RESEARCH METHODOLOGY & INTELLECTUAL PROPERTY RIGHTS

23RMP57

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MODULE -1
INTRODUCTION

Module - I

Introduction: Meaning of Research, Objectives, and Motivation in Engineering Research, Criteria for Good Research, Types of Engineering Research, Research Process, Research Problem, Selection and Components of the Research Problem, Techniques Involved in Defining a Problem.

Ethics in Engineering Research- Ethics in Engineering Research Practice, Types of Research Misconduct, Ethical Issues Related to Authorship.

08 Hours

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Objectives of Engineering Research
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Ethics in Engineering Research Practice
Types of Research Misconduct
Ethical Issues Related to Authorship.

PART-1

Research is a component of two Syllabus "Re" and "Search".

Re- is the prefix meaning Again/Over Again/ A new.

Search- To examine closely and carefully

MEANING OF RESEARCH

Research refers to –

- A careful, well-defined (or redefined), objective, and systematic method of search for knowledge, or formulation of a theory which is unknown and useful on a particular aspect so as to make an original contribution to expand the existing knowledge.
- **Research involves-**

  Formulation of hypothesis

  Data analysis

  Deduction

  Ascertaining whether the conclusions fit the hypothesis.

Research is a process of creating, or formulating knowledge that does not yet exist.

Research cycle

Start with a practical problem: The research begins with identifying a real-world problem that needs a solution.

Clarify the problem: Be clear about what the problem is and why it's important to solve it.

Form a research question: The problem leads to a specific question that guides the research. Without this question, it's easy to get overwhelmed by too much information.

Define the research project: The research question helps create a clear research project, which is a series of activities aimed at solving the problem.

Achieve a result: The research process eventually leads to a solution or result that helps solve the original practical problem.

In short, it's a cycle of identifying a problem, asking a question, conducting research, and finding a solution.

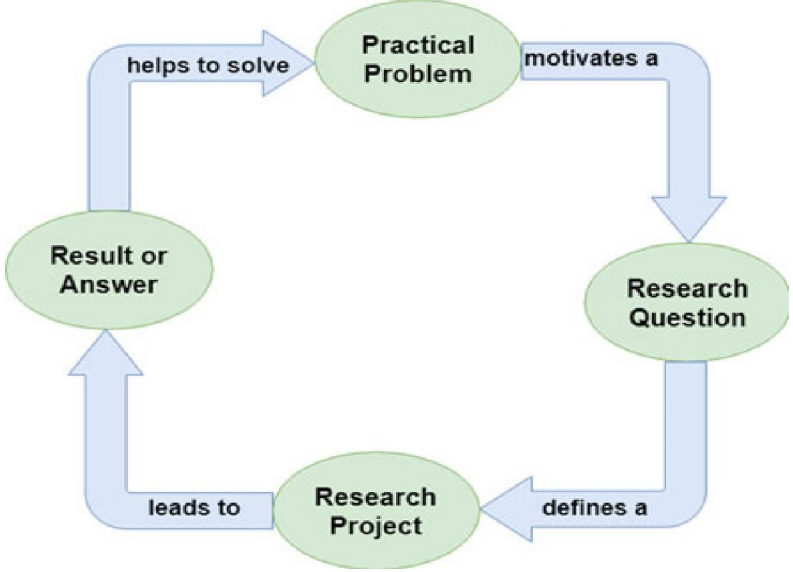

Fig. 1.1 The research flow diagram

- **Research is more than just reading**: It's about contributing new ideas to what we already know.

- **Ask meaningful questions**: Research starts with asking questions that are relevant to the world around us.

- **Be organized**: When doing research, it's important to follow a clear and systematic approach.

- **The goal of research**: The aim is to gain new knowledge or solve a specific problem.

Good research questions develop throughout the project actually and one can even keep modifying them.

Building background Knowledge:

Before doing research, we need to learn and connect different ideas.

This helps our minds get ready to work on new things.

Making a contribution:

Its about adding a something new, even if its small, to what we know.

Its like adding a small part to complete a puzzle.

The ways of developing and accessing knowledge come in three broad categories:

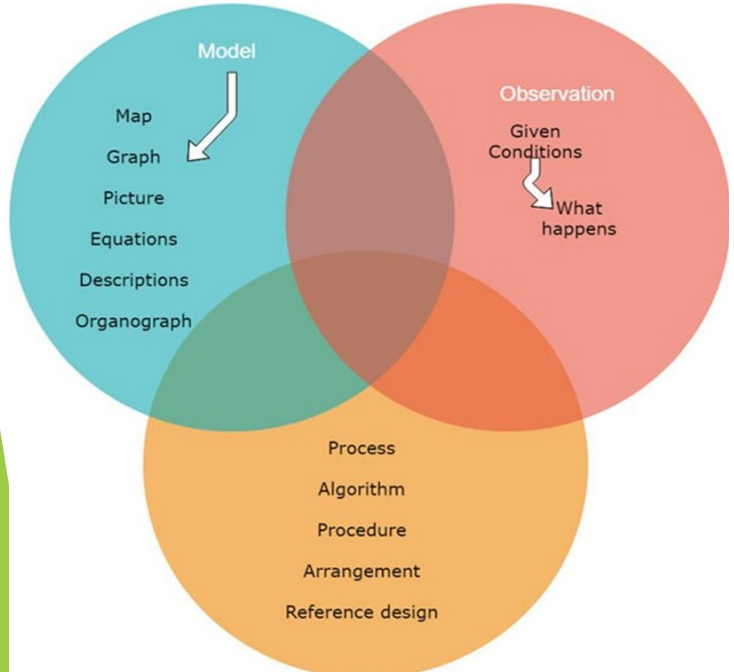

Fig. 1.2 The categories of knowledge in research

The categories of knowledge in research

- **Observation** is the most fundamental way of obtaining information from a source. It becomes particularly important when the subject being observed is unusual, exciting, or challenging to study. Observation can take various forms, ranging from traditional measurements in a laboratory setting to conducting surveys among a group of subjects
- **Models** are approximated, often simplified ways of describing sometimes very complex interactions in the form of a statistical relationship, a figure, or a set of mathematical equations. (Map ,graphs, pictures ,equations, etc)
- **Processes and Algorithms**: The final category is a way of **arranging** or doing things through processes, algorithms, procedures, arrangements, or reference designs, to get a certain desired result.
- **Example 1: In gardening research, observation involves directly watching and recording how plants respond to sunlight. This may include noting changes in leaf color, growth patterns, or flowering times. For instance, you might observe that certain plants thrive in direct sunlight, while others prefer shaded areas. These direct observations form the foundation of your understanding of the plants' behavior in different light conditions.**
- **For example, your model might suggest that plants receiving more sunlight tend to grow taller or produce more flowers. Finally, you develop a process (a watering schedule) to achieve the desired plant growth. Your process could involve adjusting the frequency and amount of water based on the observed sunlight levels.**

Example 2 : **Let us consider an example related to the development of a smartphone**

- Engineers observe user interactions with existing smartphones, studying how people use
- different features, how they hold the device, and identifying common issues such as battery
- life and durability concerns.
- This observation helps engineers understand user behavior and preferences, as well as identify potential problems or areas for improvement.
- Based on the observed data, engineers create models to simulate the behavior of various smartphone components.
- These models help predict factors like power consumption, signal strength, and heat dissipation, influencing design choices.
- Engineers follow a detailed development process for manufacturing the smartphone.
- This involves procedures for designing the circuit board, arranging hardware components such as the battery, processor, camera, and sensors within the device, implementing algorithms for software functionalities, and adhering to reference designs to ensure compatibility with Industry standards

OBJECTIVES OF ENGINEERING RESEARCH

(i)**Innovation and Advancement**: By exploring new ideas, concepts, and methodologies, researchers seek to innovate and advance the field, leading to the development of new technologies and solutions.

(ii) **Problem Solving:** Researchers aim to address challenges and issues faced by industries, communities, or individuals, seeking practical and effective solutions through the application of engineering principles.

(iii) **Optimization:** optimizes existing processes, sys tems, and products. This involves improving efficiency, reducing costs, enhancing performance, and minimizing environmental impacts.

(iv) **Knowledge Expansion**: Through experimentation, analysis, and doc umentation, researchers contribute to the understanding of fundamental principles and phenomena in various engineering disciplines.

(v) **Interdisciplinary Collaboration:** Many engineering challenges require a multi disciplinary approach. Research objectives may involve collaboration between en gineers, scientists, and professionals from other fields to address complex problems that span multiple domains.

(vi) **Education and Training**: Engineering research contributes to the education and training of future engineers and scientists. The dissemination of research findings through publications, conferences, and other channels helps educate the next gener ation of professionals.

Different types of research studies

- **Exploratory or Formulative**: This type of research is about exploring new ideas or defining problems that haven't been studied much before.
- **Descriptive**: Focuses on describing characteristics or patterns of a situation, group, or event.
- **Diagnostic**: Aims to identify causes or problems, often in specific situations.
- **Hypothesis-testing**: Involves testing a hypothesis or theory to confirm or disprove it.

MOTIVATION IN ENGINEERING RESEARCH

The intention of doing research may be one or more of the following:

(i) Studies have shown that **intrinsic motivations** like interest, challenge, learning, meaning, purpose, are linked to strong creative performance;

(ii) **Extrinsic motivating** factors like rewards for good work include money, fame, awards, praise, and status are very strong motivators, but may block creativity. For example: Research outcome may enable obtaining a patent which is a good way to become rich and famous.

(iii) **Influences** from others like competition, collaboration, commitment, and encouragement are also motivating factors in research.

For example:

My friends are all doing research and so should I, or, a person that I dislike is doing well and I want to do better.

(iv) **Personal motivation** in solving unsolved problems, intellectual joy, service to community, and respectability are all driving factors.

(v) Several other factors like **government directives**, **funding opportunities** in certain areas, and terms of employment, can motivate people to get involved in engineering research.

Research process

Formulating the Research Problem: Identifying and defining the research question or problem that needs to be addressed.
Literature Review: Conducting a thorough review of existing literature and research related to the topic to understand what has already been studied and discovered.
Developing the Hypothesis: Creating a clear and testable statement that predicts the relationship between variables in the research.
Research Design: Planning the overall structure and approach of the study, including selecting the research methods and data collection techniques.
Sample Design: Determining the sample size and selecting the participants or subjects that will be part of the study.
Data Collection: Gathering relevant data through various methods, such as surveys, interviews, experiments, or observations.

Research process

Execution of the Project: Implementing the research plan and collecting the data as per the designed approach.

Data Analysis: Analysing the collected data using appropriate statistical or qualitative techniques to draw meaningful conclusions.

Hypothesis Testing: Evaluating the hypothesis based on the analysis to determine whether it is supported or rejected.

Generalizations and Interpretation: Making broader connections and interpretations of the findings in the context of the research problem.

Conclusion and Recommendations: Summarizing the research results, drawing conclusions, and suggesting potential future research or practical implications.

Aspect	Descriptive Research	Analytical Research
Purpose	To describe characteristics, functions, or facts	To analyze, explain, or evaluate relationships and causes
Nature	Observational and factual	Critical and evaluative
Focus	"What is?"	"Why is it?" or "How is it?"
Approach	Qualitative or quantitative	Mostly quantitative
Data Collection	Surveys, observations, case studies, existing records	Use of existing data and statistical methods for analysis
Data Use	Presents data as it is	Interprets data to make inferences or test hypotheses
Hypothesis	May or may not involve a hypothesis	Involves hypothesis testing
Outcome	Description of current status, trends, or conditions	Explanation of causes, effects, and relationships
Examples	Population census, market research, case reports	Statistical analysis of factors affecting disease spread, economic models

Parameters	Fundamental Research	Applied Research
Meaning	Basic research refers to the study that is aimed at enhancement of scientific knowledge.	Applied research is the practical application of science.
Type of Knowledge	Scientific discovery (Science)	Technological application (Technology)
Research Approach	Theoretical	Practical
Application	Has no practical application	Has practical application
Question	*Is it true?*	*Does it work?*
Scope of Research	Universal	Limited
Uses	To add new knowledge to existing knowledge	To solve specific, practical questions facing society
Research Purpose	Intellectual curiosity	Solving problems

	Qualitative Research	Quantitative Research
Research Focus	Exploratory, descriptive, and interpretive	Confirmatory and explanatory
Data Collection	Interviews, focus groups, observations, etc.	Surveys, experiments, structured observations, etc.
Data Type	Non-numeric (text, images, audio, etc.)	Numeric (quantitative measurements)
Sample Size	Smaller sample sizes	Larger sample sizes
Data Analysis	Themes, patterns, narratives	Statistical analysis
Researcher's Role	Subjective interpretation	Objective measurement
Generalizability	Limited to specific contexts	Wider generalizability
Causality	Inductive reasoning	Deductive reasoning
Theory Development	Emerging from data	Testing existing theories
Research Questions	Open-ended questions	Closed-ended questions
Research Design	Flexible and adaptive	Structured and controlled
Time and Resource	Time-consuming and resource-intensive	More efficient data analysis
Validity and Reliability	Establishing rigor through triangulation	Ensuring reliability and validity through standard procedures
Focus on Context	Emphasis on understanding the context	Context often controlled for
Examples	Case studies, ethnographies, interviews	Surveys, experiments, statistical analyses

Finding and Solving a Worthwhile Problem

- A researcher may start out with the research problems stated by the Supervisor or posed by others that are yet to be solved.
- It may involve rethinking of a basic theory, or need to be formulated or put together from the information provided in a group of papers suggested by the Supervisor.
- Research scholars are faced with the task of finding an appropriate problem on which to begin their research.

Finding and Solving a Worthwhile Problem

- Skills needed to accomplish such a task at the outset, while taking care of possible implications .
- A worthwhile research problem would have one or more attributes.

  - It could be non intuitive/counterintuitive even to someone who knows the area.

  -Something that the research community had been expecting for sometime.

-A new result which would start off a new subject or an area, provides a new method or improves upon known methods of doing something which has practical applications.

- The researcher has to be convinced that the problem is worthwhile before beginning to tackle it because best efforts come when the work is worth doing.
- The problem and/or solution has a better chance of being accepted by the research community. Not all problems that one solves will be great, and sometimes major advancements are made through solutions to small problems dealt with effectively.

- The recommended steps to solve a research problem are:

1. **Understand** the problem, **restate** it as if its your own, **visualize** the problem by drawing figures, and determine if something more is needed.

2. One must start somewhere and systematically explore possible **strategies** to solve the problem or a simpler version of it while looking for **patterns**.

3. **Execute** the plan to see if it works, and if it does not then start over with **another approach**. Having delved into the problem and returned to it multiple times, one might have a flash of insight or a **new idea** to solve the problem.

4. **Looking back** and reflecting helps in understanding and assimilating the **strategy**, and is a sort of investment into the future.

PART-2

Ethics in Engineering Research

- Ethics generally refers to a set of rules distinguishing acceptable and unacceptable conduct, distinguishing right from wrong.
- Although everyone recognizes some common ethical norms, but there is difference in interpretation and application.
- Ethical principles can be used for evaluation, proposition or interpretation of laws .
- Government bodies, and universities worldwide have adopted certain codes for research ethics.
- Research ethics examines the appropriate application of research outcomes, while responsible conduct of research deals with the way the work is undertaken.

- **Ethics in engineering**: Ethics in engineering research is important to ensure new technologies and solutions are developed responsibly, benefiting society and reducing harm.

- **Key aspects of ethics**: It includes how researchers treat subjects, being transparent and honest, and considering the broader impact of their work.

- **Engineering ethics**: This involves addressing issues like safety, sustainability, and social responsibility in engineering.

- **Ethical choices**: Researchers make decisions that shape the impact of technology, and starting with the right ethical requirements can guide its positive effect.

- **Influence through design**: Researchers can influence technology by designing it to meet the required needs, while considering ethical priorities during the design process.
- **Choosing alternatives**: Researchers must choose between different options that serve similar functions, ensuring they minimize risks and hazards.
- **Safety responsibility**: It's the researchers' ethical duty to reduce risks and consider safer alternatives, designing systems that are inherently safe or have safety features to prevent harm.

TYPES OF RESEARCH MISCONDUCT

- Engineering research should be conducted to improve the state-of-the-art of technologies.
- Research integrity should be dealt fairly with others, honesty about the methods and results, replicating the results wherever possible so as to avoid errors, protecting the welfare of research subjects, ensuring laboratory safety, and so forth.
- In order to prevent mistakes, peer reviews should take place before the research output is published.
- There may be different types of research misconduct which can be summarized as follows:

1. **Fabrication** (Illegitimate creation of data): Fabrication is the act of conjuring data or experiments with a belief of knowledge about what the conclusion of the analysis or experiments would be, but cannot wait for the results possibly due to timeline pressures from supervisor or customers.

2. Falsification (Inappropriate alteration of data):

- Falsification is the misrepresentation or misinterpretation, or illegitimate alteration of data or experiments.
- Falsification and fabrication of data and results, hamper engineering research, cause false empirical data to percolate in the literature, wreck trustworthiness of individuals involved, and cause actual and avoidable delays in technical advancement.
- Misleading data can also crop up due to poor design of experiments or incorrect measurement practices.

3. Plagiarism (Taking other's work sans attribution):

- Plagiarism takes place when someone uses or reuses the work (including portions) of others (text, data, tables, figures, illustrations or concepts) as if it were his/her own without explicit acknowledgement.

- **Self-plagiarism**: Copying or reusing your own previous work without proper citation is also considered plagiarism.
- **Plagiarism and the internet**: The internet makes it easier to copy work but also helps detect plagiarism using software tools.
- **Plagiarism detection tools**: There are free and paid tools for detecting plagiarism, but they can't always guarantee a conclusive result.

Other Aspects of Research Misconduct

- **Research misconduct**: Serious violations of accepted research practices are considered misconduct.

- **Fraud**: If there's deception and harm caused, it's considered fraud. Eventually, ethical violations are usually discovered.

- **Simultaneous submission**: Submitting the same article to two different journals at the same time is against publication rules.

- **Mistakes in published work**: When mistakes are found in published research, they are often not reported or corrected unless a researcher takes the initiative to fix and update them.

ETHICAL ISSUES RELATED TO AUTHORSHIP

- Academic authorship involves communicating scholarly work, establishing priority for their discoveries, and building peer-reputation.

- There important research conduct and ethics related issues connected to authorship of research papers are summarized herewith in the context of engineering research. Credit for research contributions is attributed in three major ways in research publications by:

--Authorship (of the intended publication),

--Citation (of previously published or formally presented work), and

--Through a written acknowledgment (of some inputs to the present research).