and standard deviation of satisfaction ratings, researchers can understand the central tendency and variability in employees' satisfaction levels.

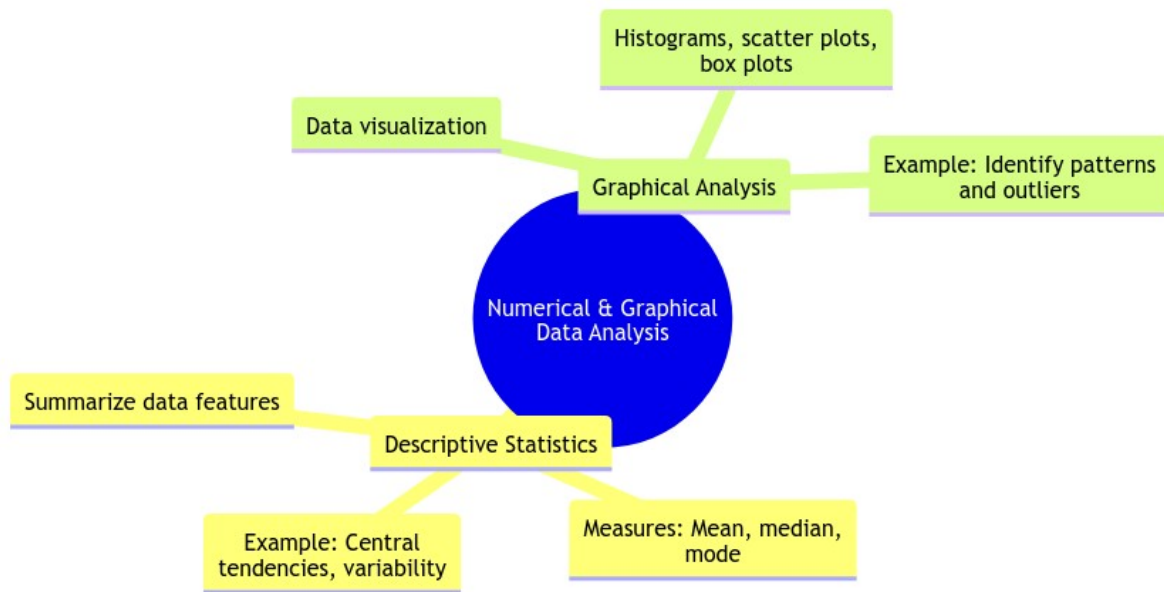


Figure 3.15: Mindmap on Numerical and Graphical Data Analysis.

3.11.2 Graphical Analysis

Graphical analysis involves visualizing data through plots and charts to identify patterns, trends, and outliers.

For example, a scatter plot might be used to explore the relationship between study hours and test scores. By plotting individual data points, researchers can visually assess whether more study hours are associated with higher test scores and identify any outliers in the data.

3.12 Inferential Statistics & Interpretation of Results

Inferential statistics allow researchers to make generalizations about a population based on sample data. Techniques include hypothesis testing, confidence intervals, and regression analysis.

For example, researchers might use hypothesis testing to determine whether there is a significant difference in test scores between two teaching methods. By analyzing the data and calculating p-values, they can draw conclusions about the effectiveness of the teaching methods and their generalizability to other settings Knuth (1984).

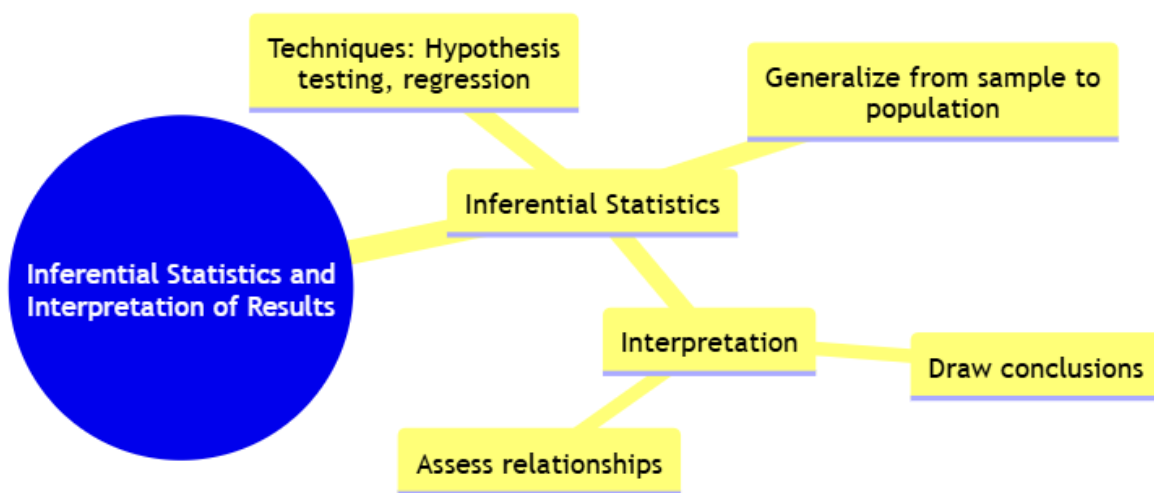


Figure 3.16: Inferential Analysis.

4 Publication Ethics and Standards

This module covers the ethical standards and best practices in publication ethics, supported by case studies for practical understanding.

4.1 Importance of Publication Ethics

4.1.1 Understanding Publication Ethics

Publication ethics involves principles that guide the responsible, honest, and transparent sharing of research findings. Adhering to ethical guidelines safeguards the credibility of scientific literature, ensures public trust, and upholds researchers' accountability.

Example: Researchers at a public university must disclose funding sources and any potential conflicts of interest to prevent bias. Failing to do so can result in a retraction if the findings are later questioned.

4.1.2 Role of Ethical Guidelines in Credibility

Ethical guidelines, like those provided by COPE (Committee on Publication Ethics) and ICMJE (International Committee of Medical Journal Editors), prevent issues such as duplicate publications, selective reporting, and biased interpretations. These guidelines encourage transparent practices that ensure research credibility.

Case Study Example: A medical study on a new drug follows COPE guidelines for transparent disclosure, including funding and methodology. This transparency allows peers to verify the findings, strengthening the study's credibility.

4.1.3 Consequences of Unethical Publication Practices

Unethical practices, including plagiarism, falsification, or failure to disclose conflicts of interest, can lead to retraction, reputational damage, and diminished trust from the public and scientific community.

Example: A high-profile academic paper is retracted due to plagiarism, harming the author's reputation and highlighting the importance of giving credit to others' contributions.

4.2 Best Practices, Standards, and Guidance for Ethical Publication

4.2.1 Overview of Best Practices

Best practices in publication ethics include accurate reporting, thorough peer review, proper citation, acknowledgment of contributions, and transparent disclosure. These practices help prevent issues like fabrication and redundant publication.

Case Study: A study on AI ethics transparently details each contributor's role, adheres to publication standards, and uses proper citations for prior research. By following best practices, the study maintains high ethical standards.

4.2.2 Guidelines for Ethical Conduct in Publication

Organizations like COPE and ICMJE provide protocols for ethical conduct. These cover areas like handling complaints, authorship guidelines, conflicts of interest, and data transparency.

Example: A journal uses COPE guidelines to address a conflict of interest complaint, reviewing the authors' disclosures and deciding on the next steps to ensure fairness.

4.2.3 Role of Institutional and International Standards

Universities and journals enforce institutional protocols to uphold publication standards. Familiarity with both institutional and international standards helps researchers avoid ethical missteps and ensures accountability.

Case Study: A university's policy mandates five-year data retention for all published studies, ensuring that findings can be reviewed if questions arise.

4.3 Conflicts of Interest in Research and Publication

4.3.1 Identifying Conflicts of Interest

A conflict of interest (COI) arises when a researcher's personal, financial, or professional interests could bias their work. Recognizing and managing COIs helps protect research objectivity.

Case Study: A researcher investigating the efficacy of a drug receives funding from the drug's manufacturer, creating a potential COI that must be disclosed to allow transparent evaluation of the findings.

4.3.2 Managing and Disclosing Conflicts

Ethical guidelines mandate that researchers disclose any potential conflicts to maintain transparency and ensure unbiased peer review.

Example: A professor with equity in a tech company studying a relevant technology discloses this COI when submitting a research paper, allowing reviewers to assess potential biases.

4.3.3 Impact of Conflicts of Interest on Research Integrity

Failing to manage COIs can harm the integrity of research and public trust, as undisclosed COIs may lead readers to question the study's objectivity.

Case Study: A paper that downplays risks associated with a new technology is later discovered to have undisclosed financial ties, damaging the authors' and the study's reputations.

4.4 Misconduct in Publication

4.4.1 Understanding Publication Misconduct

Publication misconduct includes plagiarism, data fabrication, falsification, and improper authorship. These actions violate research integrity and damage the credibility of scientific work.

Example: Submitting the same manuscript to multiple journals without informing them constitutes misconduct. Duplicate submissions waste reviewers' time and may lead to sanctions.

4.4.2 Types of Publication Misconduct

- **Plagiarism:** Using others' work without credit. Can be intentional (copying text) or accidental (poor paraphrasing).
- **Falsification:** Altering data or research processes to mislead.
- **Fabrication:** Creating data or results that don't exist.

Case Studies: - *Plagiarism:* A researcher copies sections of another study without citation, leading to a retraction and ethical sanctions. - *Falsification:* An author adjusts raw data to make results seem more favorable. When peers review the raw data, the falsification is exposed. - *Fabrication:* A study on environmental impacts includes fabricated data to support claims. Upon investigation, the lack of original data leads to a retraction.

4.4.3 Impact of Misconduct on Scientific Community

Misconduct erodes trust within the scientific community and the public, impacting the reliability of scientific knowledge.

Case Study: A major paper is retracted due to data fabrication, sparking scrutiny of other studies by the same lab and affecting the reputation of all involved.

4.5 Problems Leading to Unethical Behavior

4.5.1 Pressure to Publish

Researchers under pressure to meet academic or funding milestones may engage in misconduct, such as duplicate publication or selective reporting, to increase their publication count.

Example: A young researcher, eager to publish, splits the results of a single study across multiple papers (salami slicing), resulting in ethical scrutiny and rejections.

4.5.2 Lack of Awareness of Ethical Guidelines

New researchers may lack familiarity with publication standards, leading to unintentional ethical violations. Training on ethical guidelines is essential to prevent such issues.

Case Study: A graduate student plagiarizes parts of a literature review, unaware of citation requirements. The university addresses the issue with educational resources on research ethics.

4.6 Violations of Publication Ethics: Authorship and Contributorship Issues

4.6.1 Issues with Authorship and Contributorship

Ethical publication requires only those who contribute substantially to be credited as authors. Issues such as ghost authorship (uncredited significant contributors) and honorary authorship (credit without contribution) are unethical.

Example: A senior researcher requests authorship on a paper despite minimal involvement, causing disputes over fair attribution.

4.6.2 Managing Authorship Disputes

To prevent disputes, it's important to establish clear criteria for authorship and contributorship from the beginning. Guidelines such as the ICMJE criteria can help.

Case Study: A large interdisciplinary project lists each author's role and contributions, avoiding conflicts and enhancing transparency.

4.6.3 Resolving Authorship and Contributorship Violations

Journals and institutions often address authorship violations by issuing retractions or corrections, and by involving ethics committees in serious cases.

Example: A journal issues a correction when it's discovered that a significant contributor was omitted from authorship.

4.7 Identifying and Addressing Publication Misconduct

4.7.1 Methods for Identifying Misconduct

Advanced tools (like iThenticate for plagiarism detection) and peer reviews help identify misconduct such as plagiarism, data fabrication, and conflicts of interest.

Example: A journal detects plagiarism in a submission through software screening, alerting the authors to revise the manuscript for proper citations.

4.7.2 Handling Complaints and Appeals

Ethical procedures allow for complaints to be addressed fairly. Authors accused of misconduct can appeal decisions, ensuring due process.

Case Study: An author appeals a rejection for alleged plagiarism, arguing that the similar text was their own earlier work. The journal investigates and accepts the appeal, confirming the author's claim.

4.7.3 Steps for Addressing Proven Misconduct

Confirmed misconduct may result in actions such as retractions, corrections, or sanctions. Consequences may extend to institutional sanctions, like suspension or funding restrictions.

Example: A researcher found guilty of data falsification is suspended from publishing in certain journals for two years, demonstrating the serious consequences of ethical violations.

5 Sample Research Methodology MCQs

6 Multiple Choice Questions

6.1 General

6.1.1 *What is the primary purpose of research methodology?*

- a) To collect data
- b) To analyze the data
- c) To systematically conduct a study to solve a problem or answer a research question
- d) To interpret the findings

Answer: c) To systematically conduct a study to solve a problem or answer a research question

6.1.2 *Which of the following is NOT a characteristic of quantitative research?*

- a) Involves numerical data
- b) Focuses on measuring variables
- c) Emphasizes subjective interpretation
- d) Uses statistical tools for analysis

Answer: c) Emphasizes subjective interpretation

6.1.3 *A literature review in research primarily aims to:*

- a) Collect primary data
- b) Analyze research findings
- c) Identify gaps in existing research
- d) Develop hypotheses

Answer: c) Identify gaps in existing research

6.1.4 What does “sampling” refer to in research methodology?

- a) Selecting a sample population to represent a larger group
- b) Collecting data from a census
- c) Analyzing the collected data
- d) Testing a hypothesis

Answer: a) Selecting a sample population to represent a larger group

6.1.5 Which research method is most likely to be used for exploratory research?

- a) Case study
- b) Survey
- c) Experiment
- d) Longitudinal study

Answer: a) Case study

6.1.6 What is the key difference between “inductive” and “deductive” reasoning?

- a) Inductive reasoning begins with a theory, while deductive reasoning starts with observations.
- b) Inductive reasoning builds generalizations based on specific observations, while deductive reasoning tests hypotheses based on existing theories.
- c) Inductive reasoning focuses on qualitative data, while deductive reasoning focuses on quantitative data.
- d) There is no difference between the two.

Answer: b) Inductive reasoning builds generalizations based on specific observations, while deductive reasoning tests hypotheses based on existing theories.

6.1.7 What is a “hypothesis” in research?

- a) A fact
- b) An educated guess or prediction based on existing knowledge
- c) A conclusion drawn after data analysis
- d) A systematic collection of data

Answer: b) An educated guess or prediction based on existing knowledge

6.1.8 Which of the following is an example of a primary data source?

- a) A published research paper
- b) A census report
- c) An interview with a subject expert
- d) A book review

Answer: c) An interview with a subject expert

6.1.9 In research, a “control group” is used to:

- a) Minimize the effect of extraneous variables
- b) Identify the variables being tested
- c) Ensure a higher response rate
- d) Increase sample size

Answer: a) Minimize the effect of extraneous variables

6.1.10 Which of the following is NOT a type of research design?

- a) Descriptive research
- b) Correlational research
- c) Experimental research
- d) Exploratory research

Answer: d) Exploratory research (Note: Exploratory research is more of a purpose, not a design type. It can use different designs.)

6.2 Unit 1

6.2.1 What is the first step in the research process?

- a) Formulating a hypothesis
- b) Reviewing the literature
- c) Identifying a research problem or question
- d) Collecting data

Answer: c) Identifying a research problem or question

6.2.2 Which of the following is NOT typically a characteristic of qualitative research?

- a) Non-numerical data
- b) In-depth understanding of human experiences
- c) Use of statistical tools for data analysis
- d) Focus on context and meaning

Answer: c) Use of statistical tools for data analysis

6.2.3 *The purpose of research questions in a study is to:*

- a) Summarize the findings
- b) Guide the entire research process
- c) Describe the methodology used
- d) Analyze the collected data

Answer: b) Guide the entire research process

6.2.4 *Which of the following is an example of exploratory research?*

- a) Analyzing the impact of advertising on consumer behavior
- b) Conducting focus groups to explore perceptions of a new product
- c) Testing a new drug on a control group
- d) Examining the relationship between smoking and lung cancer using statistical methods

Answer: b) Conducting focus groups to explore perceptions of a new product

6.2.5 *Which type of research design is used when the researcher wants to establish cause-and-effect relationships?*

- a) Descriptive research design
- b) Experimental research design
- c) Correlational research design
- d) Phenomenological research design

Answer: b) Experimental research design

6.2.6 Quantitative research primarily involves:

- a) Describing individual experiences
- b) Collecting numerical data to establish patterns or relationships
- c) Deeply exploring social phenomena in their natural setting
- d) Focusing on the richness and depth of data

Answer: b) Collecting numerical data to establish patterns or relationships

6.2.7 Which of the following is NOT a characteristic of qualitative research?

- a) Focuses on understanding people's experiences
- b) Uses statistical analysis to generalize findings
- c) Relies on textual, visual, or audio data
- d) Involves a subjective approach to data interpretation

Answer: b) Uses statistical analysis to generalize findings

6.2.8 Confirmatory research focuses on:

- a) Discovering new patterns or insights
- b) Testing and validating existing theories or hypotheses
- c) Generating new questions
- d) Gathering subjective experiences

Answer: b) Testing and validating existing theories or hypotheses

6.2.9 Which of the following is a key difference between experimental and theoretical research?

- a) Experimental research involves testing theories through controlled experiments, while theoretical research focuses on conceptual frameworks without direct testing.
- b) Experimental research is always conducted in a laboratory setting, while theoretical research is always field-based.
- c) Experimental research does not require data collection, while theoretical research does.
- d) There is no difference between experimental and theoretical research.

Answer: a) Experimental research involves testing theories through controlled experiments, while theoretical research focuses on conceptual frameworks without direct testing.

6.2.10 Building and validating theoretical models in research involves:

- a) Collecting primary data without any hypotheses
- b) Creating frameworks to explain phenomena and testing them against empirical data
- c) Writing detailed literature reviews
- d) Conducting exploratory research to identify new variables

Answer: b) Creating frameworks to explain phenomena and testing them against empirical data

6.2.11 Which of the following is true about reasoning in research?

- a) Reasoning is not necessary in research; only data collection matters.
- b) Both inductive and deductive reasoning are used to make sense of data and develop theories.
- c) Reasoning is only required in qualitative research, not in quantitative research.
- d) Reasoning is only applied during the conclusion stage of research.

Answer: b) Both inductive and deductive reasoning are used to make sense of data and develop theories.

6.2.12 *Theoretical research is primarily concerned with:*

- a) The development of practical solutions to real-world problems
- b) Understanding, refining, or extending existing theories and concepts
- c) Collecting and analyzing data in real-world settings
- d) Exploring new areas where data collection methods are unknown

Answer: b) Understanding, refining, or extending existing theories and concepts

6.2.13 *What distinguishes quantitative research from qualitative research?*

- a) Quantitative research uses numerical data; qualitative research uses non-numerical data
- b) Quantitative research explores people's experiences, while qualitative research focuses on patterns and trends
- c) Quantitative research is unstructured, while qualitative research is highly structured
- d) Quantitative research always uses fieldwork, while qualitative research does not

Answer: a) Quantitative research uses numerical data; qualitative research uses non-numerical data

6.2.14 *In the context of research design, randomization is used primarily in:*

- a) Experimental research
- b) Descriptive research
- c) Exploratory research
- d) Phenomenological research

Answer: a) Experimental research

6.2.15 *Exploratory research is most appropriate when:*

- a) There is a well-established theory that needs to be tested
- b) The researcher is trying to confirm existing theories
- c) The researcher is attempting to investigate an unclear or poorly understood issue
- d) The research is focused on precise numerical analysis

Answer: c) The researcher is attempting to investigate an unclear or poorly understood issue

6.3 UNIT 2

1. The primary purpose of conducting a literature survey is to:

- a) Collect primary data for research
- b) Find a gap in existing research and build upon it
- c) Generate new hypotheses and predictions
- d) Analyze collected data using statistical tools

Answer: b) Find a gap in existing research and build upon it

2. A literature search should ideally be planned:

- a) After the research data has been collected
- b) Before formulating research questions
- c) Simultaneously with data collection
- d) At the conclusion of the research process

Answer: b) Before formulating research questions

3. Which of the following is the first step in planning a literature search?

- a) Identifying key concepts and keywords
- b) Analyzing the data from the literature
- c) Writing the literature review

- d) Conducting a meta-analysis
Answer: a) Identifying key concepts and keywords
- 4. Key concepts and keywords in a literature search are important because:
 - a) They help organize the research findings
 - b) They allow for the quick identification of relevant literature
 - c) They help in formulating research hypotheses
 - d) They are only necessary for the final stages of the research process
Answer: b) They allow for the quick identification of relevant literature
- 5. Which of the following is the most effective way to locate relevant literature?
 - a) Searching in only one database
 - b) Relying solely on books from the library
 - c) Using a combination of databases and academic search engines, and employing a broad search strategy
 - d) Relying on articles from the first page of search results
Answer: c) Using a combination of databases and academic search engines, and employing a broad search strategy
- 6. In the context of literature search, reliability of a source refers to:
 - a) The cost of accessing the source
 - b) The credentials of the authors and the publication's reputation
 - c) The length of the article or book
 - d) The geographical location of the research
Answer: b) The credentials of the authors and the publication's reputation
- 7. Which of the following is NOT a reliable source for academic research?
 - a) Peer-reviewed journal articles
 - b) Articles published in well-known academic journals
 - c) Social media posts or blogs without credible references

- d) Books written by experts in the field
Answer: c) Social media posts or blogs without credible references
- 8. When performing a literature search, using Boolean operators (AND, OR, NOT) helps in:
 - a) Narrowing or expanding the scope of the search
 - b) Accessing sources that require a subscription
 - c) Writing the literature review
 - d) Ensuring all keywords are included in the search results
Answer: a) Narrowing or expanding the scope of the search
- 9. The reliability of a research source can be assessed by checking:
 - a) The publication date only
 - b) The reputation of the publisher or journal
 - c) The length of the paper
 - d) The number of references listed
Answer: b) The reputation of the publisher or journal
- 10. A systematic literature review differs from a regular literature review in that:
 - a) It is more subjective and opinion-based
 - b) It involves a structured, methodical approach to finding, evaluating, and synthesizing research
 - c) It is only done at the end of the research process
 - d) It excludes grey literature (unpublished research)
Answer: b) It involves a structured, methodical approach to finding, evaluating, and synthesizing research
- 11. What is a key advantage of using online academic databases like JSTOR, PubMed, or Google Scholar in a literature search?
 - a) They offer free access to all research papers
 - b) They automatically analyze and synthesize the literature for you

- c) They provide access to a large number of peer-reviewed articles and journals
 - d) They only provide data from government-sponsored research
- Answer:** c) They provide access to a large number of peer-reviewed articles and journals
12. When locating relevant literature, it is important to:
- a) Limit the search to a specific time period to avoid outdated research
 - b) Include a wide range of sources to ensure comprehensive coverage of the topic
 - c) Use only the first search result in a database
 - d) Focus only on quantitative studies
- Answer:** b) Include a wide range of sources to ensure comprehensive coverage of the topic
13. What is the main purpose of using keywords in a literature search?
- a) To determine the author's main findings
 - b) To improve the efficiency of the search and retrieve relevant results
 - c) To identify the publication year of the article
 - d) To understand the methodology used in the study
- Answer:** b) To improve the efficiency of the search and retrieve relevant results
14. Which of the following is an example of grey literature?
- a) A book published by a reputable academic press
 - b) An article in a peer-reviewed journal
 - c) A government report that is not peer-reviewed
 - d) A thesis or dissertation from a recognized university
- Answer:** c) A government report that is not peer-reviewed
15. When assessing the reliability of a source, impact factor of a journal is:
- a) A good indicator of the journal's visibility and frequency of citation, but not always a guarantee of content quality
 - b) The only factor to consider when evaluating a journal

c) Irrelevant to the reliability of the content

d) The main determinant of the validity of the research

Answer: a) A good indicator of the journal's visibility and frequency of citation, but not always a guarantee of content quality

16. A literature review should be based on:

a) Only the most recent publications

b) Only publications from sources that are easy to access

c) Relevant, peer-reviewed sources that are credible and have been properly cited

d) Any sources, including those that are not related to the research question

Answer: c) Relevant, peer-reviewed sources that are credible and have been properly cited

##> UNIT 3: Research Process and Experimental Design

6.3.1 Problem formulation in the research process involves:

- a) Defining the research question and determining the scope of the study
- b) Writing the conclusions and recommendations of the study
- c) Selecting the research methodology
- d) Conducting the experiment

Answer: a) Defining the research question and determining the scope of the study

6.3.2 Modeling and simulation in research is used to:

- a) Conduct experiments in the real world
- b) Represent and study complex systems or phenomena using mathematical or computational models
- c) Collect data from field experiments
- d) Validate hypotheses through direct observation

Answer: b) Represent and study complex systems or phenomena using mathematical or computational models

6.3.3 In experimental research, establishing a cause-effect relationship requires:

- a) Observing the relationship between two variables without intervention
- b) Using theoretical models to predict outcomes
- c) Manipulating one variable to observe its effect on another variable
- d) Conducting surveys to understand public opinion

Answer: c) Manipulating one variable to observe its effect on another variable

6.3.4 The development of a hypothesis is:

- a) The final step in the research process
- b) A guess made after collecting data
- c) A testable statement based on theory or observation
- d) A generalization based on previous studies

Answer: c) A testable statement based on theory or observation

6.3.5 Measurement systems analysis (MSA) helps in:

- a) Designing experiments
- b) Determining the validity of measurement tools and ensuring accurate data collection
- c) Analyzing the correlation between variables
- d) Formulating hypotheses

Answer: b) Determining the validity of measurement tools and ensuring accurate data collection

6.3.6 Error propagation refers to:

- a) The accumulation of errors in data collection
- b) The way in which errors in measurements affect the results of a calculation or analysis
- c) The random distribution of data points in an experiment
- d) The process of correcting errors in experimental data

Answer: b) The way in which errors in measurements affect the results of a calculation or analysis

6.3.7 Validity of experiments refers to:

- a) The consistency of the experimental results over time
- b) The degree to which an experiment measures what it is intended to measure
- c) The number of trials conducted in the experiment
- d) The cost-effectiveness of the experimental process

Answer: b) The degree to which an experiment measures what it is intended to measure

6.3.8 The statistical design of experiments involves:

- a) Designing experiments in a way that reduces the number of variables being studied
- b) Randomly assigning participants to treatment groups
- c) Planning how to control and measure variables to draw valid conclusions from experimental data
- d) Conducting surveys and interviews with participants

Answer: c) Planning how to control and measure variables to draw valid conclusions from experimental data

6.3.9 Field experiments are primarily characterized by:

- a) Being conducted in laboratory settings
- b) Manipulating variables in natural, real-world settings
- c) Collecting data via surveys
- d) Using existing datasets without any manipulation

Answer: b) Manipulating variables in natural, real-world settings

6.3.10 Data/variable types and classification includes:

- a) Measuring the accuracy of data collection tools
- b) Classifying variables as dependent or independent, and qualitative or quantitative
- c) Setting up statistical models for analysis
- d) Collecting data using observation techniques

Answer: b) Classifying variables as dependent or independent, and qualitative or quantitative

6.3.11 Data collection in research typically involves:

- a) Conducting experiments to collect primary data
- b) Relying only on secondary data sources
- c) Analyzing data before it is collected
- d) Writing up research findings

Answer: a) Conducting experiments to collect primary data

6.3.12 Sampling is a technique used to:

- a) Collect data from the entire population
- b) Reduce the amount of data needed for analysis by selecting a representative subset
- c) Analyze all data collected without any adjustments
- d) Create experimental designs

Answer: b) Reduce the amount of data needed for analysis by selecting a representative subset

6.3.13 Observational studies involve:

- a) Manipulating variables to observe their effect
- b) Collecting data by observing subjects in their natural environment without intervention
- c) Designing experiments with a specific hypothesis in mind
- d) Using survey instruments to collect self-reported data

Answer: b) Collecting data by observing subjects in their natural environment without intervention

6.3.14 Surveys are commonly used in research to:

- a) Collect qualitative data through open-ended questions
- b) Obtain a broad range of responses from a large group of people to understand attitudes or behaviors
- c) Collect experimental data in laboratory conditions
- d) Analyze existing literature and publications

Answer: b) Obtain a broad range of responses from a large group of people to understand attitudes or behaviors

6.3.15 Inferential statistics is used to:

- a) Summarize the basic features of data
- b) Make predictions or inferences about a population based on sample data
- c) Measure the spread of data points in a dataset
- d) Create graphs and charts

Answer: b) Make predictions or inferences about a population based on sample data

6.3.16 The interpretation of results involves:

- a) Presenting raw data without analysis
- b) Drawing conclusions based on statistical analysis and relating them back to the research question
- c) Designing the experiment based on the results
- d) Writing up a report on the methodology used in the research

Answer: b) Drawing conclusions based on statistical analysis and relating them back to the research question

6.3.17 R-software is commonly used in research for:

- a) Collecting data from experiments
- b) Writing literature reviews
- c) Performing statistical analysis, including data visualization and hypothesis testing
- d) Conducting field experiments

Answer: c) Performing statistical analysis, including data visualization and hypothesis testing

6.3.18 When analyzing data using R-software, the function `lm()` is used for:

- a) Plotting graphs
- b) Performing linear regression analysis
- c) Running descriptive statistics
- d) Importing data into R

Answer: b) Performing linear regression analysis

6.3.19 Numerical data analysis in research often includes:

- a) Analyzing text data for themes and patterns
- b) Describing and summarizing data using measures such as mean, median, and standard deviation
- c) Conducting qualitative interviews with participants
- d) Collecting observational data from experiments

Answer: b) Describing and summarizing data using measures such as mean, median, and standard deviation

6.3.20 In experimental research, the independent variable is:

- a) The variable that is measured or observed in the experiment
- b) The variable that is manipulated to observe its effect on the dependent variable
- c) The variable that is not controlled in the experiment
- d) The variable that is held constant throughout the experiment

Answer: b) The variable that is manipulated to observe its effect on the dependent variable

6.4 UNIT 4: Research Ethics and Philosophy

6.4.1 Philosophy is primarily concerned with:

- a) The study of social behavior
- b) The study of the nature of reality, knowledge, and ethics
- c) The development of new scientific theories
- d) The collection of empirical data

Answer: b) The study of the nature of reality, knowledge, and ethics

6.4.2 Which of the following is NOT a branch of philosophy?

- a) Metaphysics
- b) Epistemology
- c) Psychology
- d) Logic

Answer: c) Psychology

6.4.3 Ethics in the context of research refers to:

- a) A set of guidelines for data collection
- b) The moral principles that govern a researcher's behavior and conduct
- c) The financial aspects of conducting research
- d) The scientific methods used in research design

Answer: b) The moral principles that govern a researcher's behavior and conduct

6.4.4 Moral philosophy focuses on:

- a) Political theories about governance
- b) The nature of knowledge and how it is acquired
- c) Questions about what is right and wrong, good and bad
- d) The process of scientific reasoning

Answer: c) Questions about what is right and wrong, good and bad

6.4.5 The nature of moral judgments and reactions in ethics typically involves:

- a) Deciding how to allocate resources in research
- b) Evaluating actions as right or wrong based on ethical principles
- c) Following the latest research trends in a particular field
- d) Conducting experiments to prove ethical theories

Answer: b) Evaluating actions as right or wrong based on ethical principles

6.4.6 Scientific conduct refers to:

- a) The methods and procedures followed to conduct experiments
- b) The ethical guidelines researchers must follow during the research process
- c) The theoretical framework guiding research
- d) The statistical tools used in research analysis

Answer: b) The ethical guidelines researchers must follow during the research process

6.4.7 Intellectual honesty in research involves:

- a) Reporting research results regardless of their accuracy
- b) Acknowledging the work of others and avoiding misrepresentation of data
- c) Publishing papers without peer review
- d) Ignoring contradictory data to support a hypothesis

Answer: b) Acknowledging the work of others and avoiding misrepresentation of data

6.4.8 Scientific misconduct includes all of the following EXCEPT:

- a) Fabrication of data
- b) Falsification of research results
- c) Plagiarism
- d) Reviewing articles without conflict of interest

Answer: d) Reviewing articles without conflict of interest

6.4.9 Falsification of data refers to:

- a) Copying another researcher's work without acknowledgment
- b) Manipulating research data to fit a desired outcome
- c) Publishing data from experiments that were never conducted
- d) Including data from sources that are not scientifically valid

Answer: b) Manipulating research data to fit a desired outcome

6.4.10 Fabrication of data involves:

- a) Reporting results based on real experiments
- b) Misrepresenting data to support conclusions that are not supported by the actual data
- c) Reusing data from previous studies without acknowledgment
- d) Selecting only favorable results for publication

Answer: b) Misrepresenting data to support conclusions that are not supported by the actual data

6.4.11 Plagiarism in research is the act of:

- a) Rewriting someone else's research in your own words
- b) Citing a paper without reading it
- c) Using someone else's ideas or research results without proper acknowledgment
- d) Conducting research without any prior hypothesis

Answer: c) Using someone else's ideas or research results without proper acknowledgment

6.4.12 Redundant publication refers to:

- a) The repetition of the same study results in multiple journals without new data
- b) The publishing of findings in the same journal multiple times
- c) Publishing results from a single study in different formats
- d) Using data from old studies in new research

Answer: a) The repetition of the same study results in multiple journals without new data

6.4.13 Salami slicing is an unethical publishing practice where:

- a) A large research project is broken down into multiple small publications
- b) The same research is published in different languages for broader reach
- c) Data from various studies is pooled together
- d) All of the above

Answer: a) A large research project is broken down into multiple small publications

6.4.14 Selective reporting involves:

- a) Disclosing all results from a study in the final report
- b) Choosing to report only the data that supports the hypothesis while ignoring data that contradicts it
- c) Reporting findings from peer-reviewed sources
- d) Reviewing all available literature in a systematic manner

Answer: b) Choosing to report only the data that supports the hypothesis while ignoring data that contradicts it

6.4.15 The misrepresentation of data can occur when:

- a) Data is presented out of context or with altered figures to make results appear more favorable
- b) Results are reported without the use of proper statistical tools
- c) Data is misinterpreted due to incorrect analysis
- d) Data is collected using inaccurate measurement tools

Answer: a) Data is presented out of context or with altered figures to make results appear more favorable

6.4.16 Publication ethics ensures:

- a) That research findings are widely shared regardless of their validity
- b) That researchers adhere to established standards and guidelines to maintain integrity in publishing
- c) That articles are always published in high-impact journals
- d) That publications are made as quickly as possible

Answer: b) That researchers adhere to established standards and guidelines to maintain integrity in publishing

6.4.17 Best practices for publishing include:

- a) Ensuring that all co-authors agree with the content and results of the paper
- b) Ensuring that the research is freely available to the public, regardless of ethical guidelines
- c) Disregarding ethical standards in favor of rapid publication
- d) Publishing a paper without peer review

Answer: a) Ensuring that all co-authors agree with the content and results of the paper

6.4.18 A conflict of interest in research can arise when:

- a) The research is funded by a third party that could benefit from the results
- b) Authors do not disclose their affiliations with the funding body
- c) A researcher has personal or financial interests that could affect their impartiality
- d) All of the above

Answer: d) All of the above

6.4.19 Publication misconduct can be identified when:

- a) Data is presented with a high degree of transparency and accuracy
- b) There is a lack of acknowledgement of the contributions of others
- c) Results are consistent with the methodology used
- d) All of the above

Answer: b) There is a lack of acknowledgement of the contributions of others

6.4.20 Problems leading to unethical behavior in research often include:

- a) Lack of awareness about ethical guidelines
- b) Pressure to publish frequently or in high-impact journals
- c) Misinterpretation of research findings
- d) All of the above

Answer: d) All of the above

6.4.21 A violation of publication ethics can occur when:

- a) Data is honestly reported, but authorship is wrongly attributed
- b) Authors adhere to ethical guidelines in data reporting
- c) A study is published after thorough peer review
- d) Proper acknowledgments and citations are provided

Answer: a) Data is honestly reported, but authorship is wrongly attributed

6.4.22 The authorship of a research paper should be assigned based on:

- a) The amount of funding received for the project
- b) The order of contributions made during the research
- c) Who provides the most financial support for the project
- d) The seniority of researchers involved

Answer: b) The order of contributions made during the research

6.4.23 The process for addressing publication misconduct typically includes:

- a) Ignoring complaints of misconduct to maintain the reputation of the journal
- b) Filing complaints with the relevant institutional or journal authorities and investigating the claim
- c) Allowing the researcher to publish regardless of ethical breaches
- d) Denying access to data from questionable publications

Answer: b) Filing complaints with the relevant institutional or journal authorities and investigating the claim

6.4.24 Complaints and appeals related to publication misconduct should be addressed by:

- a) The editor of the journal or the publisher
- b) The research participants
- c) The author(s) of the paper
- d) The general public

Answer: a) The editor of the journal or the publisher

7 Review Section

7.1 Review questions

7.1.1 1. What is plagiarism? Explain the role of literature review in preventing and detecting plagiarism.

Plagiarism is the unauthorized use of another's work or ideas without proper attribution, violating academic integrity.

Role of Literature Review: - Familiarizes researchers with existing research, aiding accurate attribution.

- Enhances citation practices, helping to avoid unintentional plagiarism.
 - Improves skills in paraphrasing and summarization.
 - Highlights research gaps, encouraging original contributions.
 - Encourages the use of plagiarism-detection tools, promoting ethical research.
-

7.1.2 2. Explain the criteria for selecting a viable research problem. Discuss challenges researchers may face during formulation and strategies to overcome them.

Criteria for Selecting a Viable Research Problem

1. *Relevance:* Addresses a real need or gap, contributing to current knowledge.
2. *Originality:* Provides a fresh perspective or innovative approach.
3. *Feasibility:* Realistic within time, resources, and expertise available.
4. *Specificity and Focus:* Clearly defined and narrow in scope.
5. *Ethical Acceptability:* Aligns with ethical guidelines.
6. *Significance:* Holds theoretical or practical value with broader impact.

Challenges:

- *Ambiguity in problem definition*: Address by starting broad, then refining.
- *Limited resources*: Plan research within available budget and time.
- *Literature overload*: Focus on recent, high-quality sources.

Strategies: - Break down the problem into smaller, manageable questions. - Seek feedback from mentors or peers. - Use systematic review techniques to manage and organize literature.

7.1.3 3. How is authorship credited if two people work on a similar topic and publish jointly, but most of the work is done by one person?

- *Authorship* should reflect contributions. The person who contributed more may be listed as the first author.
 - *Acknowledgments* can note specific contributions, ensuring transparency and fairness.
-

7.1.4 4. What is the format for in-text citation and bibliographic item in APA style?

- *In-Text Citation*: (Author's Last Name, Year)
Example: (Smith, 2023).
 - *Reference List Entry*: Author's Last Name, First Initial. (Year). Title of the work. Publisher.
Example: Smith, J. (2023). *Research Basics*. Academic Press.
-

7.1.5 5. What is DOI?

A *DOI* (Digital Object Identifier) is a unique alphanumeric string assigned to publications to enable reliable digital access. It identifies and links electronic articles.

7.1.6 6. Difference between patented products and research output?

- *Patented Product*: Legally protected innovation with potential commercial application.
 - *Research Output*: Scholarly work adding to knowledge, typically without legal protection unless patented.
-

7.1.7 7. What is the role of editors in a journal?

Editors manage the review process, ensure quality control, maintain ethical standards, guide revisions, and make publication decisions, all of which uphold the journal's credibility.

7.1.8 8. What is the impact factor of a journal, and how do I find it?

- *Impact Factor*: Measures a journal's average citation count per article, indicating its influence.
 - *Finding Impact Factor*: Check journal websites, use Web of Science, or visit the publisher's page.
-

7.1.9 9. What is the H5-index and H5-median on Google Scholar?

- *H5-index*: Reflects the number of articles with at least five citations in the past five years.
 - *H5-median*: Shows the median citation count of articles in the H5-index, giving insight into citation distribution.
-

7.1.10 10. What is an author's H-index?

An *H-index* quantifies an author's productivity and citation impact, where an author has h articles each cited at least h times, indicating sustained research influence.

7.1.11 11. Differentiate between a Broad Research Topic and a Well-Defined Research Problem. Explain the steps to narrow down to a research problem with an example.

Broad Research Topic: - A general area of interest that sets the research direction but lacks specific objectives. - *Example:* “Impacts of social media on mental health” covers various aspects like platforms, demographics, and mental health outcomes.

Well-Defined Research Problem: - A focused, specific issue that the research aims to address, providing clear boundaries. - *Example:* “How does daily Instagram usage affect anxiety levels among college students?” This question specifies the platform (Instagram), target group (college students), and mental health aspect (anxiety).

Steps to Narrow Down a Broad Topic to a Research Problem

1. *Identify a Broad Interest Area:*

- Choose an area aligned with academic, professional, or societal needs.
- *Example:* “Social media and mental health.”

2. *Conduct Preliminary Literature Review:*

- Examine current research trends and gaps to identify specific areas within the topic.
- *Example Finding:* Limited studies on how specific platforms influence specific mental health issues.

3. *Refine the Focus:*

- Narrow to a subgroup, context, or specific variable to create a targeted scope.
- *Example:* Focusing on Instagram usage’s impact on anxiety in a specific demographic.

4. *Formulate the Research Problem:*

- Draft a research question that highlights the core issue and the population involved.
- *Final Example:* “What is the relationship between daily Instagram usage and anxiety levels among college students?”

7.1.12 12. Discuss the ethical issues involved in the scenario where a former student’s data is used without permission.

Solution:

- *Ownership of Data:*
The primary ethical issue is data ownership. The former student has rights over their data, and using it without permission violates ethical standards. Failing to obtain consent infringes upon the former student's intellectual and proprietary rights over their own research contributions.
- *Informed Consent:*
Ethical research mandates informed consent from all contributors. The co-authors should have explicitly sought permission from the former student before utilizing their data. Obtaining consent ensures transparency and maintains trust among collaborators.
- *Integrity of Research:*
Using data without proper authorization can compromise the research's integrity, raising doubts about the credibility and validity of the findings. Ethical lapses in data use can lead to the research being scrutinized or dismissed by peers.
- *Consequences of Misconduct:*
If the former student denies permission to use the data, the authors face an ethical decision. They must either honor the student's decision and seek alternative data sources or risk repercussions, which may include damage to their professional reputations and potential academic consequences.

7.1.13 13. Throughout this course you have been repeatedly asked about the importance of interpreting the findings of your research study. Explain why this is an essential element of high-quality research work.

Solution:

Interpreting research findings is a critical element in high-quality research because it:

- *Ensures Contextual Understanding:* Proper interpretation allows researchers to place their findings within the broader context of existing literature and theories, linking their work to prior research and advancing the field.
- *Draws Meaningful Conclusions:* Interpretation transforms raw data into actionable insights. It helps in identifying patterns, trends, and relationships that lead to meaningful conclusions and recommendations.
- *Validates the Hypothesis:* It helps determine whether the findings support or contradict the original hypothesis, providing a clear understanding of the research question.
- *Enhances Credibility:* Transparent and rigorous interpretation demonstrates the researcher's competence, ensuring the research is credible and trustworthy.

- *Guides Future Research:* A clear interpretation of findings highlights gaps, limitations, and potential directions for future research, contributing to the scientific discourse.
-

7.1.14 14. In a literature survey, a researcher includes a paragraph from another work as running text without using in-text citation but instead puts (see the work of ...) in brackets. Is this plagiarism? If so, what is the right way to correct this misconduct?

Solution:

Yes, this is considered **plagiarism**. Plagiarism occurs when another researcher's work, ideas, or words are used without proper attribution, regardless of whether the author intends to claim the work as their own. Simply placing a reference in brackets like "(see the work of ...)" does not satisfy the ethical requirement of citation. This is not a valid method of citing someone else's work, and it misrepresents the origin of the ideas or text.

Corrective Steps:

To correct this misconduct, the researcher should:

- **Properly Attribute the Source:** The correct way to cite the paragraph would be to explicitly include the appropriate in-text citation, such as (Author, Year), where "Author" is the last name of the original author and "Year" is the year of publication.
 - **Use Direct Quotation for Exact Text:** If the text is directly quoted, it must be placed in quotation marks and followed by the proper citation. For example:
> "Exact text from the original work" (Author, Year).
 - **Paraphrase and Cite:** If the researcher paraphrases the idea or findings from the original work, they must still provide an in-text citation, e.g., (Author, Year), to acknowledge the source of the ideas.
-

7.1.15 15. If a literature survey misconduct, such as failing to properly cite a source, is considered a serious issue under the university's code of conduct and leads to the cancellation of registration, should this misconduct be forgivable, or as a dean, should the person be required to reapply for the program?

Solution:

As a dean, the decision about whether the misconduct is forgivable or whether the student should reapply for the program should be carefully considered, taking into account the severity of the misconduct and the broader context.

Factors to Consider:

1. Intent and Acknowledgement:

- *Unintentional Mistake:* If the student can demonstrate that the failure to cite correctly was an honest mistake or misunderstanding of citation practices, and they acknowledge this, it could be treated as a learning opportunity. In such cases, a corrective action, such as re-taking academic integrity training or re-submitting the work with proper citations, could be considered.
- *Deliberate Misconduct:* If the student knowingly plagiarized or attempted to deceive, this is a more serious violation. Academic integrity violations of this nature can compromise the reputation of the university and the student's academic standing.

2. Pattern of Behavior:

- If this is a *first-time offense* and there is no history of similar misconduct, there might be grounds for allowing the student to reapply, provided they demonstrate genuine remorse and a willingness to learn from the incident.
- A *repeated offense* or a pattern of academic dishonesty would suggest that the student has not taken the university's code of conduct seriously, and in such cases, stricter actions, including requiring them to reapply, may be necessary.

3. University Code of Conduct:

- The university's *code of conduct* should clearly outline the consequences of academic misconduct. If the code specifies that a violation of this nature leads to registration cancellation, then it is important to follow the rules, while still considering the possibility of remedial actions to help the student.

4. Educational Opportunity:

- If the student is willing to accept responsibility, undergo corrective measures, and demonstrate a commitment to academic integrity moving forward, the option to *reapply for the program* may be a reasonable one, allowing the student to learn from the mistake and return with a better understanding of the university's expectations.

Recommendation: If the misconduct is considered serious but not entirely malicious, *forgiveness with conditions* could be an option. This could include allowing the student to *reapply* after a specified time period, provided they complete educational modules on academic integrity, and submit a reformed research proposal with proper citation. However, if the misconduct reflects a more profound disregard for academic norms, then *reapplication* may be necessary to ensure that the student fully understands the gravity of the issue and the university's commitment to academic integrity.

7.1.16 16. Two PhD students working under the same supervisor have similar work. One drafts a paper and asks the other to revise it. The supervisor approves, and the paper gets accepted at a conference. It appears in both students' PhD theses. Is this responsible conduct? What action would you take as the Dean? Is the supervisor irresponsible?

Solution:

Ethical Issues:

1. *Authorship Misrepresentation:* The second student did most of the work, but both students were listed as co-authors. According to the APS Code of Conduct, authorship should reflect substantial intellectual contribution. The first student should not be a co-author unless they significantly contributed to the paper beyond the initial draft.
2. *Supervisor's Responsibility:* The supervisor's role is to ensure *proper credit* is given to all contributors. In this case, the supervisor failed to ensure proper authorship distribution, potentially misrepresenting the contributions and undermining academic integrity.
3. *Academic Integrity:* Using the same paper for both students' theses raises concerns of *redundant publication*. This can be seen as misleading since both students are claiming the same work as part of their independent research.

Actions as Dean:

1. *Investigate* the contributions of both students and the supervisor's involvement in the authorship decision.
2. *Correct authorship:* The second student should be credited as the primary author, with the first student acknowledged in the acknowledgment section, if applicable.
3. *Counsel the supervisor* about their responsibility in ensuring fair authorship and proper attribution.

4. *Review the theses* to ensure that no redundant publication is claimed, and take necessary corrective action if required.
-

7.1.17 17. Two PhD students working under the same supervisor have similar work. One drafts a paper based on an exercise from an external source with some original contribution. Due to time constraints, he/she ask the other to revise it. The supervisor approves, and the paper is accepted at a conference with joint authorship. It appears in both students' PhD theses. Is this responsible conduct? What action would you take as the Dean? Is the supervisor irresponsible?

Solution:

Ethical Issues:

1. *Authorship and Contribution:*

- The student who did the draft should be credited for their original contributions, but the second student, who did the majority of the revisions, should not be an equal co-author unless they made substantial intellectual contributions.
- According to ethical research practices, authorship should reflect the level of contribution made to the work. If the second student did the majority of the work, their authorship status should be more prominent. Simply revising the work does not usually justify equal authorship.

2. *Use of External Source:*

- The use of an exercise from an external source should be properly acknowledged in the paper to avoid any plagiarism or misrepresentation of ideas. If the work is borrowed, citing the original source is necessary.

3. *Thesis and Redundant Publication:*

- If the same paper is included in both PhD theses, this could lead to *self-plagiarism* if the students claim the same work as original contributions in their theses. The students must differentiate their contributions in their theses or use the paper as a basis for further, independent research.

Actions as Dean:

1. *Investigate the Contributions:*

- Review the contributions of each student in the paper and confirm if the authorship is correctly assigned. If one student did most of the work, they should be the primary author, and the other should be appropriately acknowledged.

2. *Ensure Proper Citations:*

- Ensure that the external source of the exercise is properly cited in the paper to avoid plagiarism.

3. *Address Redundant Publication:*

- If the paper appears in both students' theses, ensure that this is not treated as original research for both. Advise the students to differentiate their research work in the theses, ensuring there is no overlap or redundancy.

4. *Counsel the Supervisor:*

- The supervisor should take a more active role in overseeing authorship and ensuring proper research practices. Supervisors are responsible for ensuring that credit is assigned accurately and ethically. They should have reviewed the paper thoroughly and ensured that authorship was determined based on substantial contribution.
- *Not responsible conduct:* The authorship issue needs correction, and the students must ensure their individual contributions are properly acknowledged in their theses. The supervisor is also partially responsible for this situation as they did not adequately review and address authorship and contributions.
- *Actions:* Correct the authorship and clarify the contributions of each student in both the paper and the theses. The supervisor should also be reminded of their ethical responsibility in overseeing proper research conduct and authorship assignment.

7.1.18 18. What is the difference between reference and a bibliography in research publications?

Solution:

- *Reference:* A list of sources that are directly cited in the research paper. Each reference corresponds to a specific in-text citation used to support claims or provide context within the work.
- *Bibliography:* A comprehensive list of all sources consulted during the research process, regardless of whether they were cited in the paper. It may include references, but also sources that were read for background information or inspiration.

7.2 Case studies:

7.2.1 Scenario 1:

A researcher works in a laboratory and records data and results in a research diary. After a few years, the researcher changes institutions, joins a new lab, and applies for a patent for work that was completed in the previous lab.

Questions and Answers:

1. *What ethical concerns arise when a researcher applies for a patent based on work completed at a previous institution?*

Answer: The primary ethical concern in this scenario is the *ownership of intellectual property*. The researcher should have acknowledged the previous institution's contribution, as the work was completed there. Applying for a patent without informing the previous lab or obtaining permission can be considered a breach of ethical standards and can undermine the integrity of the research process. According to the *American Physical Society* (APS) Code of Conduct, researchers should ensure proper attribution and respect for the work of previous collaborators.

2. *Is the researcher's action of applying for a patent without acknowledging the previous institution or lab a violation of research ethics?*

Answer: Yes, this action violates research ethics. According to the APS Code of Conduct, researchers must properly acknowledge all contributors and institutions involved in the research. The failure to disclose the prior institution and its involvement in the research can lead to accusations of misappropriation of intellectual property and lack of transparency.

3. *How does the lack of prior approval or acknowledgment of the former lab impact the integrity of the research process?*

Answer: The lack of prior approval or acknowledgment of the former lab compromises the *integrity of the research process* by neglecting to provide fair credit to all parties involved in the research. It also creates a potential conflict over intellectual property rights, which can lead to disputes. The APS Code emphasizes the importance of collaboration and transparency, which are essential to maintaining trust in the research community.

4. *Does this scenario constitute academic misconduct? If so, which ethical principles are violated?*

Answer: Yes, this scenario could constitute academic misconduct. The primary ethical principles violated include *intellectual property rights*, *misrepresentation*, and *lack of transparency*. The researcher failed to consult with the previous institution and did not

acknowledge the contributions of the original lab, which could be seen as misappropriating the work for personal gain without giving proper credit.

5. *Is the researcher's failure to inform the previous lab and obtain consent for the patent application considered research misconduct? Why or why not?*

Answer: Yes, the researcher's failure to inform the previous lab and obtain consent for the patent application is considered a form of research misconduct. According to the APS Code of Conduct, researchers must act with integrity and ensure that all contributors are properly acknowledged. By omitting the previous institution from the patent application, the researcher violated the ethical standards related to honesty, attribution, and the responsible conduct of research.

6. *How does intellectual property law intersect with research ethics in this case?*

Answer: Intellectual property law plays a critical role in determining who holds the rights to the research and its outputs, such as patents. From an ethical standpoint, the APS Code of Conduct aligns with intellectual property law by promoting the fair and transparent attribution of work. The researcher should have followed both ethical guidelines and legal protocols by obtaining consent from the previous institution before filing for a patent. This ensures respect for intellectual property and prevents disputes over ownership.

7. *As an academic institution, how would you address the ethical violation in this case? What actions should be taken to ensure proper acknowledgment and handling of intellectual property?*

Answer: As an academic institution, the first step would be to investigate the case to understand the facts. If the researcher did not follow proper procedures for acknowledging the previous institution, the institution should work with the researcher to address the issue. Actions could include issuing a formal warning, requiring the researcher to properly acknowledge the previous institution in any subsequent publications or patent applications, and ensuring that any legal disputes are resolved. Additionally, institutions should provide clear guidelines on intellectual property management and the importance of acknowledging all contributors.

8. *What steps should the researcher take to rectify the situation if the patent application has already been filed?*

Answer: If the patent application has already been filed, the researcher should immediately inform the previous institution and any co-authors involved in the original work. They should seek approval from the previous lab and update the patent application to include the proper acknowledgment. The researcher should also ensure that the previous institution's rights are respected and that all contributions are accurately documented. If necessary, the researcher should work with legal advisors to resolve any conflicts over intellectual property rights.

9. *What strategies can be implemented in research institutions to prevent similar ethical issues from arising in the future?*

Answer: Research institutions can implement several strategies to prevent similar ethical issues, such as:

- Providing clear guidelines on intellectual property rights and patent applications.
- Ensuring that all researchers understand the importance of acknowledging contributions from previous institutions or labs.
- Promoting transparency and open communication regarding the ownership of research data and outcomes.
- Offering training on responsible research practices, particularly in relation to patenting and publication.

10. *How should institutions handle intellectual property agreements with researchers to ensure transparency and accountability?*

Answer: Institutions should establish clear intellectual property agreements that outline the ownership and rights to research outputs. These agreements should be discussed at the outset of a research project and updated as necessary, particularly when researchers move between labs or institutions. By setting clear expectations and ensuring that all parties are aware of their rights and responsibilities, institutions can foster a culture of transparency and accountability. Furthermore, institutions should have mechanisms in place to resolve disputes and provide guidance on ethical issues related to intellectual property.

7.2.2 1. Scenario: Unauthorized Use of Laboratory Equipment

A researcher in a university laboratory uses the equipment after hours without informing the lab supervisor or other researchers. The researcher completes a significant part of their experiment using the equipment, but the work is not properly documented.

Ethical Issue: Unauthorized use of institutional resources, lack of transparency, and neglecting to inform others involved in the research.

Solution: According to the *American Physical Society* Code of Ethics, researchers must act with integrity and respect institutional policies. The researcher should have sought approval from the supervisor and ensured proper documentation of all work. The researcher should be reminded of the importance of transparency and the ethical obligation to respect institutional resources.

7.2.3 2. Scenario: Duplicate Publication of Research Results

A researcher submits the same research findings to two different journals without informing the editors or authors of the other publication.

Ethical Issue: Duplicate publication and failure to disclose prior submissions.

Solution: The *APS Code of Ethics* prohibits duplicate publication. The researcher should withdraw one submission, disclose the prior submission to both journals, and ensure that future submissions adhere to ethical guidelines. Both journals should be notified, and the researcher should be educated about the ethical obligation to disclose prior submissions to avoid misleading the academic community.

7.2.4 3. Scenario: Co-authorship Dispute

Two researchers work on a project and contribute equally to the research. However, when the paper is submitted, one researcher's name is omitted from the authorship list, despite their significant contributions.

Ethical Issue: Inappropriate authorship attribution and failure to acknowledge all contributors.

Solution: As per the *APS Code of Ethics*, proper authorship must reflect the contributions of all involved. The omitted researcher should be added to the authorship list with appropriate acknowledgment. The supervisor should review the situation and ensure that authorship guidelines are clear and followed in the future. Institutions should establish protocols to resolve authorship disputes.

7.2.5 4. Scenario: Fabrication of Data in a Research Experiment

A researcher fabricates data in an experiment to make their results appear more significant. The data is later used in multiple publications.

Ethical Issue: Fabrication of data and misleading the scientific community.

Solution: The *APS Code of Ethics* clearly condemns data fabrication. The researcher's actions must be reported to the institution, and a thorough investigation should be conducted. The researcher should retract all affected publications, and any false claims should be corrected. Institutions should have strong procedures to prevent and address data falsification.

7.2.6 5. Scenario: Plagiarism in Thesis Work

A PhD student uses paragraphs directly from previously published articles without proper citation, integrating them into their thesis as part of their literature review.

Ethical Issue: Plagiarism and failure to properly attribute intellectual property.

Solution: The *APS Code of Ethics* emphasizes the importance of proper citation to give credit to original authors. The student should be required to revise their thesis to properly cite all sources. The institution should implement a plagiarism detection process, and the student should undergo additional training on academic integrity.

7.2.7 6. Scenario: Misuse of Research Funding

A researcher uses a portion of their allocated research grant for personal expenses, violating the terms of the funding agreement.

Ethical Issue: Misuse of research funds and financial misconduct.

Solution: According to the *APS Code of Ethics*, researchers must manage research funds responsibly. The researcher should be held accountable, and any misuse should be investigated thoroughly. The institution should implement stronger oversight of funding usage, and the researcher may be required to repay the misused funds.

7.2.8 7. Scenario: Misleading Author Contributions

A paper is published in which the order of authors is not reflective of their actual contributions. One author who contributed significantly is listed last, while another who did minimal work is placed first.

Ethical Issue: Misleading authorship order and failure to properly acknowledge contributions.

Solution: The *APS Code of Ethics* requires proper attribution and transparency in authorship. The authorship order should be corrected, and all contributions should be clearly stated. Future publications should establish clear communication among authors regarding contributions and order of authorship.

7.2.9 8. Scenario: Data Sharing Conflict

A researcher collects unique data for their project but refuses to share it with other researchers, hindering collaboration and scientific progress.

Ethical Issue: Failure to share data and promote collaborative research.

Solution: The *APS Code of Ethics* promotes openness and sharing of data to advance scientific knowledge. The researcher should be encouraged to share the data with others and collaborate in a way that benefits the scientific community. Institutions should foster an environment of transparency and collaboration by creating clear data-sharing policies.

7.2.10 9. Scenario: Lack of Informed Consent for Experiment Participation

A researcher conducts experiments involving human participants but does not obtain informed consent from all participants, as required by institutional ethics guidelines.

Ethical Issue: Violation of informed consent and failure to protect research participants.

Solution: The *APS Code of Ethics* emphasizes the need for informed consent in all research involving human subjects. The researcher should stop the experiment and ensure that all participants are properly informed and consent to the study. The research must be reviewed by the institution's ethics committee, and the researcher should undergo additional training on ethical research practices involving human participants.

7.2.11 10. Scenario: Supervisor Taking Credit for Student's Research

A PhD student completes the majority of the work for their dissertation, but the supervisor insists on being listed as the first author on the resulting publication without contributing significantly.

Ethical Issue: Unjustified authorship and failure to recognize the primary contributor.

Solution: The *APS Code of Ethics* states that authorship should be based on actual contributions. The supervisor's insistence on being the first author without significant input violates ethical guidelines. The student should discuss the situation with the supervisor and institution to ensure proper recognition of their contributions. Clear authorship guidelines should be established to avoid similar conflicts in the future.

References

Knuth, Donald E. 1984. “Literate Programming.” *Comput. J.* 27 (2): 97–111. <https://doi.org/10.1093/comjnl/27.2.97>.