RESEARCH METHODOLOGY

Research Design

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RESEARCH METHODOLOGY

Ch. 3: Research Design

Department of Computer Science and Engineering

Contents – Chapter 3

MEANING OF RESEARCH DESIGN

Research Design is the preparation of the design of the research project. It constitutes the blueprint for the collection, measurement and analysis of data.

Design decisions revolve around the following questions:

1. What is the study about?
2. Why is the study being made?
3. Where will the study be carried out?
4. What type of data is required?
5. Where can the required data be found?
6. What periods of time will the study include?
7. What will be the sample design?
8. What techniques of data collection will be used?
9. How will the data be analyzed?
10. In what style will the report be prepared?

NEED FOR RESEARCH DESIGN

1. It facilitates the smooth sailing of the various research operations.

2. Making research as efficient as possible yielding maximal information with minimal expenditure of effort, time and money.

3. We need a research design or a plan in advance of data collection and analysis for our research project.

4. 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.

RESEARCH DESIGN-BREAK DOWN

1. The sampling design
   - Deals with the method of selecting items to be observed for the given study.
2. The observational design
   - Relates to the conditions under which the observations are to be made.
3. The statistical design
   - Concerns with the question of how many items are to be observed and how the information and data gathered are to be analyzed.
4. The operational design
   - Deals with the techniques by which the procedures specified in the sampling, statistical and observational designs can be carried out.

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)

IMPORTANT CONCEPTS RELATING TO RESEARCH DESIGN

Dependent and Independent Variable

Variable: A concept which can take on different quantitative values.

For example, concepts like weight, height, income, etc.

Continuous variables – phenomena which can take on quantitatively different values even in decimal points.

For example, age.

Discontinuous or Discrete variables – If some variables can only be expressed in integer values.

For example, no. of children.

If one variable depends upon or is a consequence of the other variable, it is termed as dependent variable, and
the variable that is *antecedent* to the dependent variable is termed as independent variable.

IMPORTANT CONCEPTS RELATING TO RESEARCH DESIGN

Dependent and Independent Variable

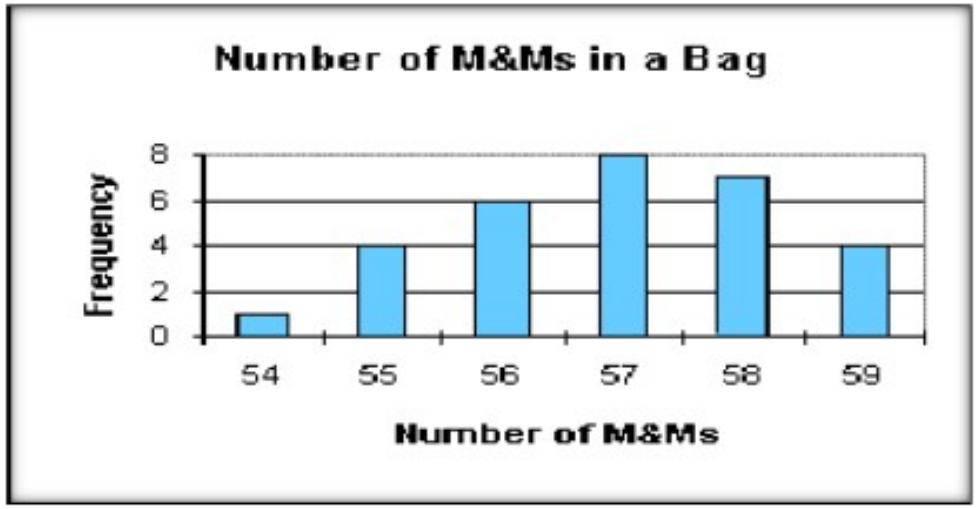
CONTINUOUS VARIABLE

Phenomena which can take on quantitatively different values even in decimal points .

AGE IS AN EXAMPLE

IMPORTANT CONCEPTS RELATING TO RESEARCH DESIGN

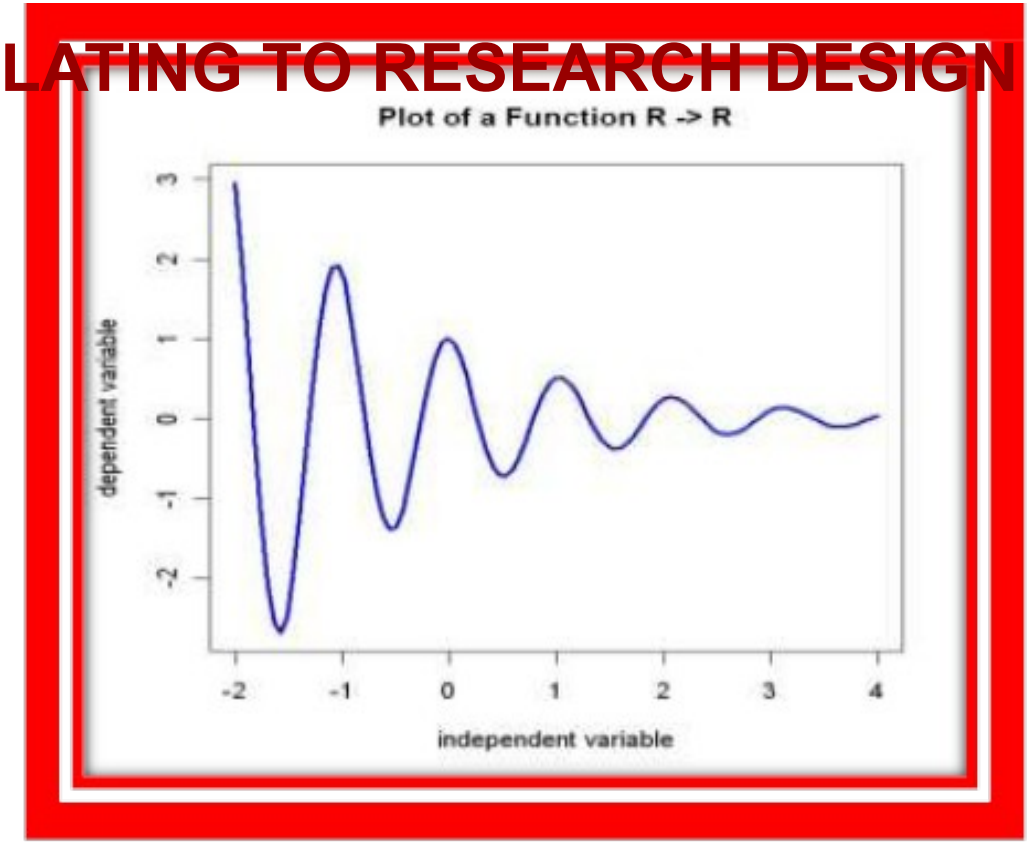
DISCRETE VARIABLE



All variables are not continuous.
Only if they are expressed in integer values they are non continuous variables.

IMPORTANT CONCEPTS RELATING TO RESEARCH DESIGN

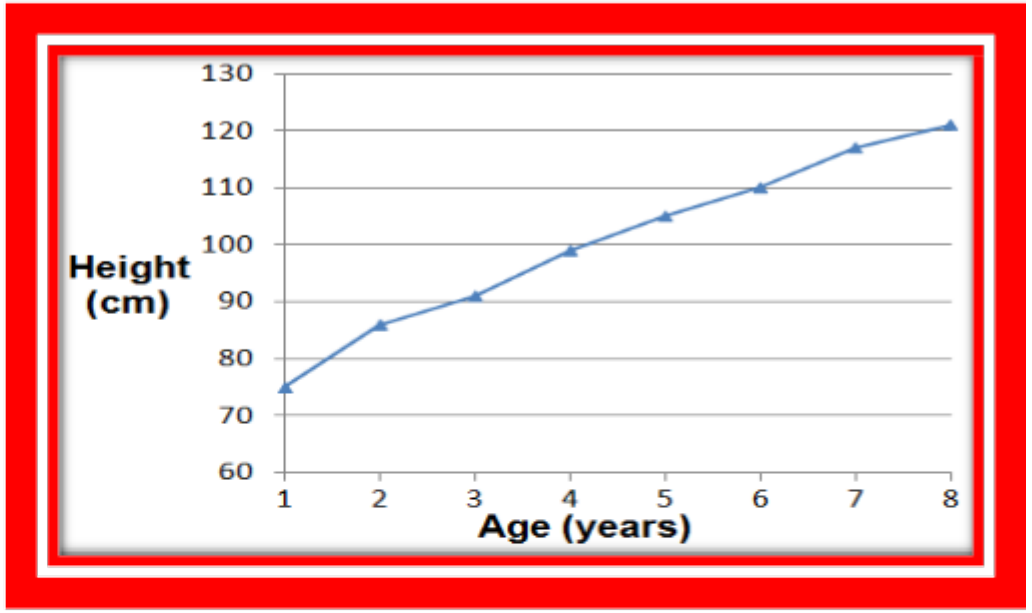
INDEPENDENT VARIABLE



If one variable depends upon or is a consequence of the other variable, it is termed as a dependent variable, and the variable that is antecedent to the dependent variable

IMPORTANT CONCEPTS RELATING TO RESEARCH DESIGN

EXAMPLE



For instance, if we say that height depends upon age, then height is a dependent variable and age is an independent variable.

IMPORTANT CONCEPTS RELATING TO RESEARCH DESIGN

Example for Independent and Dependent Variable:

Age → Height,
Smoking → Cancer
(Height and Cancer are dependent variables whereas Age and Smoking are independent variables).

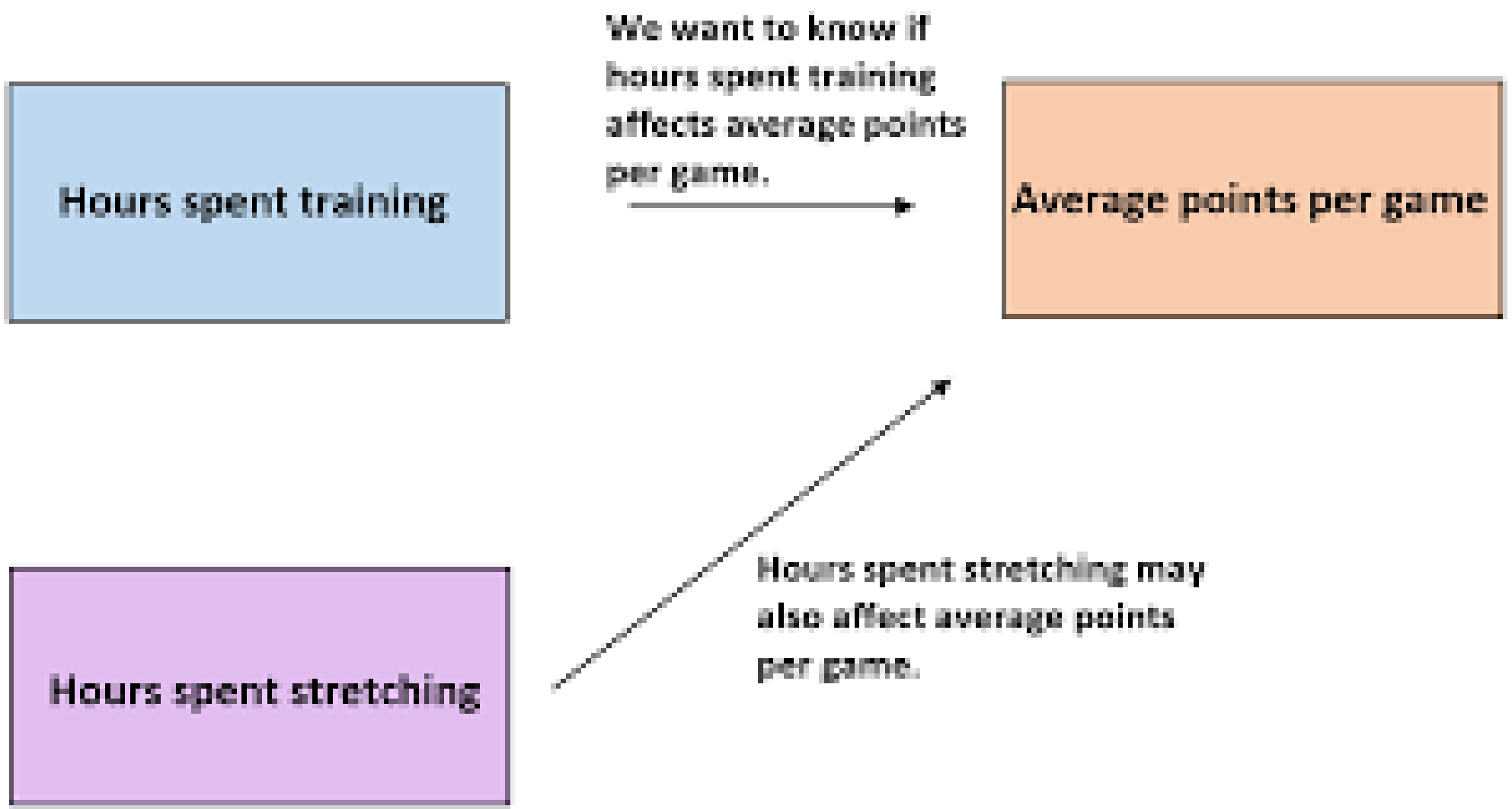
IMPORTANT CONCEPTS RELATING TO RESEARCH DESIGN

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.**

Whatever effect is noticed on dependent variable as a result of extraneous variable(s) is technically described as '***experimental error***'.

IMPORTANT CONCEPTS RELATING TO RESEARCH DESIGN



IMPORTANT CONCEPTS RELATING TO RESEARCH DESIGN

Suppose the researcher wants to test the hypothesis that there is a relationship between student working hours and exam performances. In this case student working hours is an independent variable and exam performances is a dependent variable.

Intelligence may as well affect the exam performances, but since it is not related to the purpose of the study undertaken by the researcher, it will be termed as an extraneous variable.

IMPORTANT CONCEPTS RELATING TO RESEARCH DESIGN

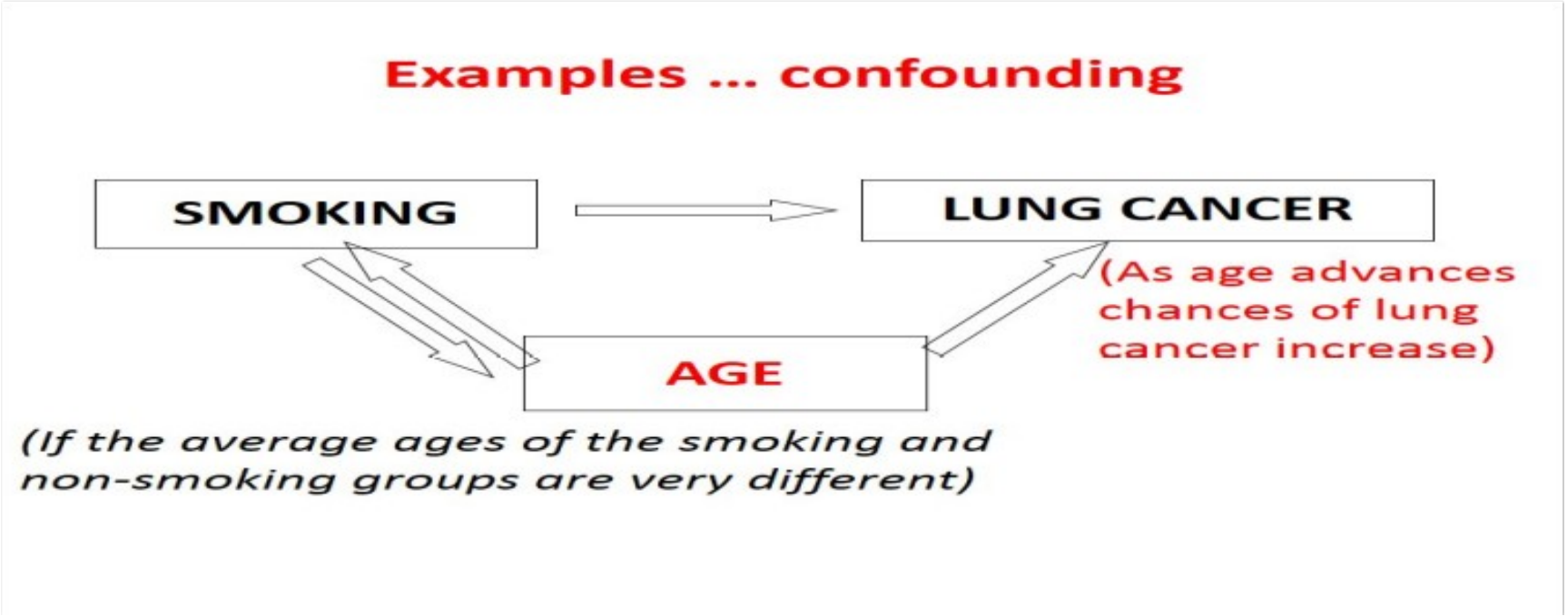
CONTROL :

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.

IMPORTANT CONCEPTS RELATING TO RESEARCH DESIGN

ConfoundedRelationship

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).



IMPORTANT CONCEPTS RELATING TO RESEARCH DESIGN

Research Hypothesis

- When a prediction or a hypothesis relationship is to be tested by scientific methods, it is termed as ‘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.
- For example, “e-Learning enhances teaching learning experience”. Here, the dependent variable is “teaching learning experience”, whereas “e-Learning” is the independent variable.
- *Listening to music lowers blood pressure level.*

IMPORTANT CONCEPTS RELATING TO RESEARCH DESIGN

1. Dependent and Independent Variables
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6. Experimental and Non-experimental Hypothesis-Testing Research
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IMPORTANT CONCEPTS RELATING TO RESEARCH DESIGN

Experimental and Non-experimental Hypothesis-Testing Research

- Purpose = Test Research Hypothesis:

1) Experimental Hypothesis-testing Research – independent variable is manipulated
2) Non-experimental Hypothesis-testing Research – independent variable NOT manipulated

Example:
Effectiveness of a training programme on the student's performance-level:

- Researcher randomly selects 50 students from a group of students who are to take a course in statistics and then divides them into two groups by randomly assigning 25 to Group A, the usual studies programme, and 25 to Group B, the special studies programme.
- At the end of the course, he administers a test to each group in order to judge the effectiveness of the training programme on the student's performance-level.
- (Exp Hypothesis testing) Why? The type of training programme is manipulated.

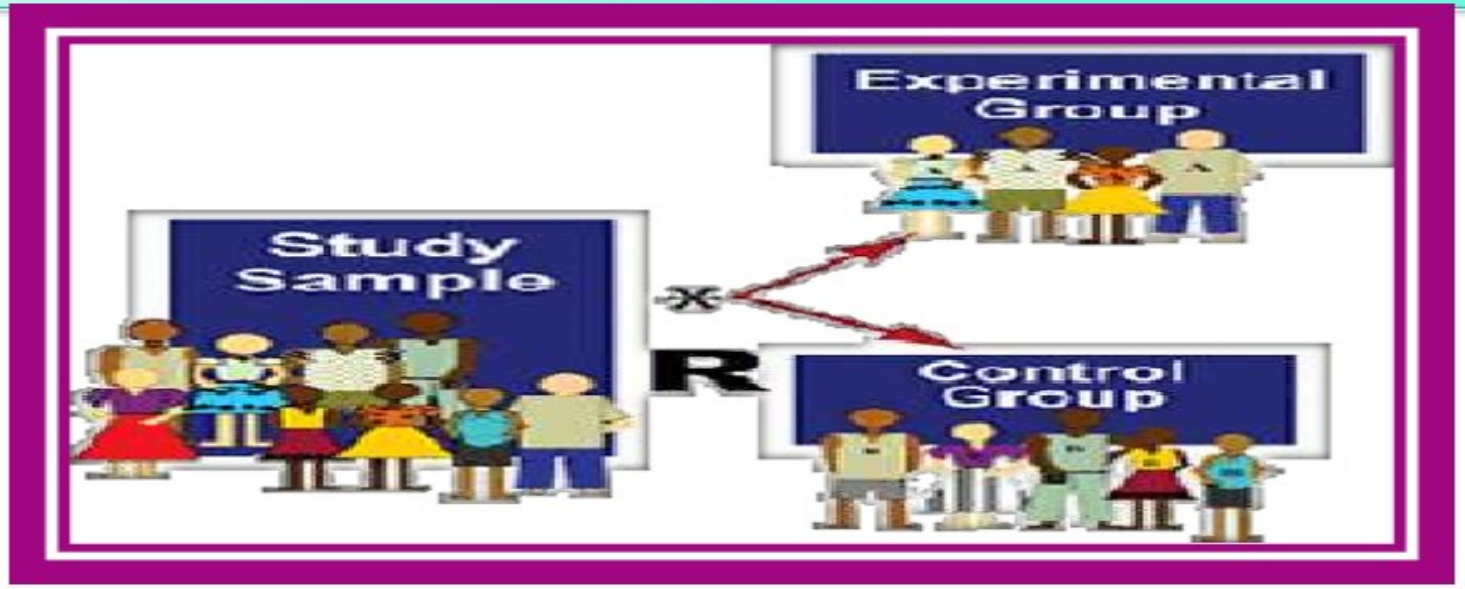
IMPORTANT CONCEPTS RELATING TO RESEARCH DESIGN

- Experimental and control groups
  - In an experimental hypothesis-testing research when a group is exposed to usual conditions, it is termed as 'control group', but when a group is exposed to some novel or special condition, it is termed as 'experimental group'.

Example:
A student is testing to see if plants will grow without sunlight.
Which would be the experimental group and which would be the control group?

IMPORTANT CONCEPTS RELATING TO RESEARCH DESIGN

In the above illustration, the Group A can be called a control group and the Group B an experimental group. If both groups A and B are exposed to special studies programmes, then both groups would be termed 'experimental groups.' It is possible to design studies which include only experimental groups or studies which include both experimental and control groups.



IMPORTANT CONCEPTS RELATING TO RESEARCH DESIGN

Treatment

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

In the illustration taken above, the two treatments are the usual studies programme and the special studies programme. Similarly, if we want to determine through an experiment the comparative impact of three varieties of fertilizers on the yield of wheat, in that case the three varieties of fertilizers will be treated as three treatments.

IMPORTANT CONCEPTS RELATING TO RESEARCH DESIGN

IMPORTANT CONCEPTS RELATING TO RESEARCH DESIGN

- Experiment

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

- For example, we can conduct an experiment to examine the usefulness of a newly developed fertilizer. Experiments can be of two types viz., absolute experiment and comparative experiment.
- Absolute experiment – Determining the impact of a fertilizer on the yield of a crop.
- Comparative experiment – Determining the impact of one fertilizer as compared to the impact of some other fertilizer.

IMPORTANT CONCEPTS RELATING TO RESEARCH DESIGN

IMPORTANT CONCEPTS RELATING TO RESEARCH DESIGN

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

Basic Principles of Experimental Design

Professor Fisher has enumerated three principles of experimental designs:

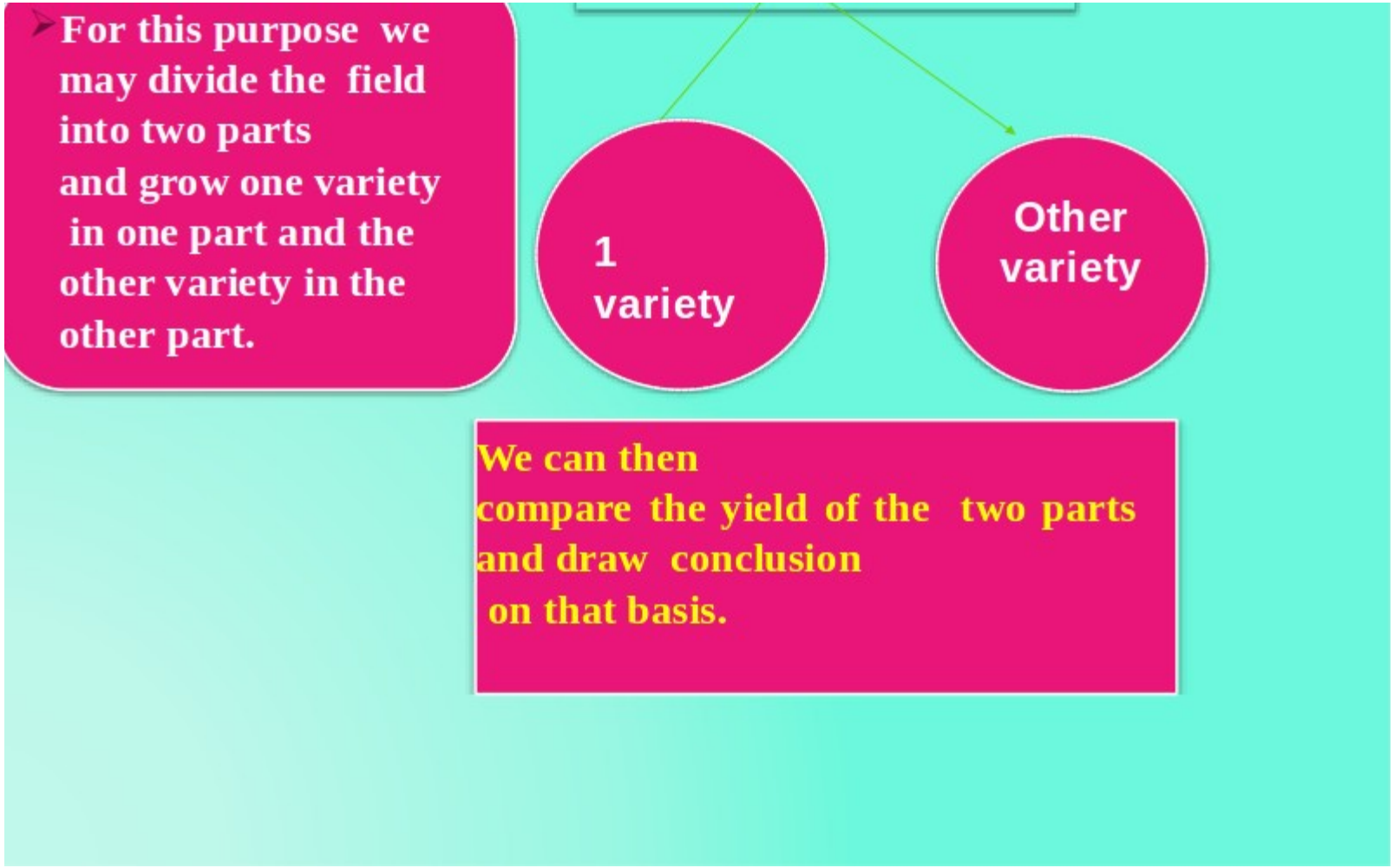
1. Principle of Replication
2. Principle of Randomization
3. Principle of Local Control

Basic Principles of Experimental Design

[1] PRINCIPLE OF REPLICATION

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

Basic Principles of Experimental Design



Basic Principles of Experimental Design

PRINCIPLE OF RANDOMIZATION

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."

Basic Principles of Experimental Design

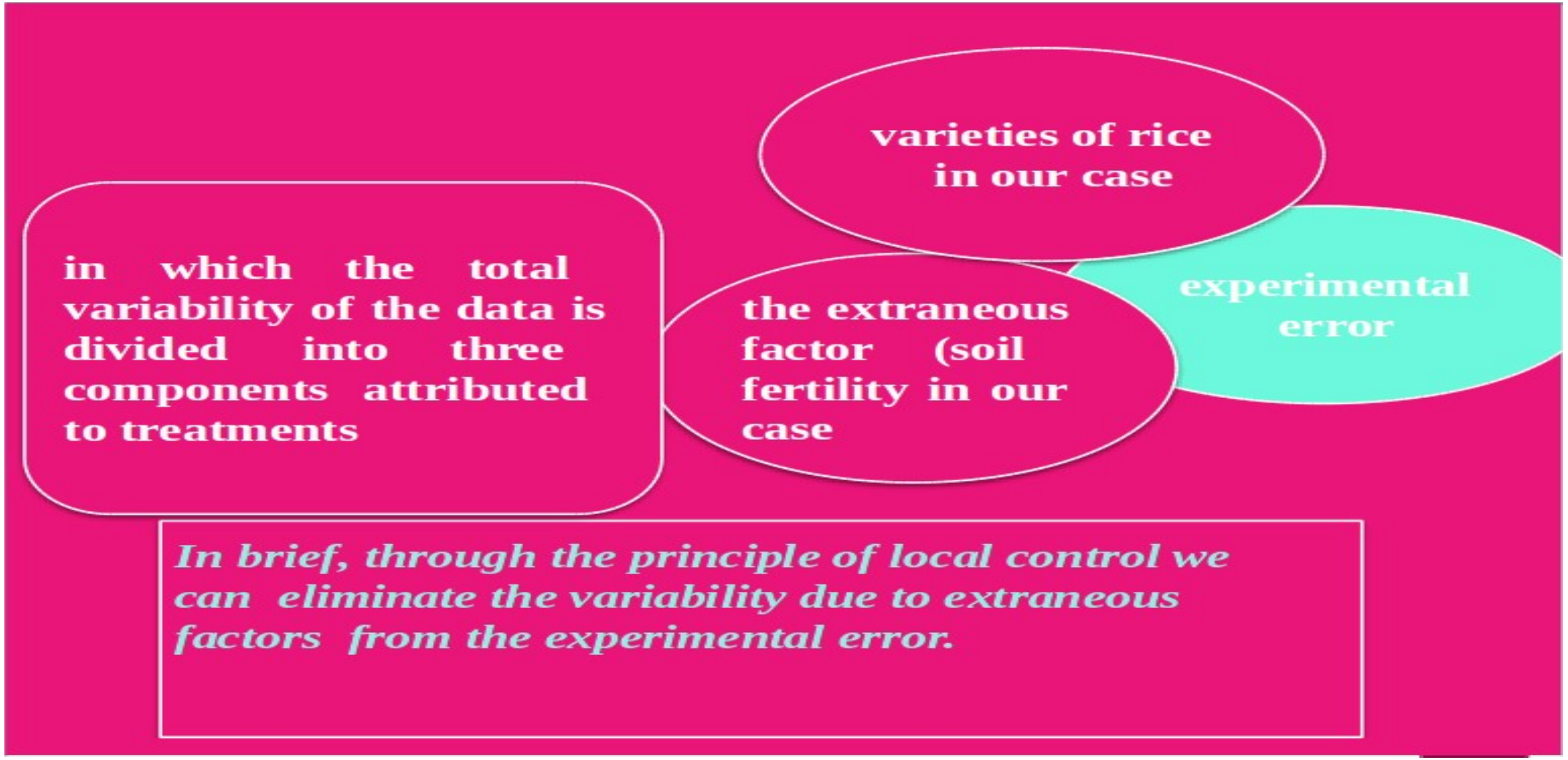
Basic Principles of Experimental Design

[2] PRINCIPLE OF LOCAL CONTROL

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

Basic Principles of Experimental Design

- Suppose , if we perform a two-way analysis of variance,



Basic Principles of Experimental Design

- Principle of Local Control
  - two-way analysis of variance
    - Treatments [variety of rice]
    - Extraneous factor [soil fertility]
    - Experimental error
  - Divide the field into homogeneous parts = Blocking
  - #Parts = no. of treatments planned
  - Homogeneous parts
  - Block = keep extraneous factor fixed
  - Measure its value to check its contribution to total variability by way of two-way analysis of variance
  - Eliminate the variability due to extraneous factor/s from Experimental Error [EE]

Important Experimental Design

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 :-
Informal Experimental Designs:

1. Before-and-after without control design.
2. After-only with control design.
3. Before-and-after with control design

Formal Experimental Designs:

4. Completely Randomized Design (C. R. Design)
5. Randomized Block Design (R. B. Design)
6. Latin Square Design (L. S. Design)
7. Factorial Designs

Important Experimental Designs

- **The treatment is then introduced and then the dependent variable is measured again .**
  - The effect of the treatment
    - **the level of the phenomenon after the treatment - the level of the phenomenon before the treatment .**
      - The design can be represented thus:

Test area:	Level of phenomenon before treatment (X)	Treatment introduced →	Level of phenomenon after treatment (Y)
	Treatment Effect = (Y) – (X)		

Important Experimental Design

2. After-only with control design

- **Two groups or areas (test area and control area) ar**
  and the treatment is introduced into the test area

Test area:	Treatment introduced	Level of phenomen treatment (Y)
Control area:	⟶	Level of phenomen treatment (Z)
	Treatment Effect = (Y) – (Z)	

Important Experimental Design

3.Before and after with Control design

In this design two areas are selected and the dependent variable is measured in both the areas for an identical time-period before the treatment. The treatment is then introduced into the test area only, and the dependent variable is measured in both for an identical time-period after the introduction of the treatment

The design can be represented thus:

	Time Period I		Time Period II
Test area:	Level of phenomenon before treatment (X)	Treatment introduced →	Level of phenomenon after treatment (Y)
Control area:	Level of phenomenon without treatment (A)		Level of phenomenon without treatment (Z)

Treatment Effect = (Y – X) – (Z – A)

Important Experimental Design

FORMAL EXPERIMENTAL DESIGNS

[A]Completely randomized design (C.R. design)

Involves only two principles i.e the principle of replication and the principle of randomization of experimental designs.

Important Experimental Design

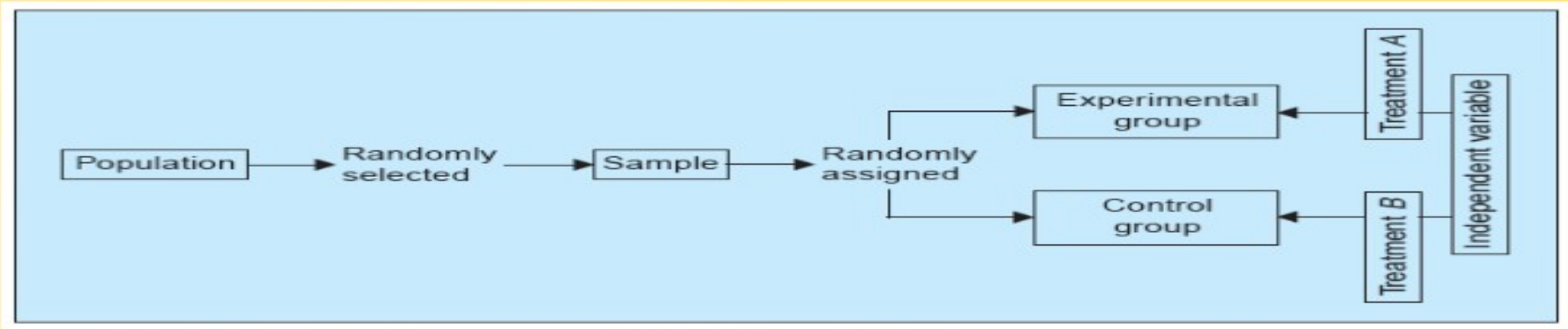
[A] Completely Randomized Design

(1) Two Group Simple Randomized Design

We can present a brief description of the two forms of such a design as :-

[1] Two-group simple randomized design

first of all the population is defined and then from the population a sample is selected randomly . After being selected randomly from the population, be randomly assigned to the experimental and control groups (Such random assignment of items to two groups is technically described as principle of randomization)



Important Experimental Design
[A] Completely Randomized Design

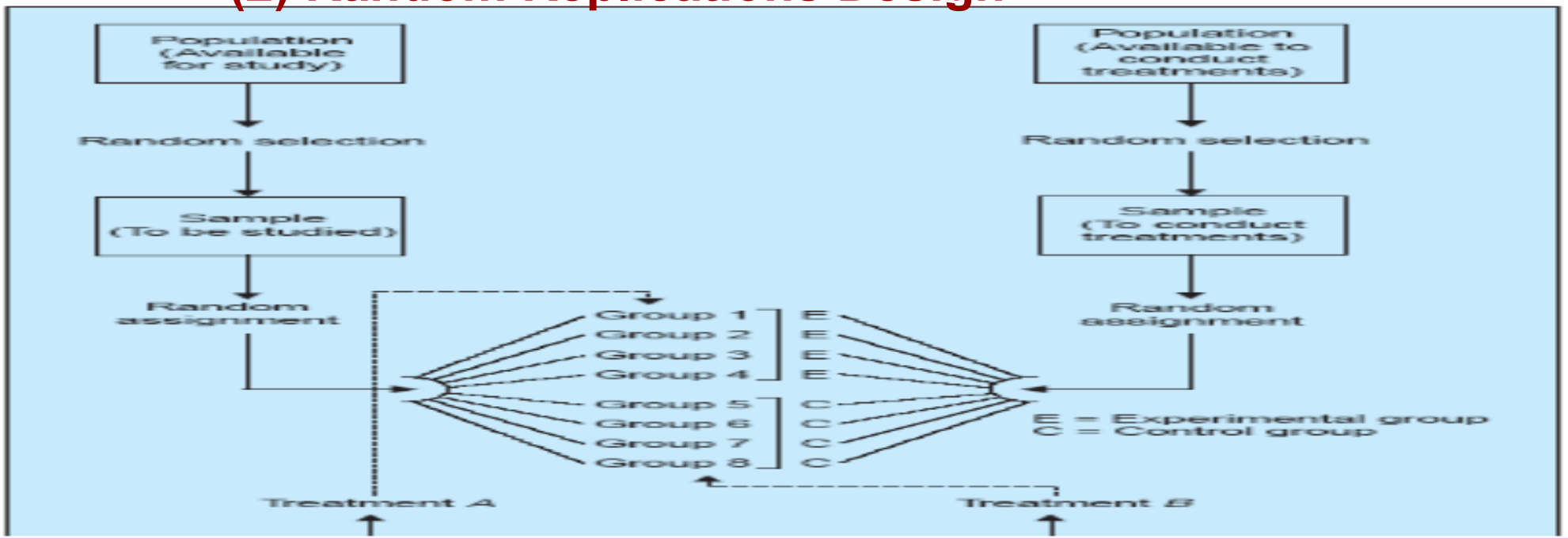
(2) Random replications design

- The limitation of the two-group randomized design is usually eliminated within the random replications design. In the illustration just cited above, the *teacher differences* on the dependent variable were ignored, i.e., the extraneous variable was not controlled. But in a random replications design, the effect of such differences are minimised (or reduced) by providing a number of repetitions for each treatment. Each repetition Is technically called a 'replication'.

Important Experimental Design

[A] Completely Randomized Design

(2) Random Replications Design



there are two populations in the replication design .sample is taken randomly from the population available to conduct experiments . and the eight individuals so selected should be randomly assigned to the eight groups. Similarly ,the sample is taken randomly from the population available for study and is randomly assigned to, say, four experimental and four control groups.

Important Experimental Design
[B] Randomized Block Design

[B] Randomized block design (R.B. design)

- In the R.B. design the principle of *local control* can be applied along with the other two principles of experimental designs.
- In the R.B. design, subjects are first divided into groups, known as blocks. In general, blocks are the levels at which we hold the extraneous factor fixed, so that its contribution to the total variability of data can be measured. The main feature of the R.B. design is that in this each treatment appears the same number of times in each block. The R.B. design is analysed by the two-way analysis of variance (two-way ANOVA)* technique.

Important Experimental Design
[B] Randomized Block Design

Suppose four different forms of a standardised test in statistics were given to each of five students (selected one from each of the five I.Q. blocks) and following are the scores which they obtained.

	Very low I.Q.	Low I.Q.	Average I.Q.	High I.Q.	Very high I.Q.
	Student A	Student B	Student C	Student D	Student E
Form 1	82	67	57	71	73
Form 2	90	68	54	70	81
Form 3	86	73	51	69	84
Form 4	93	77	60	65	71

If each student separately randomized the order in which he or she took the four tests (by using random numbers or some similar device), we refer to the design of this experiment as a R.B. design. The purpose of this randomization is to take care of such possible extraneous factors (say as fatigue) or perhaps the experience gained from repeatedly taking the test.

Important Experimental Design
[C] Latin Square Design

[C] Latin square design (L.S. design)

- **It is an experimental design very frequently used in agricultural research.**

Seeds differences	FERTILITY LEVEL I	II	III	IV	V
X_1	A	B	C	D	E
X_2	B	C	D	E	A
X_3	C	D	E	A	B
X_4	D	E	A	B	C
X_5	E	A	B	C	D

Important Experimental Design
[D] Factorial Designs

[D] FACTORIAL DESIGNS

- Factorial designs are used in experiments where the effects of varying more than one factor are to be determined. They are specially important in several economic and social phenomena where usually a large number of factors affect a particular problem.
- Factorial designs can be of two types:
  i) simple factorial designs
  ii) complex factorial designs

Important Experimental Design
[D] Factorial Designs

Simple Factorial Design

- In case of simple factorial designs, we consider the effects of varying two factors on the dependent variable, but when an experiment is done with more than two factors, we use complex factorial designs.
- Simple factorial design is also termed as a 'two-factor-factorial design', whereas complex factorial design is known as 'multifactor-factorial design.'

Important Experimental Design

[D] Factorial Designs

Complex Factorial Design

- Experiments with more than two factors at a time involve the use of complex factorial designs. A design which considers three or more independent variables simultaneously is called a *complex factorial design.*
- In case of three factors with one experimental variable having two treatments and two control variables, each one of which having two levels, the design used will be termed 2 × 2 × 2 complex factorial design which will contain a total of eight cells.

FEATURES OF A GOOD RESEARCH DESIGN

A research design appropriate for a particular research problem, usually involves the consideration of the following factors:

- The means of obtaining information
- The availability and skills of the researcher and his staff, if any;
- The objective of the problem to be studied;
- The nature of the problem; and
- The availability of time and money for the research work.
- It should be flexible enough to consider different aspects of the study in case of exploratory.
- The design should be accurate with minimum bias in case of accurate description

THANK YOU

RESEARCH METHODOLOGY

Research Design

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