RESEARCH METHODOLOGY & INNTELECTUAL PROPERTY RIGHTS – 21RMI56

MODULE 1

Introduction: Meaning of Research, Objectives of Engineering Research, and Motivation in Engineering Research, Types of Engineering Research, Finding and Solving a Worthwhile Problem. Ethics in Engineering Research: Ethics in Engineering Research Practice, Types of Research Misconduct, Ethical Issues Related to Authorship.

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 that is driven by inquisitiveness for that which is unknown and useful on a particular aspect so as to make an original contribution to expand the existing knowledge base. Research involves formulation of hypothesis or proposition of solutions, data analysis, and deductions; and ascertaining whether the conclusions fit the hypothesis. Research is a process of creating, or formulating knowledge that does not yet exist.

Research Cycle: The research cycle starts with basically a practical problem: one must be clear what the problem being attempted to solve is and why it is important. This problem motivates a research question without which one can tend to get lost in a giant swamp of information. The question helps to collect manageable volume of information, and in turn defines a research project which is an activity or set of activities, that ultimately leads to result or answer, which in turn helps to solve the practical problem that one started with in the first place as shown in figure 1.1.

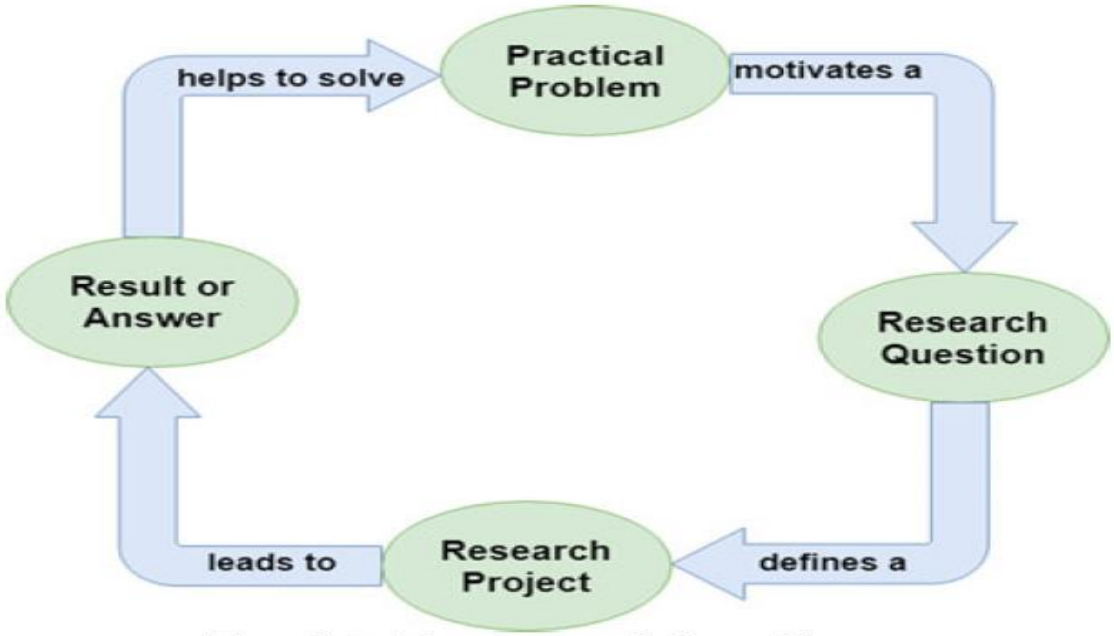


Fig. 1.1: The research flow diagram

Good research questions develop throughout the project and one can even keep modifying them. Through research, one would like to make, or develop, new knowledge about the world around us which can be written down or recorded in some way, and that knowledge can be accessed through that writing or recording.

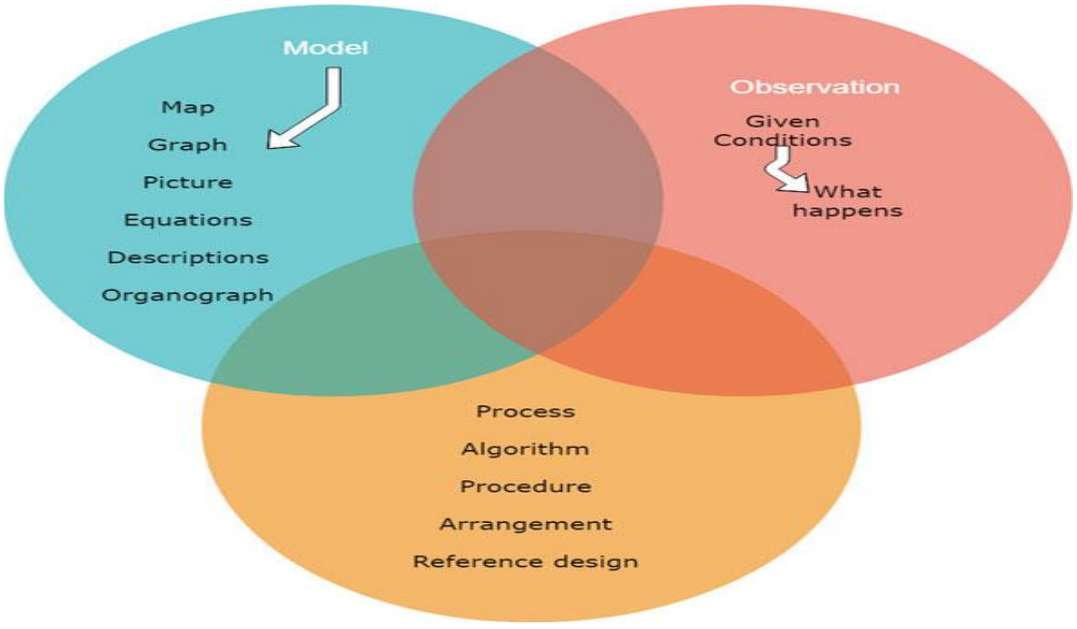
The ways of developing and accessing knowledge come in three categories:

(i) Observation is the most fundamental way of obtaining information from a source, and it could be significant in itself if the thing that we are trying to observe is really strange or exciting, or is difficult to observe. Observation takes different forms like measurements in a laboratory or a survey among a group of subjects to the time it takes for a firmware routine to run. The observational data often needs to be processed in some form and this leads to the second category of knowledge, the model. The observational data often needs to be processed in some form and this leads to the second category of knowledge, the model.

(ii) **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. For instance, the modelling equation captures the relationship between different attributes or the behaviour of the device in an abstract form and enables us to understand the observed phenomena.

(iii) 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.

The categories of knowledge as enumerated above are shown in Fig. 1.2.



Good research involves systematic collection and analysis of information and is followed by an attempt to infer a little bit beyond the already known information in a way that is a significant value addition. Usually, engineering research is a journey that traverses from a research area (example: Signal Processing), to the topic (example: Digital Image Compression) and finally onto the problem (example: Real-Time Implementation of Efficient Image Compression Algorithms.) (Area → Topic → Problem). Getting a good problem to solve is more than half the work done. However the journey can be reverse, for example, the traversal from (Problem → Topic →Area). This can happen when one is led to a problem through a connection to another problem whose top structure is different.

Objectives of Engineering Research

- The objective of engineering research is to solve new & important problems, and at the end of one's research outcome has to be new, but when one starts, the conclusion is unknown.
- Knowing where and how to find different types of information helps one solve engineering problems, in both academic and professional career. Lack of investigation into engineering guidelines, standards, and best practices result in failures.
- Main aim of the research is to apply scientific approaches to seek answers to open questions.
- The objectives of engineering research should be to develop new theoretical or applied knowledge.
- The objectives should be framed such that in the event of not being able to achieve the desired result, one can express why it is not possible, because that is also a contribution toward ongoing research in solving that problem.

Motivation in Engineering Research

The possible motives may be the result of one or more of the following desires:

1. Intrinsic motivations: Interest, challenge, learning, meaning, purpose, are linked to strong creative performance;

2. Extrinsic motivating: 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.

3. Influences from others: 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.

4. Personal motivation in solving unsolved problems, intellectual joy, service to community, and respectability are all driving factors.

The following factors would be a mix of extrinsic & intrinsic aspects:

i. Wanting to do better than what has been achieved in the world,
ii. Improve the state of the art in technology,
iii. Contribute to the improvement of society,
iv. Fulfillment of the historical legacy in the immediate sociocultural context.

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

Types of Engineering Research

The different types of research are

(i) Descriptive versus Analytical: Descriptive research includes comparative and correlational methods, and fact-finding inquiries, to effectively describe the present state of art. The researcher holds no control over the variables; rather only reports as it is. Descriptive research also includes attempts to determine causes even though the variables cannot be controlled. On the contrary, in analytical research, already available facts for analysis and critical evaluation are utilized. Some research studies can be both descriptive and analytical.

(ii) Applied versus Fundamental: Research can either be applied research or fundamental (basic or pure) research. Applied research seeks to solve an immediate problem facing the organization, whereas fundamental research is concerned with generalizations and formulation of a theory. Research concerning natural phenomena or relating to pure mathematics are examples of fundamental research. Research to identify social or economic trends, or those that find out whether certain communications will be read and understood are examples of applied research. The primary objective of applied research is to determine a solution for compelling problems in actual practice, while basic research is aimed at seeking information which could have a broad base of applications in the medium to long term.

(iii) Quantitative versus Qualitative: Quantitative research uses statistical observations of a sufficiently large number of representative cases to draw any conclusions, while qualitative researchers rely on a few non representative cases or verbal narrative in behavioural studies such as clustering effect in intersections in transportation engineering to make a proposition.

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. Alternately, 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. Once the problem is vaguely identified, the process of literature survey and technical reading would take place for more certainty of the worthiness of the intended problem.

A worthwhile research problem would have one or more attributes. It could be non-nutritive/counterintuitive even to someone who knows the area, something that the research community had been expecting for some time. 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, and the problem and/or solution has a better chance of being accepted by the research community.

The recommended steps to solve a research problem are

i. Understand the problem, restate it as if it's your own, visualize the problem by drawing figures, and determine if something more is needed.
ii. One must start somewhere and systematically explore possible strategies to solve the problem or a simpler version of it while looking for patterns.
iii. 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.
iv. Looking back and reflecting helps in understanding and assimilating the strategy, and is a sort of investment into the future.

ETHICS IN ENGINEERING RESEARCH

Ethics generally refers to a set of rules distinguishing acceptable and unacceptable conduct, distinguishing right from wrong, or wise. 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.

Although ethics are not laws, but laws often follow ethics because ethics are our shared values.

Research ethics and the responsible conduct of research are often erroneously used interchangeably. 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 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 impact of their research. Engineering ethics gives us the rule book; tells us, how to decide what is okay to do and what is not.

Engineering research is not work in isolation to the technological development taking place. Researchers make many choices that matter from an ethical perspective and influence the effects of technology in many different ways:

(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 to fulfil those requirements). During the design process, decision is to be made about the priority in importance of the requirements 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, or if possible a supervisory mechanism to take control if the primary process fails.

Types of Research Misconduct

Research ethics involves dealing fairly with others, honesty about the methods and results, replicating the results wherever possible so as to avoid errors, ensuring

laboratory safety, etc. In order to prevent mistakes, peer reviews should take place before the research output is published.

The different types of research misconduct 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, even if partly, to support a desired hypothesis even when the actual data received from experiments suggest otherwise.

(iii) Plagiarism (excluding the use of someone else's work): 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. Verbatim 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 construed 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 published content, they are generally not reported for public access.

Ethical Issues Related to Authorship

Academic authorship involves communicating scholarly work, establishing priority for their discoveries, and building peer-reputation, and comes with intrinsic burden of acceptance of the responsibility for the contents of the work. It is the primary basis of evaluation for employment, promotion, and other honors.

The important research conduct and ethics related issues connected to authorship of research papers are summarized below:

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. A person is expected to be listed as an author only when associated as a significant contributor in research design, data interpretation, or writing of the paper.

Including "guest" or "gift" (coauthorship bestowed on someone with little or no contribution to the work) authors dilutes the contribution of those who actually did the work and is ethically a red flag highlighting research misconduct. Sometimes, the primary author dubiously bestows coauthorship on a junior faculty or a student to boost their chances of employment or promotion, which can be termed as "**Career-boost authorship**".

The coauthorship that can also be described as "**Career-preservation authorship**" wherein a head of the department, a dean, or other administrators are added as Co-authors because of some understanding wherein the principal author benefits from a "good relation" with the superiors and the administrator benefits from authorship without doing the required work for it.

Sometimes, an actual contributor abstains from the list of authors due to nondisclosed conflict of interest within the organization. Such coauthorships can be termed as **"Ghost coauthorship"**. Full disclosure of all those involved in the research is important so that evaluation can happen fairly.

Some authors, in trying to acquire a sole-authored work, despite relying on significant contribution to the research work from others, recognize that effort only by an acknowledgment, thereby misrepresenting the contributions of the listed authors. The unrecognized "author" is as a consequence, unavailable to readers for elaboration.

All listed authors have the full obligation of all contents of a research article, and so naturally, they should also be made aware of a journal submission by the corresponding author.

Double submission is an important ethical issue related to authorship, which involves submission of a paper to two forums simultaneously. The motivation is to increase publication possibility and possibly decrease time to publication. Reputed journals want to publish original papers, i.e., papers which have not appeared elsewhere, and strongly discourage double submission.

Assignment Questions

1. Define Research. With diagram, explain, Research Cycle.
2. With diagram, explain different categories of knowledge in Research.
3. Describe the objectives in Engineering Research.
4. Mention the motivations in Engineering Research.
5. Briefly explain the types of Engineering Research.
6. Describe the steps recommended to solve a research problem.
7. Write a short notes on ethics to be followed in Engineering Research practice.
8. Summarize different types of Research misconduct.
9. Briefly explain ethical issues related to authorship.