



Unit I: Research Methodology Introduction

Q1. Define "Research" and list its primary objectives. (6 Marks)

Answer:

Definition: Research is a "search for knowledge"¹. It is a scientific and systematic search for pertinent information on a specific topic². It can be seen as a "voyage of discovery"³, moving from the known to the unknown⁴.

The primary objectives of research are⁵:

- **To gain familiarity** with a phenomenon or to achieve new insights into it⁶.
- **To portray accurately** the characteristics of a particular individual, situation, or group⁷.
- **To determine the frequency** with which something occurs or with which it is associated with something else⁸.
- **To test a hypothesis** of a causal relationship between variables⁹.

Q2. Compare and contrast any three of the following pairs of research types:

- **Descriptive vs. Analytical**
 - **Applied vs. Fundamental**
 - **Quantitative vs. Qualitative**
- (6 Marks)

Answer:

- **Descriptive vs. Analytical Research:**
 - **Descriptive research** includes surveys and fact-finding enquiries¹⁰. The researcher simply reports what is happening or what has happened.

- **Analytical research**, on the other hand, uses facts or information that are already available and analyzes them to make a critical evaluation of the material¹¹.
- **Applied vs. Fundamental Research:**
 - **Applied research** (or action research) aims at finding a solution for an **immediate problem** facing a society or organization¹².
 - **Fundamental research** (or basic/pure research) is mainly concerned with **generalizations and the formulation of a theory**¹³. It isn't focused on an immediate practical problem.
- **Quantitative vs. Qualitative Research:**
 - **Quantitative research** is based on the measurement of **quantity or amount**¹⁴. It deals with numerical data.
 - **Qualitative research** is concerned with **qualitative phenomenon**, i.e., phenomena relating to or involving quality or kind¹⁵. It deals with non-numerical data like opinions, motivations, or behaviors.

Q3. Why is ethics important in research, and what are some key ethical principles researchers should follow? (5 Marks)

Answer:

Ethics is important because it provides guidelines for the responsible conduct of research¹⁶. It ensures the integrity of the research is upheld and helps prevent harm to people, waste of resources, and damage to the credibility of research¹⁷.

Key ethical principles include¹⁸:

- **Honesty**
- **Objectivity**
- **Integrity**
- **Carefulness**
- **Openness**
- **Respect for Intellectual Property**
- **Confidentiality**

Q4. What is research misconduct? Define its three main types: Fabrication, Falsification, and Plagiarism. (6 Marks)

Answer:

Research Misconduct is characterized as actions or questionable practices that fall short of the ethical and scholarly standards required to ensure research integrity is upheld¹⁹.

The three main types are:

1. **Fabrication:** This is **making up data or results** and recording or reporting them²⁰.
2. **Falsification:** This is **manipulating research materials, or changing or omitting data** or results such that the research is not accurately represented in the research record²¹.
3. **Plagiarism:** This is the **appropriation of another person's ideas, processes, results, or words** without giving appropriate credit²².

Q5. List and explain the three main functions of citation in a research paper. (6 Marks)

Answer:

The three main functions of citation are:

1. **Verification Function:** Citations allow readers to check the original source to see if the author's assertion is justified and accurately described. This gives authors a scope for finding and correcting any intentional or unintentional distortion of research²³.
2. **Acknowledgment Function:** Researchers receive credit for their work primarily through citations²⁴. Citations play a crucial role in building a researcher's reputation, which can impact promotions and research funding²⁵.

3. **Documentation Function:** Citations are used to document the scientific concepts and historical progress of a particular technology or field over the years²⁶.

Q6. How do the "Title" and "Keywords" of a research paper impact its citations? (4 Marks)

Answer:

- **Title:** The title is the most important attribute of a paper²⁷. A good title is informative, represents the paper effectively, and gains the reader's attention²⁸. It plays a key role in marketing the paper and making it traceable, which can increase its visibility and, subsequently, its citation count²⁹.
- **Keywords:** Keywords represent the main content of the article³⁰. Search engines, digital libraries, and indexing services use keywords to **categorize the research topic** and direct the work to the **relevant audience**³¹. Effective keywords make the paper more discoverable, which helps ensure readers are aware of the article and can lead to more citations³².

Q7. Compare "Critical Reading" and "Creative Reading" in the context of a literature review. (3 Marks)

Answer:

- **Critical Reading** is the process of reading to find mistakes or flaws in a paper³³.
- **Creative Reading** is a different approach where the reader actively looks for **other applications, interesting generalizations, or extended work** that the original authors might have missed³⁴. It involves asking if plausible modifications could lead to new practical challenges or ideas³⁵.

Q8. What is the purpose of an "Acknowledgments" section, and how does it differ from a "Dedication"? (4 Marks)

Answer:

- **Acknowledgments:** This section is used to provide a brief **appreciation for the contribution of someone or an organization** to the research work³⁶. It is a common practice to recognize persons or agencies (like a funding body) responsible for the completion of the research³⁷³⁷³⁷³⁷.
- **Difference from Dedication:** An acknowledgment is for those who **helped with the work** (e.g., funding, editing, technical support)³⁸. A dedication is used almost exclusively in larger documents like books or theses and is dedicated to whomever the author chooses (e.g., parents, spouse, friend), whether they helped with the work or not³⁹.



Unit II: Research Design

Q9. What is a "research design," and why is it needed in a research project? (5 Marks)

Answer:

A research design is the plan or strategy for conducting the research⁴⁰. It involves making decisions about what, where, when, how much, and by what means the research inquiry will be conducted⁴¹.

A research design is needed for⁴²:

- Ensuring the **smooth sailing** of research operations⁴³.
- Serving as an **advance plan** of the methods to be used⁴⁴.
- **Giving direction** to the study and helping in decision making⁴⁵.
- **Preventing blind searching**⁴⁶.

- Helping researchers **anticipate potential problems** in data collection⁴⁷.
 - A good design **minimizes bias and maximizes the reliability** of the data⁴⁸.
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Q10. Define the following variables with an example for each:

- **Independent Variable**
 - **Dependent Variable**
 - **Extraneous Variable**
- (6 Marks)

Answer:

- **Independent Variable:** This is the factor that the researcher **manipulates or controls** to observe its effect⁴⁹. It is considered the "**cause**" in a cause-and-effect relationship⁵⁰.
 - *Example:* In a study on a new drug, the **dosage of the drug** is the independent variable⁵¹.
 - **Dependent Variable:** This is the outcome or **effect that the researcher measures** in response to changes in the independent variable⁵². It is considered the "**effect**" in a cause-and-effect relationship⁵³.
 - *Example:* In the drug study, the **change in blood pressure** is the dependent variable.
 - **Extraneous Variable:** This is **any variable other than the independent variable** that could also influence the dependent variable⁵⁴. If not controlled, it can "confound" the results⁵⁵.
 - *Example:* Environmental factors (like temperature), participant characteristics (like mood or fatigue), or the time of day the experiment is run⁵⁶.
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Q11. Differentiate between an Extraneous Variable and a Confounded Variable. (3 Marks)

Answer:

- An **Extraneous Variable** is any variable, besides the independent variable, that *could* potentially influence the dependent variable⁵⁷. It's a potential source of noise.
- A **Confounded Variable** is a specific situation where an extraneous variable is **intertwined with the independent variable** in such a way that their individual effects on the dependent variable **cannot be separated**⁵⁸. This occurs when the extraneous variable correlates with *both* the independent and dependent variables, leading to misleading conclusions⁵⁹.

Q12. What is a research hypothesis? Differentiate between a Null Hypothesis (\$H_0\$) and an Alternative Hypothesis (\$H_1\$). (6 Marks)

Answer:

A research hypothesis is a predictive statement that relates an independent variable to a dependent variable⁶⁰. It is a provisional conjecture or proposition set forth as an explanation for a phenomenon, which guides the investigation⁶¹.

- **Null Hypothesis (\$H_0\$):** This is a statement asserting that there is **no effect, no difference, or no relationship** between variables⁶². It is the default position that researchers aim to test against⁶³.
 - *Example:* $H_0: \mu_1 = \mu_2$, stating the mean blood pressure of patients taking a drug is *equal* to those not taking it⁶⁴.
- **Alternative Hypothesis (\$H_1\$ or \$H_a\$):** This statement **contradicts the null hypothesis**, suggesting that there *is* an effect, difference, or relationship⁶⁵. It represents what the researcher aims to support⁶⁶.
 - *Example:* $H_1: \mu_1 \neq \mu_2$, stating the mean blood pressures are *different*⁶⁷.

Q13. Explain the role of the "Experimental Group" and "Control Group" in an experiment. (4 Marks)

Answer:

- **Experimental Group:** This is the group of subjects that **receives the treatment** or intervention being tested⁶⁸. Researchers observe this group to see the effect of the independent variable⁶⁹.
- **Control Group:** This is a separate group that **does not receive the treatment**⁷⁰. It serves as a **baseline** to compare against the experimental group⁷¹. It may receive a placebo or a standard treatment⁷².

By comparing the two groups, researchers can help establish causality and ensure that any observed changes are due to the treatment and not other factors⁷³.

Q14. What is a Completely Randomised Design (CRD)? State its key advantages and limitations. (6 Marks)

Answer:

A Completely Randomised Design (CRD) is a basic experimental design in which treatments are assigned to experimental units completely at random⁷⁴. This means every unit has an equal chance of receiving any treatment⁷⁵.

Advantages:

- **Simplicity:** The layout and analysis are straightforward and easy to implement⁷⁶.
- **Statistical Efficiency:** It provides the maximum degrees of freedom for error, which enhances the sensitivity of statistical tests⁷⁷.
- **Flexibility:** It allows for any number of treatments and replications⁷⁸⁷⁸⁷⁸⁷⁸.

Limitations:

- **Homogeneity Requirement:** CRD is most effective when experimental units are homogeneous (similar)⁷⁹. It is less effective if they are not, as this can increase variability⁸⁰.
- **Less Accurate in Field Experiments:** Due to uncontrolled environmental variations, CRD may not be suitable for field experiments⁸¹.

Q15. Briefly explain a Randomized Block Design (RBD). How does "blocking" work? (6 Marks)

Answer:

A Randomized Block Design (RBD) is an experimental design where experimental units are grouped into "blocks" based on a characteristic that is expected to affect the outcome⁸². Within each block, treatments are assigned randomly⁸³.

How Blocking Works:

Blocking helps to control for variability and reduce experimental error⁸⁴. The principle is to group similar units together. For example, in an agricultural study, "soil type" or "crop type" could be a block⁸⁵. By grouping, the design ensures that variability between the blocks (e.g., difference between rice and wheat) does not hide the effect of the treatments (e.g., fertilizers). The assumption is that variability within a block is less than the variability between blocks⁸⁶. This increases the precision and statistical power of the experiment⁸⁷.

Q16. (L3 - Apply) Design or sketch a Randomized Block Design (RBD) to study the effect of three new fertilizers (F1, F2, F3) on the yield of three different crops: rice, wheat, and jowar. (6 Marks)

Answer:

In this scenario, the "crops" are the known source of variability, so they will be used as the blocks. The "fertilizers" are the treatments that will be randomly assigned within each block.

Design Sketch:

Block 1: Rice

| Plot 1: F2 | Plot 2: F3 | Plot 3: F1 |

| :--- | :--- | :--- |

(Random assignment of F1, F2, F3)

Block 2: Wheat

| Plot 4: F1 | Plot 5: F3 | Plot 6: F2 |

| :--- | :--- | :--- |

(Random assignment of F1, F2, F3)

Block 3: Jowar

| Plot 7: F3 | Plot 8: F1 | Plot 9: F2 |

| :--- | :--- | :--- |

(Random assignment of F1, F2, F3)

- **Blocks:** Rice, Wheat, Jowar
- **Treatments:** F1, F2, F3
- **Outcome (Dependent Variable):** Yield
- **Procedure:** We create three blocks, one for each crop. Within each block, we create three plots and randomly assign one fertilizer (F1, F2, or F3) to each plot. We then measure and compare the yield. This design controls for the inherent differences in yield between rice, wheat, and jowar.

Q17. What is a Latin Square Design (LSD)? Explain its structure and when it is used. (5 Marks)

Answer:

A Latin Square Design (LSD) is an experimental design used to control for two blocking factors (two sources of nuisance variability) while studying one treatment factor⁸⁸.

Structure: It is structured as an $n \times n$ grid (a square), where n is the number of treatments⁸⁹. The treatments are arranged so that each treatment appears **exactly once in each row and exactly once in each column**⁹⁰.

When it is used: It is used when the researcher needs to simultaneously control for two known sources of variability. For example, in agriculture, the "rows" might be soil type and the "columns" might be environmental conditions⁹¹.

Q18. What is a Factorial Design? What are its primary advantages and disadvantages? (6 Marks)

Answer:

A Factorial Design is a methodology used to evaluate the effects of two or more independent variables (factors) on a dependent variable simultaneously⁹².

Advantages:

1. **Studies Interactions:** It allows researchers to assess **interaction effects**, which is how the effect of one factor changes depending on the level of another factor⁹³. This is information single-factor experiments cannot provide⁹⁴.
2. **Efficiency:** It is "economic in nature" and saves time and experimental materials because it studies the combined effect of factors simultaneously, rather than in separate experiments⁹⁵.

Disadvantages:

1. **Complexity:** The execution of the experiment and the statistical analysis become more complex as more factors and combinations are involved⁹⁶.

2. **Increased Combinations:** The number of treatment combinations increases rapidly as factors are added. This can lead to large block sizes, which may increase experimental error and decrease precision⁹⁷.
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Q19. (L3 - Apply) A 3x2x2 factorial design examines the effects of three factors: (A) Type of Therapy (CBT, Psychodynamic, Humanistic), (B) Duration (short vs. long), and (C) Therapist Gender (male vs. female). List all the possible combinations. (6 Marks)

Answer:

This is a 3x2x2 design, so there will be $3 \times 2 \times 2 = 12$ total treatment combinations⁹⁸.

The 12 combinations are⁹⁹:

1. CBT, short duration, male
2. CBT, short duration, female
3. CBT, long duration, male
4. CBT, long duration, female
5. Psychodynamic, short duration, male
6. Psychodynamic, short duration, female
7. Psychodynamic, long duration, male
8. Psychodynamic, long duration, female
9. Humanistic, short duration, male
10. Humanistic, short duration, female
11. Humanistic, long duration, male
12. Humanistic, long duration, female

Q 1.b Define Independent variable, Dependent variable, Extraneous variable, Continuous variable and Discrete variables. (5 Marks)



Answer:

- **Independent Variable:** This is the factor that the researcher **manipulates or controls** to observe its effect on the dependent variable¹. It is considered the "**cause**" in a cause-and-effect relationship².
- **Dependent Variable:** This is the outcome or **effect that the researcher measures** in response to changes in the independent variable³. It is considered the "**effect**"⁴.
- **Extraneous Variable:** This is any variable **other than the independent variable** that could influence the dependent variable⁵. Researchers try to control these to prevent them from confounding the results.
- **Continuous Variable:** A variable that can take on an **infinite number of values** within a given range. It is typically *measured*.
 - *Example:* Temperature, height, yield (in kg), or time.
- **Discrete Variable:** A variable that can only take on a **finite, specific, or countable number of values**. It is typically *counted*.
 - *Example:* Number of crops, number of fertilizers (F1, F2, F3), or number of therapists.

Q 1.c Analyse and list out the key differences between engineering research and research in other fields. (4 Marks)

Answer:

While all research aims to generate new knowledge, engineering research has distinct differences from research in fields like pure science or humanities.

Key Difference	 Engineering Research	 Research in Other Fields (e.g., Pure Science)
Primary Goal	Synthesis & Design. To <i>create</i> a new, useful, and economical solution, product, process, or system.	Analysis & Discovery. To <i>understand</i> a natural phenomenon and generate new knowledge or theories.

Main Question	"How can we <i>make</i> this work?" or "How can we <i>improve</i> this?"	"Why does this happen?" or "What <i>is</i> this?"
Outcome	A functional prototype, a new algorithm, a new material, a design methodology, or a patent.	A new theory, a published paper explaining a phenomenon, or new fundamental knowledge.
Methodology	Often involves simulation, prototyping, testing against performance metrics, and iteration (design-build-test cycle).	Often involves the classical scientific method: forming a hypothesis, conducting controlled experiments, and observation.

Q 2.c Assume you and your team members are working on a research domain and you are supposed to come up with a suitable title for the project. List out the things you need to consider for framing title for your project. (3 Marks)

Answer:

When framing a title for a research project, you should consider the following:

- **Be Informative and Representative:** The title should effectively summarize the main topic and content of the paper for the reader⁶.
- **Be Discoverable (Traceable):** It should include the most important **keywords** relevant to the research area⁷. This is crucial for search engines, indexing services, and helping the right audience find your work⁸⁸⁸⁸.
- **Be Attention-Grabbing:** A good title gains the attention of the intended audience⁹.
- **Consider the Length:** The title should be concise and clear. The length of the title is a factor that can impact its effectiveness and, ultimately, its citation count¹⁰¹⁰¹⁰¹⁰.

Q1 (a). Explain the main objectives of research and state the need for a research design. (6 Marks)

Answer:

The main objectives of research are:

- To gain familiarity with a phenomenon or to achieve new insights into it.
- To accurately portray the characteristics of a particular individual, situation, or group.
- To determine the frequency with which something occurs or is associated with something else.
- To test a hypothesis about a causal relationship between variables.

A research design is needed for:

- Ensuring the smooth sailing of research operations.
- Providing a plan for the methods to be used in advance.
- Giving direction to the study.
- Preventing blind searching.
- Helping researchers anticipate potential problems, such as in data collection.
- Minimizing bias and maximizing the reliability of the data.

Q1 (b). Differentiate between a Null Hypothesis (H0) and an Alternative Hypothesis (H1). Also, explain the difference between a Directional and a Non-Directional Hypothesis. (5 Marks)

Answer:

- **Null Hypothesis (H0):** This is a statement asserting that there is **no effect, no difference, or no relationship** between variables. It's the default position researchers test against. For example, $H_0: \mu_1 = \mu_2$ states the mean of group 1 is equal to the mean of group 2.
 - **Alternative Hypothesis (H1 or Ha):** This statement **contradicts the null hypothesis**, suggesting that an effect, difference, or relationship *does* exist. It's what the researcher aims to support. For example, $H_1: \mu_1 \neq \mu_2$ states the means are different.
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- **Directional Hypothesis:** This type of hypothesis **specifies the expected direction** of the effect or relationship. It indicates if one variable is expected to be greater or less than another.
 - *Example:* $H_1: \mu_1 < \mu_2$ (predicts mean 1 is *less than* mean 2).
 - **Non-Directional Hypothesis:** This type **does not specify a direction**. It simply states that a difference or effect exists.
 - *Example:* $H_1: \mu_1 \neq \mu_2$ (predicts the means are *not equal*, but doesn't say which is larger).

Q1 (c). Define and differentiate between Fabrication, Falsification, and Plagiarism as forms of research misconduct. (4 Marks)

Answer:

These are three main types of research misconduct:

1. **Fabrication:** This is the act of **making up data or results** and then recording or reporting them as if they were real.
2. **Falsification:** This involves **manipulating research materials or changing/omitting data** or results in a way that the research is not accurately represented in the record.
3. **Plagiarism:** This is the **appropriation of another person's ideas, processes, results, or words** without giving them appropriate credit.

The key difference is that **Fabrication** *creates* false data, **Falsification** *alters* existing data, and **Plagiarism** *steals* another's words or ideas.

Question 2

Q2 (a). Explain a Completely Randomised Design (CRD). How does a Latin Square Design (LSD) control for variability? (6 Marks)

Answer:

Completely Randomised Design (CRD): A CRD is a basic experimental design where treatments are assigned to experimental units **completely at random**. This ensures every unit has an equal chance of receiving any treatment. It is most effective when the experimental units are **homogeneous** (very similar to each other). Its main limitation is that it's less effective if the units are *not* homogeneous, as this can increase variability and reduce precision.

Latin Square Design (LSD): An LSD is a more complex design used to control for **two blocking factors** (two sources of nuisance variability) simultaneously. It is structured as an $n \times n$ grid (where n is the number of treatments). The treatments are arranged so that each treatment appears **exactly once in each row and once in each column**. This structure effectively controls for the variability coming from the two blocking factors (represented by the rows and columns).

Q2 (b). Explain the purpose of an Experimental Group and a Control Group in a research study. Why is this comparison essential? (6 Marks)

Answer:

- **Experimental Group:** This is the group of subjects that **receives the treatment** or intervention being tested. Researchers observe this group to see the effects of manipulating the independent variable.
- **Control Group:** This is a separate group that **does not receive the treatment**. It serves as a **baseline** for comparison. Members of the control group might receive a placebo or a standard, existing treatment.

Importance of Comparison: This comparison is essential for **establishing causality**. By comparing the outcomes of the experimental group to the control group, researchers can determine if the changes in the dependent variable are actually *due to* the treatment (the independent variable) and not due to chance or other factors. The control group helps to **reduce bias and mitigate confounding variables**, thereby enhancing the validity of the findings.

Q2 (c). Distinguish between an Extraneous Variable and a Confounded Variable. (3 Marks)

Answer:

- **Extraneous Variable:** This is **any variable *other than* the independent variable** that *could* influence the dependent variable. If not controlled, it can introduce "noise" into the experiment.
 - *Example:* Participant's mood or time of day.
- **Confounded Variable:** This is a specific situation that occurs when an **extraneous variable is intertwined with the independent variable** in such a way that their individual effects on the dependent variable **cannot be separated**. This happens when the extraneous variable correlates with *both* the independent and dependent variables, leading to misleading conclusions.

In short, an extraneous variable is a *potential* problem, while a confounded variable is an extraneous variable that *has* compromised the experiment.

Question 3

Q3 (a). Explain how keywords impact the citation count of a research paper. Also, what is the purpose of an Acknowledgment section? (6 Marks)

Answer:

Impact of Keywords: Keywords represent the essential information and main content of an article. Search engines, digital libraries, and indexing services use keywords to **categorize the research topic** and **direct the work to the relevant audience**. Good keywords are important

to ensure that readers (and other researchers) can easily find the article , which in turn can increase its visibility and potential for being cited.

Purpose of an Acknowledgment Section: The acknowledgment section is used to provide a brief **appreciation for the contribution of a person or organization** to the research work. It is a common practice to recognize persons or agencies responsible for the completion of the research, such as for:

- Receiving funding from an organization.
- Helpful oral discussions, or technical support (like laboratory or computer work).

Q3 (b). What is a factorial design? Explain its primary advantages and disadvantages. (6 Marks)

Answer:

A **factorial design** is an experimental methodology used to evaluate the effects of **two or more independent variables (factors)** on a dependent variable simultaneously. For example, a 2x2 design studies two factors, each at two levels.

Advantages:

1. **Efficiency:** It is "economic in nature" because it allows researchers to study the combined effect of multiple factors in one experiment rather than running separate experiments. This saves time and materials.
2. **Measures Interactions:** Its biggest advantage is that it permits the evaluation of **interaction effects**. This is when the effect of one factor changes depending on the level of another factor, something single-factor experiments cannot detect.
3. **Comprehensive:** Information obtained is more complete than from single-factor experiments.

Disadvantages:

1. **Complexity:** The execution and statistical analysis become more complex as more factors or treatment combinations are involved.
2. **Wastage:** Researchers may be forced to include certain treatment combinations that are not of interest, which can waste time and materials.
3. **Large Size:** As factors increase, the number of treatment combinations increases. This can lead to large "block sizes," which may increase experimental error and decrease precision if not managed properly.

Q3 (c). Briefly describe the purpose of conducting a literature review. (3 Marks)

Answer:

The purpose of a literature review is to summarize what is **already known** from the existing state-of-the-art research. It helps the researcher to:

- Detail the key concepts and main factors in the field.
- Describe existing approaches.
- Enumerate inconsistencies or shortcomings in the published work.
- Identify reported results that are inconclusive or contradictory.
- Provide a compelling reason to do further work by identifying what is missing.