RESEARCH METHODOLOGY AND INTELLECTUAL PROPERTY RIGHTS (21RMI56)

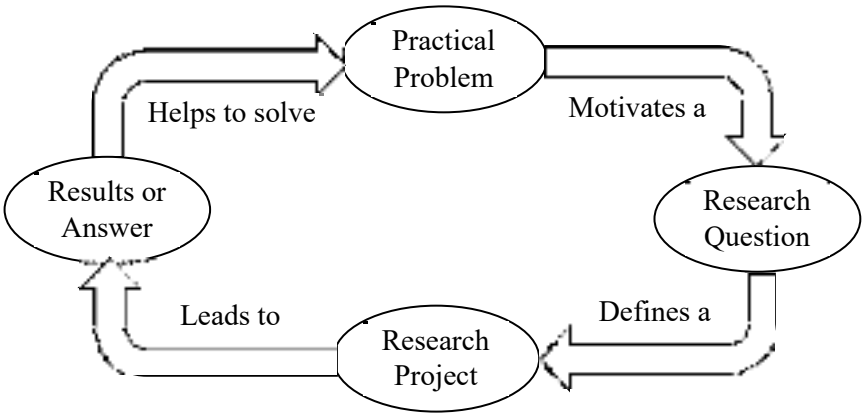
Module – 1 Questions and Answers: CO1

1. What is the meaning of research? Draw the research flow diagram.

Research refers to a careful, well-defined, objective, and systematic method of search for knowledge, or formulation of a theory that is driven by inquisitiveness (curiousness) 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 (proposal intended to explain certain observations) or proposition of solutions, data analysis, and deductions; and ascertaining (determining) whether the conclusions fit the hypothesis.

Research is a process of creating, or formulating knowledge that does not yet exist. Research is not just about reading a lot of books and finding a lot of, gathering a lot of existing information. It is instead adding, maybe small and specific, yet original, contribution to that existing body of knowledge.

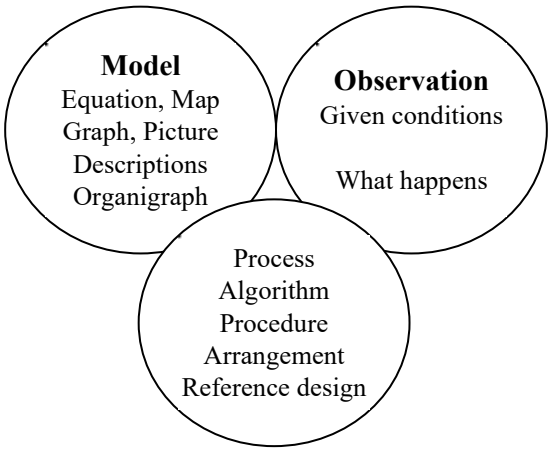


Research Flow Diagram

2. Explain the categories of developing and accessing the knowledge.

Categories of knowledge:

1. Observation is the most fundamental way of obtaining information from a source, and it could be significant in itself if the thing that are trying to observe is really strange or exciting, or is difficult to observe. Observation takes different forms from something like measurements in a laboratory to a survey among a group of subjects to the time it takes for a firmware (coded instructions or programs) routine to run.
2. Models are some forms in which the observational data needs to be processed. They 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 example, the modelling equation captures the relationship between different attributes (dimensions, properties, characteristics) or the behaviour of the device in an abstract form and enables us to understand the observed phenomena.
3. A way of arranging or doing things through processes, algorithms, procedures, arrangements, or reference designs, to get a certain desired result.



Categories of Knowledge in Research

3. What is the engineering research?

Engineering research is the process of developing the perspectives (expected to happen in the future) and seeking improvements in knowledge and skills to enable the recognition, planning, design, and execution of research in a wide range of forms relevant for engineering and technology investigations and developments.

Engineering research is based on the principles of scientific research which are based on the scientific method, in which observations (experiments), theories, calculations and models are derived from the existing body of scientific knowledge and verified independently by others who are experts in the field. This research is directed toward the practical application of science to products, services and infrastructure.

4. Discuss the objectives of engineering research.

- The objective of engineering research is to solve new and important problems, and since the conclusion at the end of one's research outcome has to be new, but when one starts, the conclusion is unknown.
- Research objectives can sometimes be convoluted (extremely complex) and difficult to follow.
- The main aim of the research is to apply scientific approaches to seek answers to open questions, and although each research study is particularly suited for a certain approach, in general, the following are different types of research studies: **exploratory or formulative, descriptive, diagnostic, and hypothesis-testing.**
- The objectives of engineering research should be to develop new theoretical or applied knowledge and not necessarily limited to obtaining abilities to obtain the desired result.
- The objectives should be framed such that in the event of not being able to achieve the desired result that is being sought, one can fall back to understanding why it is not possible, because that is also a contribution toward ongoing research in solving that problem.

5. List out the motivations in engineering research.

1) Intrinsic (very nature) motivations like interest, challenge, learning, meaning, purpose, are linked to strong creative performance.
2) Extrinsic motivating factors like rewards for good work include money, fame, awards, praise, and status are very strong motivators, but may block creativity.
   Example: Research outcome may enable obtaining a patent which is a good way to become rich and famous.
3) Influences from others like competition, collaboration, commitment, and encouragement are also motivating factors in research.
   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.

6. Explain the different types of engineering research.

1) Descriptive versus Analytical:

- Descriptive research includes comparative and correlational (statistical relation between two or more variables) 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.
- In analytical research, the researcher has to use already available facts for analysis and critical evaluation.
- Some research studies can be both descriptive and analytical.

2) Applied versus Fundamental:

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

3) Quantitative versus Qualitative:

- Quantitative research uses statistical observations (act of making and recording measurements) of a sufficiently large number of representative (typical of a class or group) cases to draw any conclusions.
- Qualitative researchers have faith on a few nonrepresentative cases or verbal narrative in behavioural studies such as clustering (group of similar things or people) effect in intersections in transportation engineering to make a proposition.
- Example: an important type of qualitative research is investigating the reasons for human behaviour (why people think or do certain things), called motivation research.

7. What is worthwhile problem?

A worthwhile research problem would have one or more attributes. It could be nonintuitive/counterintuitive (not spontaneous) even to someone who knows the area. Something that the research community had been expecting for some time:

- a major simplification of a central part of the theory
- a new result which would start off (begin) a new subject or an area
- provides a new method or improves upon known methods of doing something which has practical applications
- a result which stops further work in an area.

The researcher has to be convinced (confident) 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.

8. List out the recommended steps to solve a research problem.

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 reached 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 (take in and fully understanding) the strategy, and is a sort of investment into the future.

9. Discuss ethics in engineering research.

- Ethics generally refers to a set of rules distinguishing acceptable and unacceptable conduct, distinguishing right from wrong, or wise aphorisms (observation contains general truth) like the sayings of Chanakya.
- Most people learn such norms in their formative years, but moral development continues through different stages of growth.
- 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.
- 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 (wrongly or incorrectly) used interchangeably.
- Research ethics examines the appropriate application of research outcomes, while responsible conduct of research deals with the way the work is undertaken.

10. Explain the ethics and its effects 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 repercussions (indirect results of events or actions) 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 certain people in certain situations, and the reasons for unacceptability may be perfectly valid.
- At present, unprecedented (never done before) access to data, options for analysis of these data and consequences in engineering research related to such data are possible.
- Engineering ethics gives the rule book and tells, how to decide what is okay to do and what is not.

From an ethical perspective and influence the effects of technology in many different ways:

- By setting the ethically right requirements at the very beginning.
- Through design (a process that translates the requirements into a blueprint), decision is to be made about the priority in importance of the requirements taking ethical aspects into consideration.
- Have to choose between different alternatives fulfilling similar functions.

11. Discuss the fabrication and falsification types of research misconduct.

i) Fabrication (Illegitimate creation of data – not in accordance with laws or acceptable standards): It is the act of conjuring data (magic tricks) 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): It 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.

Falsification and fabrication of data and results, hamper engineering research, cause false empirical data to spread gradually in the literature, break forcefully trustworthiness of individuals involved, incur additional costs, delay in research progress, cause actual and avoidable delays in technical advancement, and can hurt honest researchers getting their work published.

12. Discuss the plagiarism and other aspects of research misconduct

i) Plagiarism (Taking others work without attribution):

- It 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.
- The increasing availability of scientific content on the internet seems to encourage plagiarism in certain cases, but also enables detection of such practices through automated software packages – iThenticate, Turnitin, Drill bit, etc.
- Get a similarity score/index which is a metric that provides a score of the amount of similarity between already published content and the unpublished content under scrutiny.

ii) Other aspects of research misconduct:

- Serious deviations from accepted conduct.
- When there is both deception (misleading false statement) and damage, a fraud is considered 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.
- When mistakes are found in an article or any published content, they are generally not reported for public access unless a researcher is driven enough to build on that mistake and provide a correct version of the same which is not always the primary objective of the researcher.

13. What is academic authorship?

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

14. Explain the following with respect to ethical issues related to authorship: i) Authorship, ii) Co-author or guest or gift authorship, iii) Career-boost authorship, iv) Career-preservation authorship, v) Ghost coauthor ship, and vi) Questionable authorship.

i) 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.

ii) Coauthor or guest or gift authorship: It is the right on someone with little or no contribution to the work, but dilutes the contribution of those who actually did the work, inappropriately expand credentials of the listed authors, and is ethically a red flag highlighting research misconduct.

iii) Career-boost authorship: Sometimes, the primary author doubtfully rights coauthor ship on a junior faculty or a student to boost their chances of employment or promotion.

iv) Career-preservation authorship: It is an unfortunate malpractice of coauthor ship wherein a head of the department, a dean, a university administrator (provost), or other administrators are added as coauthors because of quid pro quo (a favour given in return for something) arrangement 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.

v) Ghost coauthor ship: Sometimes, an actual contributor abstains (restrains) from the list of authors/co-authors due to non-disclosed conflict of interest within the organization.

vi) Questionable authorship: Some researchers list one another as coauthors as a reciprocal gesture with no real collaboration except minimal reading and editing, without truly reviewing the work threadbare.

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MODULE – 2: Literature Review and Technical Reading, and Attributions and Citations

Literature Review and Technical Reading

The primary goal of literature review is to know the use of content/ideas/approaches in the literature to correctly identify the problem, to encourage a specific approach adopted to understanding the problem, and to access the choice of methods used. It also helps the researcher understand clearly that the research to be undertaken would contribute something new and innovative. The quality of such review can be determined by evaluating if it includes appropriate breadth and depth of the area under study, clarity, rigor (severity), consistency, effective analysis.

New and Existing Knowledge:

New knowledge in research can only be interpreted within the context of what is already known, and cannot exist without the foundation of existing knowledge. The new knowledge can have vastly (very great extent) different interpretations depending on what the researcher's back ground, and one's perception of that new knowledge can change from indifference (no interest) to excitement (or vice versa).

The significance can normally be argued from the point of view that there is indeed an existing problem and that it is known by looking at what already exists in the field. The existing knowledge is needed to make the case that there is a problem and that it is important.

One can infer that the knowledge that is sought to be produced does not yet exist by describing what other knowledge already exists and by pointing out that this part is missing so that what we have is original. This needs the existing knowledge: the context, the significance, the originality, and the tools. Normally, one finds this knowledge by reading and surveying the literature in the field that was established long ago and also about the more recent knowledge which is in fact always changing. With this foundation in place, the new knowledge that one will make will be much more difficult to challenge than without that strong foundation in place which is ensured with lots of references to the literature.

Frequently, the textbooks contain the older established knowledge and the research papers the newer work. Reading the textbooks on one's topic provide the established knowledge and the background to be able to read the newer work usually recorded in the research papers. The research paper is written for other researchers out on the edge of knowledge and it assumes that the reader already knows a lot in that field. A researcher may find oneself continually going back to other sources to try and interpret what is going on in a particular research paper. It can be difficult to find the right work to read, but the objective with all this reading and learning is to be able to get the knowledge that one needs to build the foundation.

An effective review of literature ensures a firm foundation for advancing knowledge, facilitates theoretical growth, eliminates as areas that might be of interest, and opens new avenues of possible work. An efficient literature review is centered around concepts and not authors.

Generally, a good literature survey is the first expectation of a supervisor from the research student, and when done well can create a good impression that the state of art in the chosen field is well understood. It would not draw hurried conclusions and look into the individual references to determine the underlying causes/assumptions/mechanisms.

A literature review should be able to summarize as to what is already known from the state of the art, detail the key concepts and the main factors or parameters and the underlying relationships between those, describe any complementary existing approaches, enumerate/itemise the inconsistencies or shortcomings in the published work, identify the reported results that are inconclusive or contradictory, and provide a compulsive reason to do further work in the field.

A comprehensive literature survey should methodically analyse and synthesize quality archived work, provide a firm foundation to a topic of interest and the choice of suitable research methodologies, and demonstrate that the proposed work would make a novel contribution to the overall field of research.

A good literature survey is typically a two-step process as follows:

1) Identify the major topics or subtopics or concepts relevant to the subject under consideration.
2) Place the citation of the relevant source (article/patent/website/data, etc.) in the correct category of the concept/topic/subtopic.

Analysis and Synthesis of Prior Art:

After collecting the sources (articles, papers, textbooks), the researcher is ready to break down each article and identify the useful content in it, and then synthesize the collection of articles (integrate them and identify the conclusions that can be made from the articles as a group).

A researcher gets the available information or resources and needs to critically evaluate each resource. Relying (confidence) on refereed articles published in scholarly journals or granted patents can save the researcher a lot of time. A researcher should analyse the relevant information (shown in Table 2.1) by undertaking the following steps:

i) Understanding the hypothesis,
ii) Understanding the models and the experimental conditions used,
iii) Making connections,
iv) Comparing and contrasting the various information, and
v) Finding out the strong points and the loopholes.

Table 2.1 Literature survey grid

	Source 1	**Source 2**	**….**	**Source M**
Topic 1	✓			
Topic 2		✓		✓
….				
Topic N	✓			✓

A few criteria that could help the researcher in the evaluation of the information under study:

- **Authority:** What are the author's credentials and affiliation? Who publishes the information?
- **Accuracy:** Based on what one already knows about the topic or from reading other sources, does the information seem credible? Does the author cite other sources in a reference list or bibliography, to support the information presented?
- **Scope:** Is the source at an appropriate comprehension or research level?

There are other criteria to consider as well, such as **currency, objectivity,** and **purpose**. It is important to ensure that the search question is neither too narrow nor too broad.

Bibliographic Databases:

Bibliographic databases refer to "**abstracting and indexing services**" useful for collecting citation-related information and possibly abstracts of research articles from scholarly literature and making them available through search. Performing simultaneous searches through such large databases may allow researchers to open confidence on any one database and be limited by the intrinsic shortcoming of any one of them for quality research. A researcher should be able to quickly identify the databases that are of use in the idea or problem that one wishes to explore.

A few of the popular bibliographic databases used by engineering researchers are:

1. Scopus
2. Web of Science
3. IEEE Xplore (Institute of Electrical and Electronics Engineers)
4. ScienceDirect
5. DOAJ (Directory of Open Access Journals)
6. PubMed
7. ERIC (Education Resources Information Centre)
8. Google and Google Scholar

Scopus: Scopus is one of the big commercial, bibliographic databases that cover scholarly literature from almost any discipline. Beside searching for research articles, Scopus also provides academic journal rankings, author profiles, and an h-index calculator. (**https://www.scopus.com**).

Web of Science: Web of Science also known as Web of Knowledge is the big bibliographic database. Web of Science (formerly known as ISI (Institute for Scientific Information) or Thomson Reuters) includes multiple databases, as well as specialized tools. It is a good search tool for scholarly materials requiring institutional license and allows the researcher to search in a particular topic of interest, which can be made by selection in fields that are available in drop down menu such as title, topic, author, address, etc. The tool also allows sorting by number of citations (highest to lowest), publication date. Usually, academic institutions provide either access to Web of Science or Scopus on their campus network for free. (**https://access.clarivate.com** or **https://www.webofscience.com**).

- Put quotes around phrases, add more keywords, or use the "**Refine Results**" panel on the left to narrow down the search by keyword, phrases in quotation marks, type of material such as peer-reviewed journal articles, date, language, and more.
- "**Cited reference search**" option enables a researcher to trace articles which have cited a formerly published paper. Using this element, it is possible to find how a familiar idea has been applied, improved, or extended subsequently.
- Based on the researcher's need the search result can be broadened or narrowed down using the built-in fields provided in the website.
- When clicked on any of the search results, the website provides the **title of the paper, authors, the type of journal, volume, issue number and year of publication, abstract, keywords,** etc., so that the researcher has enough information to decide if it is worthwhile to acquire the full version of the paper.

IEEE Xplore: IEEE Xplore is the leading academic database in the field of engineering and computer science. It's not only journal articles, but also conference papers, standards and books that can be search for. It is the flagship digital platform for discovery and access to scientific and technical content published by the IEEE and its publishing partners. It contains more than 6 million documents and other materials from some of the world's most cited publications in electrical engineering, computer science, and related sciences.

Access to the documents and materials in IEEE Xplore is available through:

- A variety of institutional subscription options
- Individual subscriptions for IEEE members and society members
- eCommerce purchases of individual documents (with discounts for IEEE members). (**https://ieeexplore.ieee.org)**

Google and Google Scholar:

Google is a great place to start one's search when one is starting out on a topic. It can be helpful in finding freely available information, such as reports from governments, organizations, companies, and so on. However, there are limitations:

- It's a "black box" of information. It searches everything on the Internet, with no quality control—one does not know where results are coming from.
- There are limited search functionality and refinement options.

Google Scholar limits one's search to scholarly literature. However, there are limitations:

- Some of the results are not actually scholarly. An article may look scholarly at first glance, but is not a good source upon further inspection.
- It is not comprehensive. Some publishers do not make their content available to Google Scholar.
- There is limited search functionality and refinement options.

Search Options Examples:

- OR : Synchronous OR asynchronous will find results that have either term present.
- Brackets/Parentheses ( ) : RAM (synchronous OR asynchronous).
- Quotation marks " ": RAM (synchronous OR asynchronous) "Texas Instruments".
- Site: RAM(synchronous OR asynchronous) "Texas Instruments" site: http://ieeexplore.ieee.org.
- Filetype: RAM (synchronous OR asynchronous) "Texas Instruments" site: http://ieeexplore.ieee.org, filetype: pdf.

Effective Search: The Way Forward

A scholarly publication is one wherein the published outcome is authored by researchers, fellow experts and students in a specific field of skill. Such work cites (quotes as evidence) all source contents used and is generally peer reviewed for accuracy and validity before publication. The content is typically more complex and advanced than those found in general magazines. While most of the engineering researchers need to refer articles that appear in scholarly journals, books or other peer-reviewed sources, and more popular publications.

A researcher should use all search tools for comprehensive search. No one place or one source exists that will provide all the information. Not all information is available online. Some information is only available in print. The scholarly information or studies on a topic of interest to the researcher have not occurred/available. In such a case, the researcher should look for similar studies that would be applicable to the specific topic; look for broad information (general process, technology, etc.), as well as information that addresses the specific context of the researcher's report.

Searching is an iterative process:

- Experiment with different keywords and operators
- Evaluate and assess results, use filters
- Modify the search as needed, and
- When relevant articles are found, look at their citations and references.

After the search is complete, the researcher needs to engage in critical and thorough reading, making observation of the salient points in those sources, and summarize the findings with detailed comparison and contrast (differences). This entire process may be needed to be done multiple times.

The conclusion of the entire process of literature survey includes a summary of the relevant and important work done, and also the identification of the missing links and the challenges in the open problems in the area under study. The literature survey is a continuous and cyclical process that may involve the researcher going back and forth till the end of the research project.

(It is not as if literature survey ends and then research begins, for new literature keeps appearing, and understanding of the problem grows, one finds new connections and related/evolving problems which may need more search. It is mandatory for a Ph.D. scholar to write a synopsis of the topic and submit it to the doctoral committee for approval. During this stage, the scholar needs to undertake an extensive literature survey connected with the problem).

Introduction to Technical Reading:

Finding the right work to read can be difficult. Very rarely will one find everything that one wants close together in one place. However, it is obvious that the number of papers relevant to a particular researcher is very few, compared to the actual number of research papers available from peer-reviewed technical sources. It is also important to know where to read from. While reading an engineering research paper, the goal is to understand the technical contributions that the authors are making.

It is useful to adopt a quick, purposeful, and useful way of reading these manuscripts. It is not the same as reading a newspaper. It may require rereading the paper multiple times and one might expect to spend many hours reading the paper. The standard scientific research paper components are:

1. Title
2. Abstract
3. Introduction
4. Methodology
5. Results and Discussion
6. Conclusion
7. References

Original research articles are typically structured as Introduction, Methods, Results, and Discussion (**IMRAD**)

Start out the skimming (reading through quickly) process by reading the **title and keywords**. If on reading these, it does not sufficiently seem to be interesting; it is better to stop reading and look for something else to read.

One should then read the **abstract** to get an overview of the paper in minimum time. Again, if it does not seem sufficiently important to the field of study, stop reading further.

If the **abstract** is of interest, one should skip most of the paper and go straight to the **conclusions** to find if the paper is relevant to the intended purpose, and if so, then one should read the **figures, tables, and the captions** therein, because these would not take much time but would provide a broad enough idea as to what was done in the paper.

If the paper has continued to be of interest so far, then ready to reach into the **Introduction** section to know the background information about the work and also to ascertain why the authors did that particular study and in what ways the paper furthers the state of the art (progressive).

The next sections to read are the **Results and Discussion** sections which is really the heart of the paper. One should really read further sections like **Methodology** (**Experimental Setup/Modelling**), is really interested and wishes to understand exactly what was done to better understand the meaning of the data and its interpretation.

A researcher will always need to be searching for the relevant literature and keeping up to date with it. For this need **a strategy as there is just too much work out there to read everything**.

Conceptualizing Research

The characteristics of a research objective are that it must have new knowledge at the centre, and that it must be accepted by the community of other researchers and recognized as significant. The significance and the originality, and all the theory, and tools and methods used on a problem, all of these normally come from the existing recorded literature and knowledge in the field.

Coming up with a good research objective, conceptualizing the research (form an abstract idea) that meets all of these requirements is a tough thing to do. If one is doing research at the Ph.D. level or higher, then conceptualizing the research is probably something that one needs to do oneself. This is a very tough step because one needs to know all that literature in the field.

When working at the Ph.D. level, one needs to be prepared to become that expert, one needs to be continually reading the literature so as to bring together the three parts: (i) significant problem, (ii) the knowledge that will address it, and (iii) a possible way to make that new knowledge. These aspects will be different for every person and different in every field.

However, if one is working on a master's research project that is of a smaller scope than a Ph.D., then conceptualizing the research is possibly too tough to do, and does not have the time that it takes to become that expert at the edge of knowledge. In this case, the researcher needs the help of the supervisor. An established researcher in any field should be able to immediately point to the landmark literature that one should read first. Otherwise, one would need to spend a lot of time reading the literature to discover.

Critical and Creative Reading

Reading a research paper is a critical process. The reader should not be under the assumption that reported results or arguments are correct. Have the authors attempted to solve the right problem? Are there simpler solutions that have not been considered? What are the limitations of the solution and are there any missing links? Are the assumptions that were made reasonable? Is there a logical flow to the paper or is there a flaw (weaken) in the reasoning? These need to be ascertained apart from the relevance and the importance of the work, by careful reading.

Use of judgemental approach and boldness to make judgments is needed while reading. Flexibility to discard previous erroneous judgments is also critical. It is important to ascertain (find out) whether the data presented in the paper is right data, whether the data was gathered and interpreted in a correct manner, and to decipher (succeed in understanding) whether some other dataset would have been more compelling.

Critical reading is relatively easy. It is relatively easier to critically read to find the mistakes than to read it so as to find the good ideas in the paper.

Reading creatively is harder, and requires a positive approach in search. In creative reading, the idea is to actively look for other applications, interesting generalizations, or extended work which the authors might have missed? Are there plausible (probable/reasonable) modifications that may throw up important practical challenges?

Taking Notes While Reading

A researcher reads to write and writes well only if the reading skills are good. The bridge between reading and actually writing a paper is the act of taking notes during and shortly after the process of reading. There is a well-known saying that the faintest (dim/weak) writing is better than the best memory, and it applies to researchers who need to read and build on that knowledge to write building on the notes taken.

Many researchers take notes on the margins of their copies of papers or even digitally on an article aggregator tool. In each research paper, take notes on definitions, explanations, concepts, and questions of criticisms to reread the same content after a long time. On completing a thorough reading, a good technical reading should end with a summary of the paper in a few sentences describing the contributions.

Reading Mathematics and Algorithms

Mathematics is the foundation of new advances, for evolution and development of engineering research and practice. An engineering researcher generally cannot avoid mathematical derivations or proofs as part of research work. These are the heart of any technical paper. Therefore, one should avoid skimming them. By meticulous reading of the proofs or algorithms, one can develop sound understanding about the problem that the authors have attempted to solve.

Implementation of an intricate (very detailed) algorithm in programming languages such as C, C++ or Java is prone to errors. Even if the researcher is confident about the paper in hand, and thinks that the algorithm will work, there is a fair chance that it will not work at all. So, code it quickly to check if it actually works.

Reading a Datasheet

Researchers in different fields of engineering will need to read certain types of documents, other than technical published papers or books. Researchers in the mechanical and civil engineering need to read drawings related to mechanical parts and buildings. Researchers in the field of electronics need to read datasheets. Researchers in other fields may also need to incorporate a certain electronic part in which case careful reading of the datasheet is imperative.

Datasheets are instruction manuals for electronic components, which details what a component does and how one may use it. Datasheets enable a researcher to design a circuit or debug any given circuit with that component. The first page of the datasheet usually summarizes a part's function and features, basic specifications, and usually provides a functional block diagram with the internal functions of the part.

A pinout or pin diagram provides the physical location of a part's pins, with special mark for pin 1 so that the part can be correctly plugged into the circuit. Some parts also provide graphs showing performance versus various criteria (supply voltage, temperature, etc.), and safe region for reliable operation which should be carefully read and noted by the researcher.

The lookout for truth tables which describe what sort of inputs provide what types of outputs, and also timing diagrams which lay out how and at what speed data is sent and received from the part. Datasheets usually end with accurate dimensions of the packages a part. This is useful for printed circuit board (PCB) layout.

When working with a new part, or when deciding which part to use in the research work, it is recommended to carefully read the datasheet and that may potentially save many hours later on.

Attributions and Citations: Giving Credit Wherever Due

Academic writing, by definition, must follow certain rules and conventions. Among the most important of these are the rules and conventions about citing, referencing, attributing, and acknowledging the works of others. That means giving proper credit wherever due.

Citations: Functions and Attributes

Citing is the practice of quoting from, referring to other authors' works and ideas in the text of our work in such a way that the context is clear to the reader. Citations (references) credit others for their work, while allowing the readers to trace the source publication if needed. Any portion of someone else's work or ideas in papers, patents, or presentations must be used in any new document only by clearly citing the source. This applies to all forms of written sources in the form of texts, images, sounds, etc. and failure to do may be considered plagiarism or infringes on the rights of the researcher who did the original work.

When a bibliography of previously published patents or papers is placed in the new works of a researcher, a connection is established between the new and previous work. The researcher provides due credit through the use of a citation. Citations help the readers to verify the quality and importance of the new work and justification of the findings. It is a way to tell readers that certain material in the researcher's present work has come from another source and as an ethical responsibility, appropriate credit has been given to the original author or writer.

Materials that can be cited include journal papers, conference proceeding, books, theses, newspaper articles, websites, or other online resources and personal communication. Preferably, citations should be given at the end of a sentence or the end of a paragraph. Citation must contain enough details so that readers can easily find the referenced material.

A researcher needs to cite each source twice: (i) in-text citation, in the text of the article exactly where the source is quoted or paraphrased, and (ii) in the references, typically at the end of the chapter or a book or at the end of a research article. Most citation styles have the same or similar elements, but differ on the order of elements and layout.

LaTeX, a document preparation system often used by engineering researchers to automatically format documents that comply with standard formatting needs, is very effective to track and update citations.

There are three main functions of citation:

(i) **Verification function**: Authors have a scope for finding intentional or unintentional distortion of research or misleading statements. Citation offers the readers a chance to ascertain if the original source is justified or not, and if that assertion (belief) is properly described in the present work.

(ii) **Acknowledgment function**: Researchers primarily receive credit for their work through citations. Citations play crucial role in promotion of individual researchers and their continued employment. Many reputed organizations and institutes provide research funding based on the reputations of the researchers. Citations help all researchers to enhance their reputation and provide detailed background of the research work.
(iii) **Documentation function**: Citations are also used to document scientific concepts and historical progress of any particular technology over the years.

Citations are the currency that authors would wish to accumulate and the technical community gives them credit for these contributions.

There are certain cases when references do not fulfil the actual goal of citations and acknowledgments, and thus do not benefit the reader.

1. **Spurious citations**: In certain cases, when citation is not required or an appropriate one is not found, if the author nevertheless goes ahead with including one anyways, it would be considered as a spurious citation. (These sorts of citations do not add any value to the reader in terms of properly understanding the paper. Such actions result in loss of time of the reader or reviewer in looking for the cited paper that is otherwise not relevant).
2. **Biased citations**: When authors cite the work of their friends or colleagues despite there being no significant connection between the two works, or when they do not cite work of genuine significance because they do not wish to give credit in the form of citation to certain individuals, then such actions can be classified as biased citations.
3. Self-citations: There is nothing wrong in citing one's prior work if the citation is really relevant. Self-citation of prior papers is natural because the latest paper is often a part of a larger research project which is ongoing. It is helpful and ethical only if all the papers are really relevant to the present work. Self-citations in some cases may be either spurious or biased or even both.
(Sometimes, it is also advantageous for the reader because citations of all the related works of the same author are given in one paper and this may reduce the effort of the reader in trying to find the full versions of those papers. However, there can also be negative impact on the journal as well as individual researchers due to inappropriate and irrelevant self-citations).
4. Coercive citations: The impact factors remain a primary method of quantification of research. One side effect is that it creates an incentive for editors to allow in coercion to add citations to the editor's journal. (Even if not explicitly stated, the implied message is that the author could either add citations or risk rejection. Such demands consequently diminish the reputation of the journal).

Impact of Title and Keywords on Citations:

The citation rate of any research paper depends on various factors including significance and availability of the journal, publication types, research area, and importance of the published research work. Other factors like length of the title, type of the title, and selected keywords also impact the citation count.

Title is the most important attribute of any research paper. It is the main indication of the research area or subject and is used by researcher as a source of information during literature survey. Title plays important role in marketing and makes research papers traceable. A good title is informative, represents a paper effectively to readers, and gains their attention. Some titles are informative but do not capture attention of readers, some titles are attractive but not informative or related to the readers' research area. The download count and citation of a research paper might be influenced by title. There are three different aspects which provide a particular behaviour to the title: (i) types of the title, (ii) length of the title, and (iii) presence of specific markers

In general, titles containing a question mark, colon, and reference to a specific geographical region are associated with lower citation rates, also result-describing titles usually get citations than method-describing titles. Additionally, review articles and original articles usually receive more citations than short communication articles.

At least two keywords in the title can increase the chance of finding and reading the article as well as get more citations. Keywords represent essential information as well as main content of the article, which are relevant to the area of research. Search engines, journal, digital libraries, and indexing services use keywords for categorization of the research topic and to direct the work to the relevant audience. If maximum number of allowable keywords are used, then the chance of the article being found increases and so does the probability of citation count of the article. Usage of new keywords should be minimal as such keywords may not be well known to the research community and so may lead to low visibility of the article.

Knowledge Flow through Citation:

In engineering research, knowledge flow is primarily in the form of books, thesis, articles, patents, and reports. Citing a source is important for transmission of knowledge from previous work to an innovation. Production of knowledge can be related to the citation network. Knowledge flow happens between co-authors during research collaboration, among other researchers through their paper citation network, and also between institutions, departments, research fields or topics, and elements of research.

Fig. 2.1 shows the relationship between citations, knowledge flow, and elements such as researchers, papers, journal publications or conferences, and institutions. If paper A is cited by paper B, then knowledge flows through citation networks across institutions.

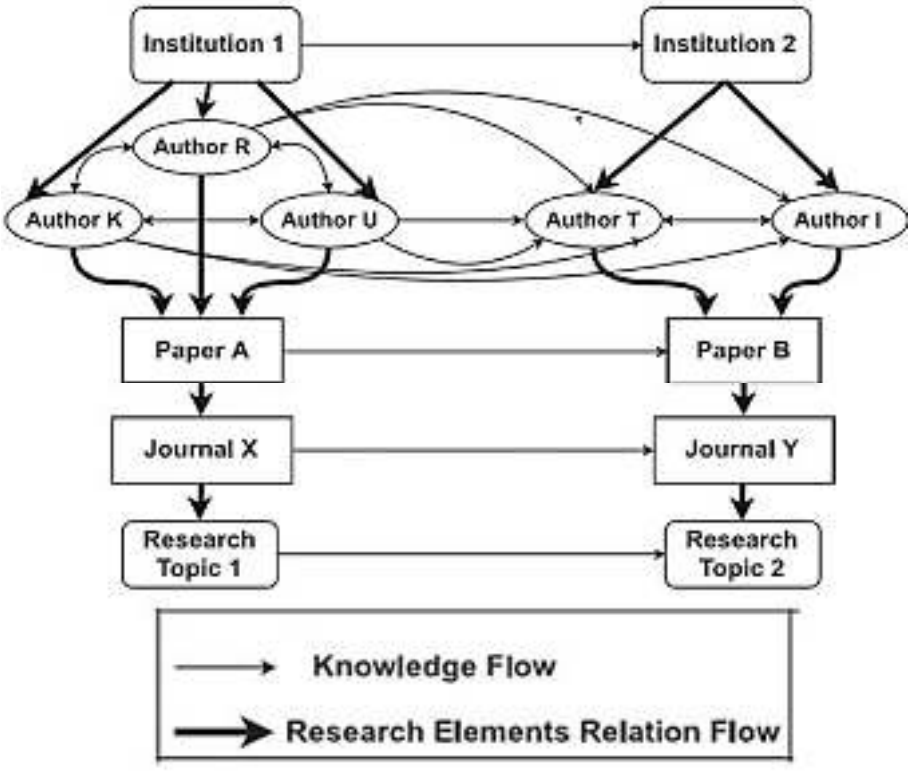

Fig. 2.1 Citation-based knowledge flow

The co-authored publications had more citations than single author paper and there was a positive co-relation between number of authors and the number of citations. Fig. 2.2 shows a relationship between co-authorship and different types of citations.

Three articles (X, Y, and Z) and five references (X1, X2, X3, Y1, and Y2) of article X and Y, respectively, are considered. A, B, and C are authors of article X, and D, E, F, G, and also A are authors of article Y. Article Z has two authors H and E. References X1, X2, X3, Y1, and Y2 have authors (A, P), (H, R), (D), (Q, B, F), and (R), respectively.

Based on co-authorship citation network, references X1 and Y1 are considered self-citation, reference X3 is a level-1 co-author citation because author of article Y is direct collaborator of author A, reference X2 is a level-1 co-author network because author A is collaborator of E who collaborated with H. The conclusion is that papers which frequently cite collaborators will also often cite collaborators of collaborators. Collaborations certainly impact citation counts.

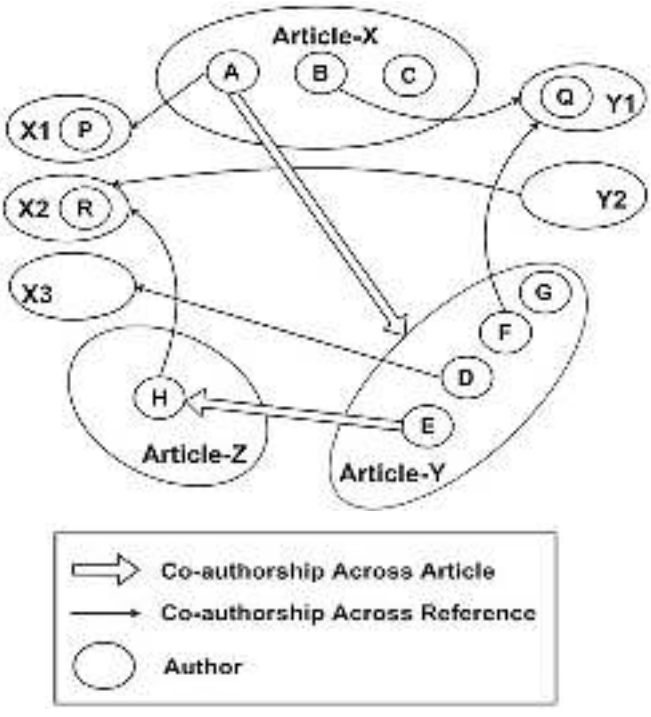

Fig. 2.2 Co-authorship network

1. Citing Datasets

Data citations should have provisions to give credit and legal attribution to all contributors/creators, enable identification and access, while recognizing that a specific style may not apply to all data. A researcher should obtain necessary permission for using data from a particular source. Citations related to datasets should include enough information.

Examples:

1. Historical Data, Sotavento (Wind Farm), Corunna, Spain (July 2016): [Accessed: 4 Oct, 2016] Retrieved from http://www.sotaventogalicia.com/en/real-time-data/historical
2. Deb, D (2016). [Personnel survey]. Unpublished raw data.

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2. Styles for Citations

Citation styles differ primarily in the order, and syntax of information about references, depending on difference in priorities attributed to concision, readability, dates, authors, and publications. Some of the most common styles for citation used by engineers are as follows:

IEEE style (Institute of Electrical and Electronics Engineers)

Book with Series Title, Volume Title, and Edition

Basic Format:

[1]. Author Name, "Title of chapter in the book*," in Title of Published Book*, X. Editor, Ed., xth ed. City of Publisher, Country: Abbrev. of Publisher, year, ch. x, sec. x, pp. xxx–xxx.

Examples:

[2]. A. Taflove, Computational Electrodynamics: The Finite-Difference Time-Domain Method *in Computational Electrodynamics II*, vol. 3, 2nd ed. Norwood, USA: Artech House, 1996.

[3]. R. L. Myer, "Parametric oscillators and nonlinear materials," *in Nonlinear Optics*, vol. 4, P. G. Harper and B. S. Wherret, Eds., San Francisco, USA: Academic, 1977, pp. 47–160.

Periodicals or IEEE Transactions:

Basic Format:

[1]. Author Name, "Name of paper," *Abbrev. Title of Periodical*, vol. x, no. x, pp. xxx-xxx, Abbrev. Month, year, doi: xxx.

Example:

[2]. M. M. Chiampi and L. L. Zilberti, "Induction of electric field in human bodies moving near MRI: An efficient BEM computational procedure," *IEEE Trans. Biomed. Eng*., vol. 58, pp. 2787–2793, Oct. 2011, doi: 10.1109/TBME.2011.2158315.

Conference Proceedings with Series Title, Volume Title, and Edition:

Basic Format:

[1]. Author Name, "Title of paper," *in Abbreviated Name of Conf.* in Volume Title, in Series Title, ed., year, pp. xxx-xxx.

Example:

[2]. A. Amador-Perez and R. A. Rodriguez-Solis, "Analysis of a CPW-fed annular slot ring antenna using DOE," *in Proc. IEEE Antennas Propag*. *Soc. Int. Symp.,* in Slot Ring Antennas II, vol. 3, 2nd ed., Jul. 2006, pp. 4301–4304.

ASCE style (American Society of Civil Engineers)

Basic Format for Journal Articles:

[1]. Authors. Year of initial publication. "Title of paper." Journal abbr. Volume (Issue): CID/page range. DOI.

Example:

[2]. Irish, J. L., and D. T. Resio. 2013. "Method for estimating future hurricane flood probabilities and associated uncertainty." J. Waterway, Port, Coastal, Ocean Eng. 139 (2): 04013001. https://doi.org/10.1061/(ASCE)WW.1943-5460.0000157.

Acknowledgments and Attributions:

These are also very important in the publications of journal or conference papers. Acknowledgment section is a place to provide a brief appreciation of the contribution of someone or an organization or funding body to the present work. Acknowledgment is a common practice to recognize persons or agencies for being responsible in some form or other for completion of a publishable research outcome. Acknowledgment displays a relationship among people, agencies, institutions, and research. Classification of acknowledgment into six different categories like moral, financial, editorial, institutional or technical, and conceptual support.

In engineering research, acknowledgments are meant for participating technicians, students, funding agency, grant number, institution, or anyone who provide scientific inputs, shared unpublished results, provided equipment, or participated in discussions.

1. What Should be Acknowledged?

Every author should know that what should/should not be acknowledged. Author should acknowledge quotation, ideas, facts, paraphrasing, funding organization, oral discussion or support, laboratory, and computer work.

(i) **Quotation:** In technical writing such as in the field of engineering, quotes are used very rarely. Quotations are of two types:

(a) Direct quotations are used when author use actual words or sentences in the same order as the original one. Author should use quotation marks for the words or sentences with proper acknowledgment.

(b) Indirect quotation summarizes or paraphrases the actual quote. In such cases, it is important to acknowledge with proper name and date.

(ii) Authors should **acknowledge people** who give appropriate contribution in their research work. Non-research work contributions are not generally acknowledged in a scientific paper but it may be in a thesis.

(iii) If the researcher received grant from a **funding agency** and if those funds were used in the work reported in the publication, then such support should always be acknowledged by providing full details of the funding program and grant number in the acknowledgment section. Failure to acknowledge funding may result in the discontinuation of current funding and/or ineligibility to receive future funding for a certain number of years or indefinitely.

Example: **Acknowledgments:**

> This research work was funded in part by the Extra Mural Research Funding 2014–17 (Individual Centric) of the Department of Science and Technology (DST), Govt. of India.

(iv) Acknowledging **that results have been presented elsewhere**: If the results were presented as an abstract in a journal, as part of scientific meeting, symposium, or other gathering then there should be a suitable citation in the form of name, place, and date.

2. Acknowledgments in Books/Dissertations

A page of acknowledgments is usually included at the beginning of a book/thesis/dissertation immediately following the table of contents. These acknowledgments are longer than the one or two sentence statements in journal papers or articles in conference proceedings. These detailed acknowledgments enable the researcher to thank all those who have contributed in completion of the research work.

Generally, one should express appreciation in order, a concise manner and avoid emotive language. The following are acknowledged: main supervisor, second supervisor, peers in the lab, other academic staff in the department, technical or support staff in the department, colleagues from other departments, other institutions, or organizations, former students, family, and friends.

Sample Acknowledgement in Thesis:

I wish to express my sincere appreciation to my supervisor **Dr. / Prof. Name** for the useful comments, remarks and encouragement throughout this thesis work. Furthermore, I wish to express my thanks to **Dr. / Prof. Name** for introducing me to the topic and for the support along the way. Also, I like to thank my peers in the Adaptive Control Lab such as **Name** and **Name**, who have shared their precious time during many lively technical discussions. I would like to thank my family members who have supported me throughout this journey in many different ways.

3. Dedication or Acknowledgments?

Dedication is almost never used in a journal paper, an article in a conference proceeding, or a patent, and it is used exclusively in larger documents like books, thesis, or dissertations. While acknowledgments are reserved for those who helped out with the book in some way or another (editing, moral support, etc), a dedication is to whomever the author would like it to be dedicated to, whether it is the author's mother, father, spouse, the best friend, the pet animal, or the name of God.