**Lesson 09: Steps of scientific research**

**Introduction:**

The decision to continue with science has a critical impact on the supply of the scientific skills necessary for a prosperous modern society. [[1]](#footnote-2)

Research process consists of series of actions or steps necessary to effectively carry out research.

The process consists of a number of closely related activities.[[2]](#footnote-3)

**1-Research Design:**

**Definition:**

The term research design means drawing for research.

It is a systematic planning of conducting research

It aims to achieve goals of the research.

as the arrangement of conditions for collection and analysis of data in a manner that aims to combine the relevance to the research purpose with economy in procedure.

a master plan, specifying the methods and procedures for collecting and analyzing the needed information.

**2-Need and Purpose of Research Design:**

It helps in smooth sailing of the research process.

It saves the money, manpower and materials.

It helps the researchers for advance planning and avoids duplication.

It helps to modify the research if any difficulties.

It gives reality to research.

3-**Research Design Process:**

Selection of research topic/problem,

Framing research design,

Framing sampling design,

Collection of data,

Data analysis/editing, coding, processing and preservation

Writing research reports.

**4-Characteristics of good research design:**

Theory-Grounded,

Environment,

Feasibility of Implementation,

Redundancy,

Efficient.

It should be flexible

It should be economical

It should be unbiased

It should fulfill the objectives of the research

It should be more appropriate to all the aspects of research.

It should guide him to achieve correct results.

It provides scientific base for his research.

It also should facilitate to complete the research work within the stipulated time.[[3]](#footnote-4)

5-**Functions of Research Design:**

It provides a blueprint of research.

It limits (dictates) the boundaries of the research activities.

It enables investigation to anticipate potential problems.

**6-Components of Research Design:**

Title of the investigation

Purpose of the study

Review of related literature

Statement of the problem

Scope of the investigation

Objectives of the study

Variables

Hypothesis

Selection of sample

Data Collection

Analysis of data. [[4]](#footnote-5)

**7-Basic principles of research design:**

Four main features of research design, which are distinct, but closely related

* Ontology: How you, the researcher, view the world and the assumptions that you make about the nature of the world and of reality
* Epistemology: The assumptions that you make about the best way of investigating the world and about reality
* Methodology: The way that you group together your research techniques to make a coherent picture
* Methods and techniques: What you actually do in order to collect your data and carry out your investigations
* These principles will inform which methods you choose: you need to understand how they fit with your ‘bigger picture’ of the world, and how you choose to investigate it, to ensure that your work will be coherent and effective[[5]](#footnote-6)

**8-Steps of scientific research :**

**8-1-Observation** : [[6]](#footnote-7)

an act of recognizing and noting a fact or occurrence often involving measurement with instruments

* Experiments performed in the laboratory.
* Experiments gained from knowledge of the literature.
* **Keys to Implementation in your Research:**
* Sorting Observations (from Literature Searches):

**8-2-Define Your objectives:**

Try to keep these simple.

The more variables the more difficult.

Use the opportunity .

Get help at this stage.

Senior colleagues.

Experienced researchers.

**8-3-Literature search:**

Check to see if your idea is original

Get articles

Read articles and their references

 Most of these will be vital when writing up reports

Find gap areas

Find obsolete measurements and results

Define objectives of the study. [[7]](#footnote-8)

**8-4-Abstract/Summary:**

* Brief background of subject
* Purpose for the study
* Major findings of the study
* Relationship between these findings and the field.

**8-5-Introduction:**

* Presents the background information for a fellow scientist (possibly in another field) to understand why the findings of this paper are significant.
* Structure is usually:
	+ Accepted state of knowledge in the field
	+ Focus on a particular aspect of the field, often the set(s) of data that led directly to the work of this paper
	+ Hypothesis being tested
	+ Conclusions (scientists don’t really like surprise endings). [[8]](#footnote-9)

**8-6-Defining the Problem & Collecting Background Information:**

* Identify the problem.
* Example: What are the effects of acid rain on salamanders?
* Collect information about the problem.

**Example:** We should know the normal development of salamanders as well as the characteristics of areas that are affected by acid rain. [[9]](#footnote-10)

**8-7-Literature Review :**

Once the problem is formulated, the researcher should undertake extensive literature connected with the problem.

**Why Literature Review?**

-Assist in refining statement of the problem

-Strengthening the argument of the selection of a research topic (Justification)

-It helps to get familiar with various types of methodology that might be used in the study (Design)[[10]](#footnote-11)

**8-8-FORMULATE A HYPOTHESIS:**

 A hypothesis is a proposed explanation of r an observable phenomenon which is capable of being tested by scientific methods.

For a researcher hypothesis is a formal question that he intends to resolve.

For example, consider a statement:

 “Drug A is equally efficient as Drug B”

 This is a hypothesis capable of being objectively verified and tested.

Hypothesis should be clear and precise, capable of being tested, limited in scope, simple in terms. [[11]](#footnote-12)

**8-9-Research Design:**

A research design is the arrangement for collection and analysis of data in an manner that aims to combine relevance to the research purpose with economy in procedure.

It is an outline of what researcher will do from writing the hypothesis and its operational implications to the final analysis of data.

Research Design includes blueprint for the collection, measurement and analysis of data. [[12]](#footnote-13)

**8-10-TESTING THE HYPOTHESIS :**

An experiment is a controlled procedure designed to test a hypothesis.

In an experiment, one variable, or condition, is changed and the response of another variable is measured.

**8-11-Experimental Testing :**

 to be assigned a standing or evaluation on the basis of tests 2 : to apply a test as a means of analysis or diagnosis .

 Good TESTS will prove or disprove your hypothesis.

 Experimental Tests can be performed within the realm of computing. (e.g. Coventor model with calculations and predictions can serve as experiment and model).

 Consider all alternatives. Experiment may not disprove all (but may disprove only parts) of your hypothesis. That is still alright to perform. Carefully note which aspects of your hypothesis this experiment will test.

 Consider the availability of instrumentation to perform your tests.

Ask questions! Schedule meetings with appropriate people in charge of equipment to inquire about capabilities and terms/conditions for use.

**8-12-Predictions:**
 to declare or indicate in advance; especially : foretell on the basis of observation, experience, or scientific reason

 Good Predictions can also be tested against your hypothesis.

 Consider going back to the basics (textbook theory) to development of a mathematical model/construct which will help to make predictions about more systems than you can reasonably test.

**8-13-Materials and Methods:**

Should be detailed enough for another scientist to replicate the work (volumes, times, company material was purchased from etc.)

In reality, often compressed and you may need to look up another paper that is referenced for more detail. [[13]](#footnote-14)

**8-14-Data Collection:**

 The data task of data collection begins after a research problem has been defined and research design chalked out.

**8-15-Data Analysis:**

Data Analysis is important to answer the research questions and to help determine the trends and relationships among the variables.

Data Analysis is a procedure of editing, coding and tabulating data.

**8-16-Interpretation and Report Writing** :

Interpretation refers to the task of drawing inferences from the collected facts after an analytical and experimental study.

Interpretation is the process of making in the sense of numerical data that has been collected, analyzed and presented.

**8-17-Research Report** :

A Research Report is a document giving summarized and interpretative information of research done based on factual data, opinions and about procedure used by the individual or group.

A Research Report is a recorded data prepared by researchers after analyzing information gathered by conducting organized research.

A Research Report generally, but not always have actionable recommendations such as investment ideas that investors can act upon, recommendations on any act or law on which government can take action, policy decisions that are practically applicable, etc. [[14]](#footnote-15)

**8-18-Results:**

While the introduction poses the questions being asked, the results describes the outcome of the experiments that were done to answer the questions.

Results are often simply stated with interpretation of them coming later in the discussion.

Figures and tables allow the reader to see the outcomes of the experiments for themselves!

**8-19-Discussion:**

Data is analyzed to show what the authors believe the data show.

Findings are related to other findings in the field (contribute to knowledge, correct errors, etc.)– How is this work significant?

**8-20-Acknowledgements:**

Thank people who contributed materials.

Thank people who contributed technically but maybe not intellectually (would not be authors). [[15]](#footnote-16)

**8-21-DRAWING CONCLUSIONS :**

Before accepting conclusions, scientists retest their hypotheses several times. Later other scientists repeat the experiment until the hypothesis and the conclusion are supported or rejected. [[16]](#footnote-17)

**8-22-LAW/THEORY :**

When a hypothesis explains how “facts of nature” occurs, it becomes scientific principle or law. Example: Law of Gravity

When a hypothesis explains why “natural” events occur through observations and investigations over a long period of time, it becomes a theory. Example: Theory of Evolution.[[17]](#footnote-18)

**8-23-References:**

* Papers cited in the text
* What parts of the paper cite other papers?
	+ Introduction
	+ Materials and Methods
	+ Discussion

(Maybe a few in Results).[[18]](#footnote-19)

**Conclusion :**

Scientific research requires organized stages and steps, all of which are important in that they perform a specific function that helps the researcher access information and data relevant to the subject of his study. Therefore, it can be said that if a defect occurs at the level of any step, the other steps will inevitably be affected.

1. [Tracey-Ann Palmer](https://www.researchgate.net/profile/Tracey-Ann-Palmer): **Student subject choice in the final years of school: why science is perceived to be of poor value,** [The Australian Educational Researcher](https://www.researchgate.net/journal/The-Australian-Educational-Researcher-2210-5328), January 2020 [↑](#footnote-ref-2)
2. Ganesh Dive : **Stages in Scientific Research Process** [↑](#footnote-ref-3)
3. AP Bell Ringer: **Scientific Method and Experimental Design** [↑](#footnote-ref-4)
4. ibid [↑](#footnote-ref-5)
5. Liz FitzGerald: **Introduction to quantitative and qualitative research** [↑](#footnote-ref-6)
6. . T. Dobbins: **Scientific Method of Research**, 1/23/2004

 [↑](#footnote-ref-7)
7. Thomas Varghese: **INTRODUCTION TO RESEARCH METHODOLOGY**, Dept. of Physics Nirmala College, Muvattupuzha, 3 October 2023 [↑](#footnote-ref-8)
8. Mc Graw : **The Nature of Research,** Mc Graw Hill companies, Inc, 2006 , P22 [↑](#footnote-ref-9)
9. Pushpalata Trimukhe: **Research mEthodoLogy**  [↑](#footnote-ref-10)
10. ibid [↑](#footnote-ref-11)
11. ibid [↑](#footnote-ref-12)
12. Pushpalata Trimukhe: **Research mEthodoLogy** [↑](#footnote-ref-13)
13. Kelly Hogan : **How to read a scientific paper** , p04- 17 [↑](#footnote-ref-14)
14. Pushpalata Trimukhe**: Research mEthodoLogy** , op, cité [↑](#footnote-ref-15)
15. Kelly Hogan : **How to read a scientific paper** , p04- 17 [↑](#footnote-ref-16)
16. Pushpalata Trimukhe: **Research mEthodoLogy**, op, cité [↑](#footnote-ref-17)
17. ibid [↑](#footnote-ref-18)
18. Kelly Hogan : **How to read a scientific paper** , p04- 17 [↑](#footnote-ref-19)