Dr. Rajeshwari. R R
Dept. of MBA

**Introduction:** Meaning of Research, Objectives of Engineering Research, and Motivation in Engineering Research, Research Process, Types of Engineering Research, Finding and Solving a Worthwhile Problem.

## Meaning of Research:

Research is a systematic and carefully defined process aimed at acquiring knowledge or formulating theories driven by curiosity about the unknown. The objective is to make an original contribution to expand the existing knowledge base. This process involves the formulation of hypotheses or proposed solutions, data analysis, and the conclusions align with the initial hypotheses. Essentially, research is the creation or formulation of knowledge that does not yet exist.

Research is a systematic and methodical process that involves the careful exploration, investigation, and analysis of a subject or phenomenon. It aims to acquire new knowledge, develop theories, or contribute to existing knowledge by posing inquiries, formulating hypotheses, collecting and analyzing data, and drawing conclusions. Research is characterized by a structured and objective approach, seeking to uncover facts, patterns, or insights to address specific questions or problems.

## Engineering research:

Engineering research is the systematic process of enhancing perspectives and skills to understand, plan, design, and execute investigations in various forms related to engineering and technology. It begins by identifying a real-world problem or challenge that needs attention. This could involve finding solutions to issues that bother us, accomplishing tasks currently beyond our knowledge, understanding existing functionalities, or experimenting to observe outcomes. The goal is to address uncertainties, improve knowledge, and facilitate advancements in engineering and technology.

## Objectives of Engineering Research:

1 The main objective of engineering research is to solve new and significant problems, even though the conclusion is initially unknown.
2 The start of research is challenging, requiring guesses based on circumstantial evidence, intuition, and imagination.
3 Guesses provide a target to work toward, and initial attempts may reveal the guess is incorrect or suggest new avenues and targets.
4 Research may lead to modifications of the initial target, require new techniques, or result in serendipitous discoveries while seeking something else.
5 Research objectives can be convoluted and challenging to follow.
6 Thorough and accurate research, along with effective communication of results, is crucial for engineers in both academic and professional settings.
7 Lack of investigation into engineering guidelines, standards, and best practices can lead to failures with severe repercussions.
8 The ability to find different types of information is essential for solving engineering problems.

9 The main aim of research is to apply scientific approaches to answer open questions, with different types of research studies, such as exploratory, descriptive, diagnostic, and hypothesis-testing.
10 The objectives of engineering research should focus on developing new theoretical or applied knowledge, not just obtaining desired results.
11 If the desired result cannot be achieved, framing objectives to understand why it is not possible contributes to ongoing research in solving the problem.
12 Others might propose different approaches where the desired objective becomes achievable.

**********

**Motivation in Engineering Research**

**Intrinsic Motivations:**

- Interest, challenge, learning, meaning, and purpose are linked to strong creative performance.

**Extrinsic Motivations:**

- Rewards for good work, such as money, fame, awards, praise, and status, are potent motivators.
- However, there is a potential downside as they may hinder creativity.
- Example: Research outcomes leading to a patent, seen as a pathway to wealth and fame.

**Influences from Others:**

- External factors like competition, collaboration, commitment, and encouragement play a motivating role.
- Examples include peer pressure ("my friends are doing research, so should I") or competitive drive ("someone I dislike is doing well, and I want to do better").

**Personal Motivations:**

- Solving unsolved problems, experiencing intellectual joy, providing service to the community, and seeking respectability are intrinsic driving factors.

**Combined Intrinsic and Extrinsic Aspects:**

- Desire to surpass global achievements, improve technological standards, contribute to societal betterment, and fulfill historical legacies involve a mix of intrinsic and extrinsic motivations.

**Other Motivational Factors:**

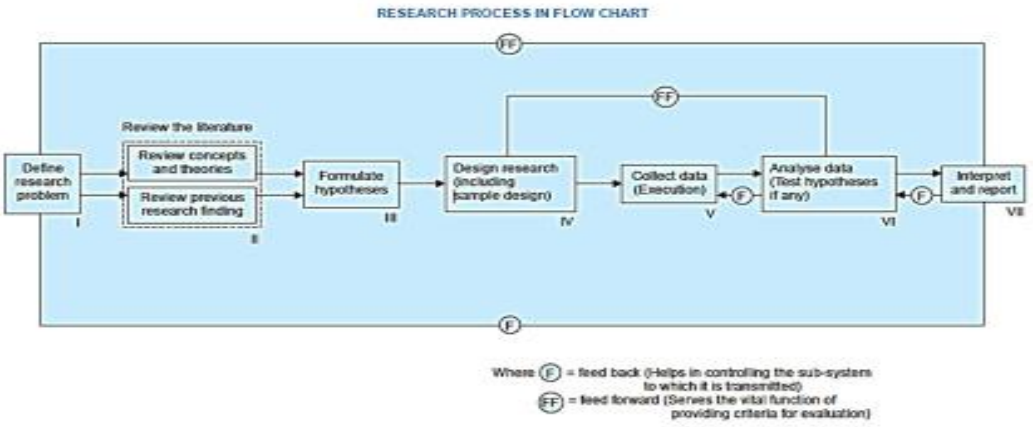
- External factors such as government directives, funding opportunities in specific areas, and terms of employment can serve as motivations to engage in engineering research.

**********

**Research Process:**

Dr. Rajeshwari. R R
Dept. of MBA

# RESEARCH PROCESS




**Identification of the Research Problem:** The first step in the research process is the identification of the research problem. It is important on the part of the researcher to have prior knowledge about the subject or the chosen topic. It starts with deciding the broader area and then moving towards the final small topic for research.

**Literature Review:** It refers to studying existing literature on a particular subject or theme. This is the second crucial step where we review prevalent literature and develop a theoretical and conceptual framework. Example: Studying the existing studies on the topic of obesity and its related areas in order to make a better understanding of the problem.

**Research Objective:** Next step in the research process is deciding the research objective that is needed to be attained throughout the whole process. At this point, the researcher becomes clearer with the factors related to the particular research problem. These variables are called experimental variables.

Independent variables will remain same and the dependent variable changes as per the changes in the independent variables.

**Formulation of Hypotheses:** This step includes predictions about a predicted relationship between the variables. It is just the assumption of the researcher before the actual process of research starts. The assumption is called the null hypothesis ($H_0$), and the one need to test is called an Alternative hypothesis ($H_1$). The primary function of a hypothesis is to bring focus and clarity to the research proposal.

**Preparing the research design:** outline or a framework of the whole research to answers the questions within the timeline of research, what will be the methods to collect the data and also what type of data is needed to be collected. The research design is the overall plan and structure of the research.

**Data collection:** There are two sources namely: Primary Data Collection methods and Secondary Data Collection methods. The data required for the study is normally collected using Census or Sampling methods. These are Probability sampling or Non-probability sampling.

Dr. Rajeshwari. R R
Dept. of MBA

**Data Analysis:** A large volume of data collected is needed to be stored in the form of tables, charts or graphs. This data is then analysed using annual data analysis and using computers. Hypothesis testing is also done here using various techniques like t-test, f-test, chi-square, ANOVA and regression etc.

**Generalisation and Interpretation:** After analysing the hypothesis and data using different techniques, the researcher may arrive at the generalisation of the topic. Now, he or she prepares a theory based on all observations and develops a general idea that could be subsequently utilised in subsequent research.

**Report Writing:** It is the final step of the report writing process during which the researcher writes all about the research he or she performed. This report includes the title, introduction, literature study, way of collecting data and analysis of the data along with its interpretation. The language used should be formal.

**********

**Types of Engineering Research**

**1.Descriptive versus Analytical:**

**Descriptive Research:**

- Uses comparative, correlational methods, and fact-finding inquiries.
- Effectively describes the current state of art.
- No control over variables; reports as-is.
- Attempts to determine causes without controlling variables.

**Analytical Research:**

- Utilizes already available facts for analysis and critical evaluation.
- Can involve both descriptive and analytical elements.

**2. Applied versus Fundamental:**

**Applied Research:**

- Aims to solve immediate organizational problems.
- Addresses practical issues.
- Seeks solutions for compelling problems in actual practice.

**Fundamental Research:**

- Concerned with generalizations and theory formulation.
- Examples include research on natural phenomena or pure mathematics.
- Aims to gather information with broad applications in the medium to long term.

**3.Quantitative versus Qualitative:**

**Quantitative Research:**

- Uses statistical observations from a large number of representative cases.
- Draws conclusions based on numerical data.

**Qualitative Research:**

- Relies on a few non-representative cases or verbal narrative.
- Common in behavioral studies, such as investigating the clustering effect in intersections in Transportation engineering to make propositions.

Dr. Rajeshwari. R R
Dept. of MBA

**********

## Finding and Solving a Worthwhile Problem

The provided information discusses the process of finding and solving a worthwhile research problem in engineering. Key points include:

1. **Initiating Research:**
   - Researchers often begin with problems posed by supervisors or others. The process may involve rethinking basic theories or formulating problems from information provided in relevant papers.
   - Identifying an appropriate problem is a crucial task requiring skills not always explicitly taught. Literature surveys and technical reading are essential to assess the worthiness of the intended problem.
2. **Initial Spark and Problem Attributes:**
   - An initial spark, such as an oral presentation or a development in another subject, may precede the literature survey. This perspective is sometimes more insightful than reading papers alone.
   - A worthwhile research problem possesses attributes like being non-intuitive, addressing long-standing expectations, simplifying a theory, starting a new subject, offering new methods, or having practical applications.
3. **Attributes of a Worthwhile Problem:**
   - A researcher must be convinced of a problem's worthiness before tackling it. Problems with attributes such as counter intuitiveness, theoretical simplification, or practical applicability are considered valuable.
   - Not all problems solved are great, but effective solutions to small problems can lead to significant advancements.
4. **Tackling Hard Problems:**
   - Some problems are universally considered hard and open, with deep implications. While researchers may not always delve into such problems, tackling them can lead to breakthroughs.
   - George Pólya's 4-step procedure for mathematical problem-solving is recommended for engineering researchers, involving understanding, exploration, execution, and reflection.
5. **Research Methodologies:**
   - The subsequent chapters of the book cover various aspects of research methodologies, presenting different elements essential for a successful engineering research career.

In summary, the text provides insights into the challenges of identifying worthwhile research problems, the attributes of such problems, and recommended approaches for effective problem-solving in engineering research.

**********

Ethics in Engineering Research, Ethics in Engineering Research Practice, Types of Research Misconduct, Ethical Issues Related to Authorship. Copyright Infringements. Copyright Infringement is a Criminal Offence. Copyright Registration

Dr. Rajeshwari. R R
Dept. of MBA

**Ethics in Engineering Research**

Ethics is a set of rules that helps us distinguish between acceptable and unacceptable behavior, determining what is right or wrong. While some ethical norms are universally recognized, interpretations and applications can vary. Ethical principles play a role in evaluating, proposing, or interpreting laws. Though ethics and laws are distinct, laws often align with ethics as they reflect our shared values.

Ethics generally refers to a set of rules distinguishing acceptable and unacceptable conduct, distinguishing right from wrong. These principles, often learned during our formative years, continue to develop as we grow. While some ethical norms are universally recognized, but there is difference in interpretation and application. Ethical principles can be used for evaluation, proposition or interpretation of laws. Although ethics are not laws, but laws often follow ethics because ethics are our shared values.

International norms for the ethical conduct of research have been there since the adoption of the Nuremberg Code in 1947. Government bodies, and universities worldwide have adopted certain codes for research ethics. Research ethics and the responsible conduct of research are often erroneously used interchangeably.

**********

**Ethics in Engineering Research Practice**

Technological developments raise a whole range of ethical concerns such as privacy issues and data related to surveillance systems, and so engineering researchers need to make ethical decisions and are answerable for the outcomes borne out of their research as outcomes. The reason that ethics matter in data used in engineering research is usually because there is impact on humans. Certain practices may be acceptable to some people in certain situations, and some for some people may be unacceptability for some reasons may be perfectly valid. We have exceptional access to data today, and unique options for analysis of these data and consequences in engineering research related to such data. Are there things that are possible to do with this data, that we agree we should not do? Engineering ethics gives us the rule book; tells us, how to decide what is okay to do and what is not.

In engineering research, the work is closely connected to ongoing technological developments. Researchers play a crucial role in shaping the impact of technology through various ethical choices.

(i) By setting the ethically right requirements at the very outset, engineering researchers can ultimately influence the effects of the developed technology.
(ii) Influence may also be applied by researchers through design (a process that translates the requirements into a blueprint). During the design process, decision is to be made about the priority and its importance taking ethical aspects into consideration.
(iii) Thirdly, engineering researchers have to choose between different alternatives fulfilling similar functions.

Research outcomes often have unintended and undesirable side effects. It is a vital ethical responsibility of researchers to ensure that hazards/risks associated with the technologies that they develop, are minimized and alternative safer mechanisms are considered. If possible, the designs should be made inherently safe such that they avoid dangers, or come with safety factors, and multiple independent safety barriers, or if possible a supervisory mechanism to take control if the primary process fails.

**********

**Types of Research Misconduct**

Engineering research should be conducted to improve the state-of-the-art of technologies. Research integrity encompasses dealing fairly with others, honesty about the methods and results, protecting the welfare of research subjects, ensuring laboratory safety, and so forth.

There may be different types of research misconduct which can be summarized as follows:

(i) 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.

(ii) Falsification (Inappropriate alteration of data): Falsification is the misrepresentation or misinterpretation, or illegitimate alteration of data or experiments, partly or fully to get a desired output even when the actual data received from experiments.

Falsification and fabrication of data and results, hamper engineering research, creates false empirical data in the literature, ruin trust worthiness of individuals involved, hamper research progress, and cause avoidable delays in technical advancement. Misleading data can also crop up due to poor design of experiments or incorrect measurement practices. The image of engineering researchers is often put in danger by the discovery of data frauds.

(iii) 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. Precise copying or reusing one's own published work is termed as self-plagiarism and is also an unacceptable practice in scientific literature.

(iv) Other Aspects of Research Misconduct: Serious deviations from accepted conduct could be seen as research misconduct. When there is both deception and damage, a fraud is deemed to have taken place. Sooner or later ethical violations get exposed. Simultaneous submission of the same article to two different journals also violates publication policies. Another issue is that when mistakes are found in an article or any published content, they are generally not reported for public access unless a researcher rectifies mistake and provide a correct version of the same.

**********

Dr. Rajeshwari. R R
Dept. of MBA

**Ethical Issues Related to Authorship:**

Academic authorship involves communication of scholarly work, establishing priority, and building peer reputation. It is a primary basis for evaluation in employment, promotion, and honors.

Newman and Jones highlight ethical issues in authorship in the context of engineering research.

**Authorship and Credit in Research Publications:**

- 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).
- Authorship establishes both accountability and gives due credit.

**Issues with "Guest" or "Gift" Authors**:

- Including authors with little or no contribution dilutes the work's value and are considered unethical and highlight research misconduct.
- "Career-boost authorship" involves dubiously bestowing co-authorship to boost employment or promotion chances.
- " Career-preservation authorship" wherein a head of the department, a dean are added as Coauthors to get a benefits "good relation" with the superiors.
- Ghost co-authorship" occurs when an actual contributor do not claim authorship due to undisclosed conflicts of interest.
- Some authors misrepresent contributions by seeking sole authorship despite significant help from others.
- All listed authors share full responsibility for the content of a research article.
- Quantifying contributions helps recognize and ascertain the degree of accountability for each co-author.
- Double submission, submitting a paper to two forums simultaneously, is an important ethical issue.
- Reputed journals discourage double submission to maintain the originality of published papers.

**Copyright Infringements:**

**Copyright Infringements as per Copyrights Act, 1957:**

- Making, selling, or letting copies for sale or hire without permission is an infringement.
- Allowing a place for public performance constituting copyright infringement is prohibited.
- Distributing copies for trade, affecting the owner's interests, is considered infringement.
- Public exhibition of infringing copies for trade purposes is against the Copyrights Act.
- Importing infringing copies and translating a work without owner permission are also infringements.

Dr. Rajeshwari. R R
Dept. of MBA

## Copyright Infringement as a Criminal Offense:

- Section 63 of the Copyright Act, 1957, designates copyright infringement as a criminal offense.
- Knowingly infringing copyright qualifies as a criminal offense.
- Punishment for infringement includes six months of imprisonment with a minimum fine of ₹50,000.
- Subsequent convictions lead to a minimum punishment of one year imprisonment and a ₹1,00,000 fine.
- A dedicated IP division handles copyright cases, and a Copyright Board, established in 1958, adjudicates certain copyright claims.

## Copyright Registration:

It is not necessary to register a work to claim. Once a work is created via any medium, the work receives automatic Copyright safety. In other words, there is no formal request to be submitted to the office of the Copyright, for acquiring Copyright. Copyright registration does not give any rights. it's like an official record in the Copyright office. But having a registration certificate can be strong evidence in legal disputes. The certificate of registration serves as prima facie evidence in a court in cases involving ownership, creation, financial matters, or rights transfer. It is advisable that the author of the work registers for Copyright for better legal protection. In India, Copyrights matters, including Copyright registration, are administered under the Copyright Act, 1957 and Copyrights Rule, 2013. Below mentioned are prominent forms for copyright registration (https://copyright.gov.in/ ).

Forms are available in e-Book page 53,54, 55. 56.

Flow chart for the process of Copyright registration.