Module 3

Research Design & Results and Analysis

Research Design:Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs case of Exploratory research studies, case of descriptive and diagnostic research, case of hypothesis -testing , Basic Principles of Experimental Designs, Important Experimental Designs.

Results and Analysis:Importance and scientific methodology in recording results, importance of negative results, different ways of recording, industrial requirement, artifacts versus true results, types of analysis (analytical, objective, subjective), outcome as new idea, hypothesis, concept, theory, model etc.

Meaning of Research Design

- **The formidable problem that follows the task of defining the research problem is the preparation of the design of the research project, popularly known as the "research design"**
- Decisions regarding what, where, when, how much, by what means concerning an inquiry or a research study constitute a research design
- **"A research design is the arrangement of conditions for collection and analysis of data in a manner that aims to combine relevance to the research purpose with economy in procedure."** In fact, the research design is the conceptual structure within which research is conducted; it constitutes the blueprint for the collection, measurement and analysis of data
- The **design decisions happen to be in respect of**: (i) What is the study about? (ii) **Why** is the study being made? (iii) **Where** will the study be carried out? (iv) **What** type of data is required? (v) Where can the **required data** be found? (vi) What **periods of time** will the study include? (vii) What will be the **sample design**? (viii) What **techniques of data collection** will be used? (ix) **How** will the data be analysed? (x) In what style will the **report be prepared**?

- overall research design into the following parts (**4 parts**):

(a) **The sampling design** which deals with the method of selecting items to be observed for the given study

(b) **The observational design** which relates to the conditions under which the observations are to be made

(c) **The statistical design** which concerns with the question of how many items are to be observed and how the information and data gathered are to be analysed

(d) **The operational design** which deals with the techniques by which the procedures specified in the sampling, statistical and observational designs can be carried out

Research design must, at least, contain— **(a)** a clear statement of the research problem; **(b)** procedures and techniques to be used for gathering information; **(c)** the population to be studied; and **(d)** methods to be used in processing and analysing data

NEED FOR RESEARCH DESIGN

- Research design is needed because it **facilitates the smooth sailing of the various research operations**, thereby making research as efficient as possible yielding maximal information with minimal expenditure of effort, time and money.
- Research design **stands for advance planning of the methods to be adopted for collecting the relevant data and the techniques** to be used in their analysis, keeping in view the objective of the research and the availability of staff, time and money
- Preparation of the **research design should be done with great care** as any error in it may upset the entire project.
- Research design, in fact, **has a great bearing on the reliability of the results** arrived at and as such constitutes the firm foundation of the entire edifice of the research work.
- The design **helps the researcher to organize his ideas** in a form whereby it will be possible for him to look for flaws and inadequacies. Such a design can even be given to others for their comments and critical evaluation.

FEATURES OF A GOOD DESIGN

- A good design is often **characterised by adjectives like flexible, appropriate, efficient, economical and so on**. Generally, the design which **minimises bias and maximises the reliability of the data collected and analysed** is considered a good design. The design which gives the **smallest experimental error is supposed to be the best design** in many investigations.
- A design may be quite suitable in one case, but may be found wanting in one respect or the other in the context of some other research problem.
- One single design cannot serve the purpose of all types of research problems.
- A research design appropriate for a particular research problem, usually involves the consideration of the following factors: (i) the means of obtaining information; (ii) the availability and skills of the researcher and his staff, if any; (iii) the objective of the problem to be studied; (iv) the nature of the problem to be studied; and (v) the availability of time and money for the research work.

Important Concepts Relating to Research Design

1. Dependent and independent variables
2. Extraneous variable
3. Control
4. Confounded relationship
5. Research hypothesis
6. Experimental and non-experimental hypothesis-testing research
7. Experimental and control groups
8. Treatments
9. Experiment
10. Experimental unit(s)

1. Dependent and independent variables

- **A concept which can take on different quantitative values is called a variable** (eg: height, weight, income)
- Qualitative phenomena (or the attributes) are also quantified
  - on the basis of the presence or absence of the concerning attribute(s)
- Phenomena which can take on quantitatively different values even in decimal points are called ‘continuous variables (eg. Age)
- But all variables are not continuous
- discrete variables (eg. number of children)

2. Extraneous variable

- **Independent variables that are not related to the purpose of the study, but may affect the dependent variable are termed as extraneous variables**
- Suppose the researcher wants to test the hypothesis that there is a relationship between children’s gains in social studies achievement and their self-concepts. In this case self-concept is an independent variable and social studies achievement is a dependent variable.
- Intelligence may as well affect the social studies achievement, but since it is not related to the purpose of the study undertaken by the researcher, it will be termed as an extraneous variable.

3. Control

- The technical term ‘control’ is used **when we design the study minimising the effects of extraneous independent variables**. In experimental researches, the term ‘control’ is used to refer to restrain experimental conditions.

4. Confounded relationship

- When the **dependent variable is not free from the influence of extraneous variable(s),** the relationship between the dependent and independent variables is said to be confounded by an extraneous variable(s).

5. Research hypothesis

•The research hypothesis is a **predictive statement** that relates an **independent variable to a dependent variable**.
•Usually a research hypothesis must contain, **at least, one independent and one dependent variable**.

6. Experimental and non-experimental hypothesis-testing research

- When the purpose of research is to test a research hypothesis, it is termed as hypothesis-testing research
- Research in which the independent variable is manipulated is termed 'experimental hypothesis-testing research' and a research in which an independent variable is not manipulated is called 'non-experimental hypothesis-testing research'

7. Experimental and control groups

- In an experimental hypothesis-testing research when a group is exposed to usual conditions, it is termed a 'control group', but when the group is exposed to some novel or special condition, it is termed an 'experimental group'.
- In the above illustration, the Group A can be called a control group and the Group B an experimental group.

8. Treatments

- The different conditions under which experimental and control groups are put are usually referred to as 'treatments"

9. Experiment

- The process of examining the truth of a statistical hypothesis, relating to some research problem, is known as an experiment.

10. Experimental unit(s)

- The pre-determined plots or the blocks, where different treatments are used, are known as experimental units. Such experimental units must be selected (defined) very carefully

Different Research Designs (Exploratory research studies, descriptive and diagnostic research and hypothesis testing)

	Type of study	
Research Design	Exploratory of Formulative	Descriptive/Diagnostic
Overall design	Flexible design (design must provide opportunity for considering different aspects of the problem)	Rigid design (design must make enough provision for protection against bias and must maximise reliability)
Sampling design	Non-probability sampling design (purposive or judgement sampling)	Probability sampling design (random sampling)
Statistical design	No pre-planned design for analysis	Pre-planned design for analysis
Observational design	Unstructured instruments for collection of data	Structured or well thought out instruments for collection of data
Operational design	No fixed decisions about the operational procedures	Advanced decisions about operational procedures.

Research design in case of hypothesis-testing research studies

- Hypothesis-testing research studies (generally known as experimental studies) are those where the researcher tests the hypotheses of causal relationships between variables.
- Such studies require procedures that will not only reduce bias and increase reliability, but will permit drawing inferences about causality.
- Usually experiments meet this requirement. Hence, when we talk of research design in such studies, we often mean the design of experiments

Basic Principles of Experimental Designs

- ***Prof. Fisher*** has enumerated ***three principles*** of experimental designs:

  (1) the Principle of Replication

  (2) the Principle of Randomization;

  (3) Principle of Local Control

- According to the ***Principle of Replication***, ***the experiment should be repeated more than once***. Thus, each treatment is applied in many experimental units instead of one. ***By doing so the statistical accuracy of the experiments is increased.***
- We can then collect the data of two varieties and draw conclusion by comparing the same. The result so obtained will be more reliable in comparison to the conclusion we draw without applying the principle of replication. The entire experiment can even be repeated several times for better results. ***Conceptually replication does not present any difficulty, but computationally it does.***

- The ***Principle of Randomization*** provides protection, when we conduct an experiment, against the effect of extraneous factors by randomization. In other words, this principle indicates that we should design or plan the experiment in such a way that the variations caused by extraneous factors can all be combined under the general heading of “chance”.
- Through the application of the principle of randomization, ***we can have a better estimate of the experimental error.***

- The ***Principle of Local Control*** is another important principle of experimental designs. Under it the extraneous factor, the known source of variability, is made to vary deliberately over as wide a range as necessary and this needs to be done in such a way that the variability it causes can be measured and hence eliminated from the experimental error.
- In brief, through the principle of local control ***we can eliminate the variability due to extraneous factor(s) from the experimental error***.

Important Experimental Designs

- Experimental design refers to the framework or structure of an experiment and as such there are several experimental designs.
- We can classify ***experimental designs into two broad categories***, viz., informal experimental designs and formal experimental designs.
- ***Informal experimental designs*** are those designs that normally use a less sophisticated form of analysis based on differences in magnitudes, whereas ***formal experimental designs*** offer relatively more control and use precise statistical procedures for analysis. Important experiment designs are as follows:

(a) Informal experimental designs:
(i)Before-and-after without control design
(ii) After-only with control design
(iii) Before-and-after with control design

(b) Formal experimental designs
(i) Completely randomized design (C.R. Design)
(ii) (ii) Randomized block design (R.B. Design)
(iii) (iii) Latin square design (L.S. Design)
(iv) (iv) Factorial designs.

Importance and scientific methodology in recording results

- **Accuracy and Objectivity**: Meticulous recording ensures accurate representation of data, minimizing biases and errors.
- **Replicability**: Detailed records allow others to replicate the study, verifying findings and building upon the research.
- **Data Integrity**: Proper recording maintains data integrity, preventing alterations or loss that could compromise the study's validity.
- **Ethical Considerations**: Accurate records demonstrate adherence to ethical guidelines, ensuring responsible research practices.
- **Data Analysis and Interpretation**: Organized records facilitate efficient data analysis and interpretation, leading to meaningful conclusions.
- **Publication and Dissemination**: Well-documented results increase the likelihood of publication in reputable journals and conferences.
- **Future Reference**: Records serve as a valuable resource for future research, providing insights and context for new studies.
- **Collaboration and Knowledge Sharing**: Shared records enable collaboration among researchers, fostering knowledge exchange and innovation.
- **Accountability and Transparency**: Detailed records promote accountability and transparency, ensuring the research process is open to scrutiny.
- **Scientific Method Adherence**: Accurate recording aligns with the principles of the scientific method, promoting rigorous and reliable research.

Importance of negative results

- **Advancement of Knowledge**: Negative results can lead to the refinement of existing theories and the development of new hypotheses.
- **Resource Allocation**: Negative results can help researchers avoid wasting time and resources on unpromising research directions.
- **Replication and Verification**: Negative results can be used to replicate and verify previous findings, ensuring the reliability of scientific knowledge.
- **Identifying Methodological Flaws**: Negative results can highlight potential methodological issues in previous studies, leading to improvements in research design.
- **Reducing Publication Bias**: Publishing negative results can help counteract the tendency to only publish positive findings, promoting a more balanced view of scientific research.
- **Ethical Considerations**: Reporting negative results can demonstrate transparency and honesty in research, upholding ethical standards.
- **Identifying New Research Avenues**: Negative results can sometimes point towards unexpected discoveries or new areas of investigation.
- **Avoiding False Positives**: Negative results can help prevent the overinterpretation of data and the acceptance of false claims.
- **Building a Cumulative Body of Knowledge**: Negative results contribute to the overall body of scientific knowledge, providing a more complete understanding of a phenomenon.
- **Encouraging Openness and Collaboration**: Sharing negative results fosters a culture of openness and collaboration among researchers, promoting the exchange of ideas and knowledge.

Different ways of recording

- **Laboratory Notebooks**: Traditional method for detailed, chronological recording of experiments, observations, and data.
- **Digital Notebooks**: Electronic tools for capturing data, images, and notes, often integrated with cloud storage and synchronization.
- **Data Management Software**: Specialized software for organizing, analyzing, and storing large datasets efficiently.
- **Spreadsheets:** Versatile tool for tabular data entry, calculations, and visualization.
- **Database Management Systems**: Structured approach for storing, organizing, and retrieving large amounts of data.
- **Audio and Video Recordings**: Useful for capturing qualitative data, interviews, and observations.
- **Photographs and Images**: Visual documentation of physical samples, experimental setups, and field observations.
- **Field Notes**: Handwritten or digital records of observations, interviews, and contextual information collected in the field.
- **Checklists and Forms**: Standardized tools for collecting specific types of data, such as survey responses or experimental measurements.
- **Online Platforms and Cloud Storage**: Remote access to data, collaboration tools, and version control for efficient data management.

Industrial requirement

- **Product Development**: Research results can inform the development of new products or the improvement of existing ones by identifying market needs, consumer preferences, and technological advancements.
- **Process Optimization**: Analyzing research data can help optimize production processes, reduce costs, and improve efficiency by identifying bottlenecks, inefficiencies, and areas for automation.
- **Quality Control**: Research results can be used to establish quality standards, monitor product performance, and identify potential quality issues, ensuring customer satisfaction and brand reputation.
- **Market Analysis**: By analyzing market trends, consumer behavior, and competitive landscapes, research can help businesses identify new market opportunities, target specific customer segments, and develop effective marketing strategies.
- **Risk Assessment**: Research can help identify potential risks, such as supply chain disruptions, regulatory changes, or economic downturns, allowing businesses to develop contingency plans and mitigate potential negative impacts.
- **Regulatory Compliance**: Research can help businesses understand and comply with relevant regulations, standards, and certifications, avoiding legal and financial penalties.
- **Decision Making**: Data-driven insights from research can inform strategic decision-making, such as investment decisions, mergers and acquisitions, and resource allocation.
- **Innovation**: Research can stimulate innovation by identifying emerging technologies, trends, and customer needs, driving the development of new products, services, and business models.
- **Problem-Solving**: Research can help identify and address specific problems or challenges faced by businesses, such as supply chain issues, quality control problems, or declining sales.
- **Competitive Advantage**: By leveraging research insights, businesses can gain a competitive advantage by developing innovative products, improving operational efficiency, and understanding customer needs better than their competitors.

Artifacts versus true results

- **Origin:** Artifacts arise from methodological flaws, human error, or external factors, while true results are derived from the underlying phenomena or processes being studied.
- **Reliability:** Artifacts are often unreliable and inconsistent across different studies, while true results tend to be more reliable and reproducible.
- **Generalizability:** Artifacts may not generalize to other populations or settings, while true results are more likely to be generalizable.
- **Practical Significance**: Artifacts may not have practical significance, while true results often have real-world implications.
- **Theoretical Implications**: Artifacts may not contribute to theoretical understanding, while true results can advance theoretical knowledge.
- **Ethical Considerations**: Artifacts can lead to misleading conclusions and misallocation of resources, while true results promote ethical and responsible research.
- **Data Analysis**: Artifacts can be identified and mitigated through careful data analysis, while true results are often robust to statistical analysis.
- **Replication:** Artifacts are less likely to be replicated in subsequent studies, while true results can be replicated and confirmed.
- **Scientific Method**: Artifacts violate the principles of the scientific method, while true results align with the core tenets of scientific inquiry.
- **Decision Making**: Artifacts can lead to poor decision-making, while true results inform sound decision-making processes.

Types of analysis (analytical, objective, subjective)

- **Analytical Analysis**

1. **Data-Driven:** Relies heavily on quantitative data and statistical methods.
2. **Systematic Approach:** Follows a structured process of data collection, analysis, and interpretation.
3. **Objective:** Aims to be unbiased and free from personal opinions or beliefs.
4. **Common Techniques:** Statistical analysis, data mining, and machine learning.
5. **Applications:** Market research, scientific research, and business intelligence.

- **Objective Analysis**

1. **Fact-Based:** Focuses on verifiable facts and evidence.
2. **Impartial:** Strives to be neutral and avoid personal biases.
3. **Critical Thinking:** Involves careful evaluation of information and arguments.
4. **Common Techniques:** Logical reasoning, critical thinking, and evidence-based reasoning.
5. **Applications:** Legal analysis, historical analysis, and scientific research.

- **Subjective Analysis**

1. **Opinion-Based:** Relies on personal opinions, feelings, and beliefs.
2. **Interpretive Approach:** Seeks to understand the meaning and significance of information.
3. **Contextual Understanding:** Considers the cultural, historical, and social context.
4. **Common Techniques:** Hermeneutics, phenomenology, and discourse analysis.
5. **Applications:** Literary criticism, art criticism, and qualitative research.

outcome as new idea

- **Innovation and Creativity**: A successful research outcome can lead to the development of new ideas, concepts, or theories that challenge existing knowledge.
- **Problem-Solving**: Research can identify problems and propose innovative solutions, leading to the development of new products, services, or processes.
- **Technological Advancements**: Research can drive technological advancements by exploring new frontiers and pushing the boundaries of scientific knowledge.
- **Policy and Decision-Making**: Research findings can inform policy decisions and shape future directions, impacting society and industry.
- **Intellectual Property**: New ideas generated through research can be protected through patents, copyrights, or trademarks, leading to commercialization and economic growth.

outcome as new idea-hyposthesis

- **Innovation and Discovery**: New ideas and hypotheses are the foundation of scientific progress and innovation. They drive research, leading to groundbreaking discoveries and advancements in various fields.
- **Problem-Solving**: New ideas and hypotheses can help address real-world problems and challenges. By generating novel solutions, researchers can contribute to societal and economic development.
- **Theoretical Advancement**: New ideas and hypotheses challenge existing theories and paradigms, leading to the development of more comprehensive and accurate explanations of phenomena.
- **Interdisciplinary Collaboration**: New ideas and hypotheses often emerge from the intersection of different disciplines. By fostering interdisciplinary collaboration, researchers can gain new perspectives and insights.
- **Future Research Directions**: New ideas and hypotheses can open up new avenues for future research, inspiring further investigation and exploration.

Outcome as new idea - Concept

- **Novelty and Originality**: A new idea or concept should offer a fresh perspective, departing from existing knowledge or theories.
- **Theoretical Significance**: The new idea should contribute to the development or refinement of existing theories or frameworks.
- **Practical Implications**: The concept should have potential real-world applications, such as solving problems, improving processes, or informing policy decisions.
- **Potential for Further Research**: The new idea should open up new avenues for future research and exploration.
- **Ethical Considerations**: The new idea should be developed and applied in an ethical manner, considering potential consequences and societal impact.

Outcome as new idea - Theory

- **Innovation and Discovery**: New ideas and theories often emerge from research, leading to advancements in various fields.
- **Theoretical Framework**: Research can contribute to the development of new theoretical frameworks that explain complex phenomena.
- **Paradigm Shifts**: Sometimes, research can challenge existing paradigms and lead to significant shifts in scientific thinking.
- **Policy Implications**: New ideas and theories generated from research can inform policy decisions and shape public policy.
- **Intellectual Contribution**: Research that produces new ideas and theories contributes to the intellectual capital of society.

Outcome as new idea - Model

- **Innovation and Creativity**: Outcome as a new idea-model fosters innovation by encouraging researchers to think outside the box and develop novel solutions to problems.
- **Theoretical Advancement**: New ideas and models contribute to the advancement of theories and frameworks in a particular field of study.
- **Practical Applications**: A well-developed idea-model can have practical applications, leading to the development of new products, services, or policies.
- **Future Research Directions**: New ideas and models can inspire future research by identifying gaps in knowledge and suggesting new avenues for investigation.
- **Knowledge Dissemination**: Sharing new ideas and models through publications, conferences, or workshops can contribute to the dissemination of knowledge and the advancement of the field.