Research Design
Lecture 3

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Research Design
Chapter 3

* **overall research design into the following parts:**

(a) **the sampling design .**

(b) the observational design .

(c) the statistical design .

(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.

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.**

FEATURES OF A GOOD DESIGN

* **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.

(v) the *availability of time and money* for the research work.

IMPORTANT CONCEPTS RELATING TO RESEARCH DESIGN

1. *Dependent and independent variables:*

A concept which can take on different *Quantitative* values is called a *variable*. As such the concepts like weight, height, income are all examples of variables. *Qualitative* phenomena (or the attributes) are also quantified on the basis of the presence or absence of the concerning attribute(s).

- **‘continuous variables’. Age ***
- **‘discrete variables’. sex****
- **For instance, if we say that height depends upon age, then height is a dependent variable and age is an independent variable.**

2. *Extraneous variable*: Independent variables

3. *Control*: One important characteristic of a good research design is to minimize the influence or effect of extraneous variable(s).

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*: When a prediction or a hypothesized 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.

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.

It can be of the *experimental* design or of the *non-experimental* design.

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*'.

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

Different research designs can be conveniently described if we categorize them as:

(1) Exploratory research studies; Exploratory research studies are also termed as formulative research studies.

(2) Descriptive And Diagnostic research studies, (((*survey design* ; Several methods (viz., observation, questionnaires, interviewing, examination of records, Cohort {incidence},cross sectional {prevalence}, and case-control studies etc.),

- **Descriptive research studies are those studies which are concerned with describing the characteristics of a particular individual, or of a group,**
- **whereas diagnostic research studies determine the frequency with which something occurs or its association with something else.**

(3) 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 ; agricultural research (such as treatment, yield, plot, block etc.)

The difference between research designs in respect of the above two types of research studies can be conveniently summarised in tabular form as under:

Table 3.1

	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)
(i) Sampling design	Non-probability sampling design (purposive or judgement sampling)	Probability sampling design (random sampling)
(ii) Statistical design	No pre-planned design for analysis	Pre-planned design for analysis
(iii) Observational design	Unstructured instruments for collection of data	Structured or well thought out instruments for collection of data
(iv) Operational design	No fixed decisions about the operational procedures	Advanced decisions about operational procedures.

* **BASIC PRINCIPLES OF EXPERIMENTAL DESIGNS :**
* **Professor Fisher has enumerated three principles of experimental designs:**

(1) the Principle of Replication;

(2) the Principle of Randomization;

(3) Principle of Local Control.

Important Experimental Designs

- ***(a) Informal experimental designs:***

(i) **Before-and-after without control design. single test group or area**

(ii) After-only with control design. two groups or areas (test area and control area)

(iii) Before-and-after with control design. two areas are selected and the dependent

variable is measured in both the areas for an identical time-period before the treatment.

1. Before-and-after without control design: In such a design a single test group or area selected and the dependent variable is measured before the introduction of the treatment. The treatme is then introduced and the dependent variable is measured again after the treatment has bee introduced. The effect of the treatment would be equal to the level of the phenomenon after t treatment minus the level of the phenomenon before the treatment. The design can be represented thu

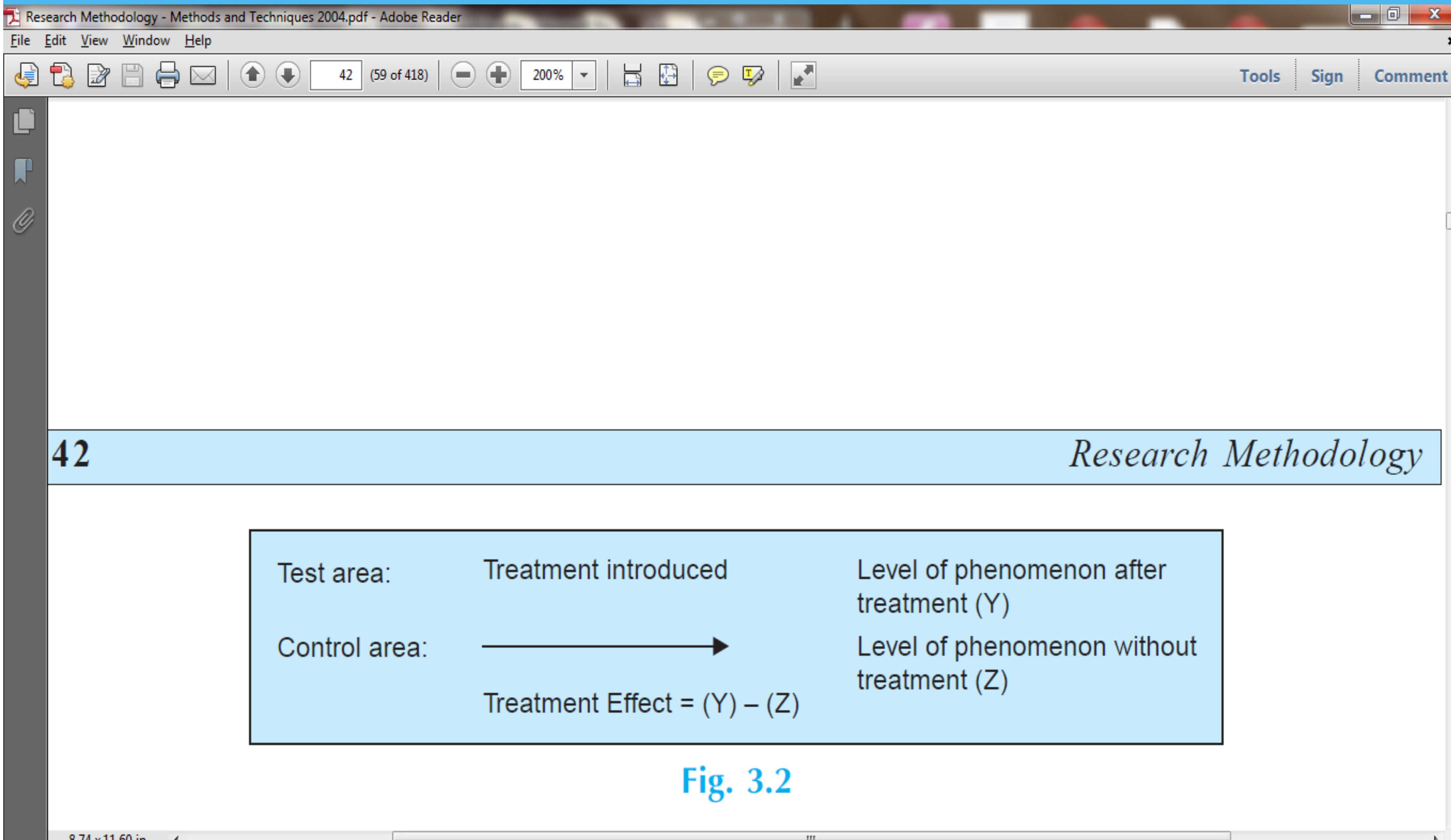
Test area:	Level of phenomenon before treatment (X)	Treatment introduced →	Level of phenomenon after treatment (Y)

Treatment Effect = (Y) – (X)

Fig. 3.1

The main difficulty of such a design is that with the passage of time considerable extraneo variations may be there in its treatment effect.

(ii) After-only with control design.



3. Before-and-after with control design: In this design two areas are selected and the depend variable is measured in both the areas for an identical time-period before the treatment. The treatm is then introduced into the test area only, and the dependent variable is measured in both for identical time-period after the introduction of the treatment. The treatment effect is determined subtracting the change in the dependent variable in the control area from the change in the depend variable in test area. This design can be shown in this way:

	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)

Fig. 3.3

(i) **Two-group simple randomized design:** In a two-group simple randomized design, first of all the population is defined and then from the population a sample is selected randomly. Further, requirement of this design is that items, 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). Thus, this design yields two groups as representatives of the population. In a diagram form this design can be shown in this way:

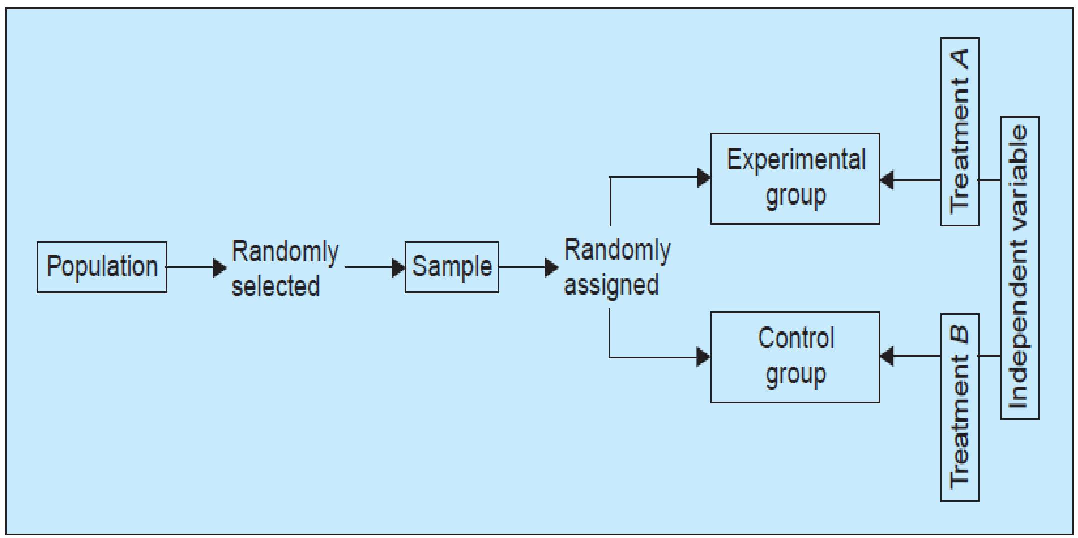


Fig. 3.4: Two-group simple randomized experimental design (in diagram form)

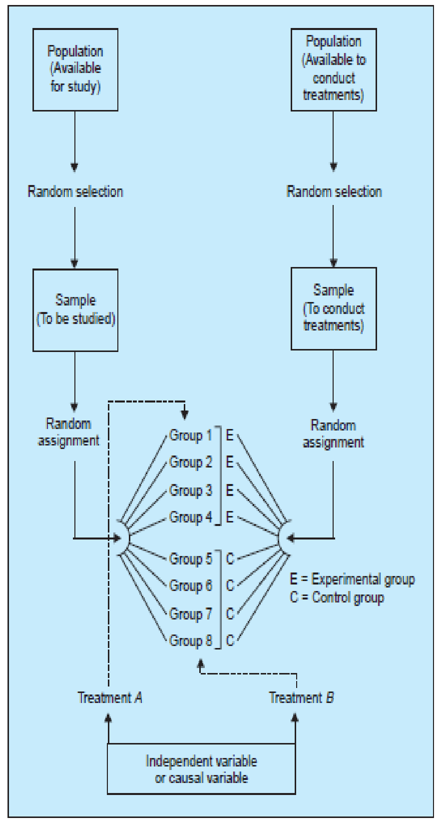


Fig. 3.5: Random replication design (in diagram form)

❖(*b*) ***Formal experimental designs:***

(i) **Completely randomized design (C.R. Design).Simple design. ; Involves only two principles viz., the principle of replication and the principle of randomization of experimental designs. (one-way ANOVA)***

(1) **Two-group simple randomized design:**

Population Randomly selected, Sample Randomly assigned Experimental group Treatment A & Control group reatment B (both are Independent variable)

(2) **Random replications design: The limitation of the two-group randomized design is usually eliminated within the random replications design.**

* **(ii) *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, such that within each group the subjects are relatively homogeneous in respect to some selected variable. (two-way ANOVA)*

Let us illustrate the R.B. design with the help of an example. Suppose four different forms of a andardised test in statistics were given to each of five students (selected one from each of the five 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

Fig. 3.6

(iii) Latin square design (L.S. Design). is an experimental design very frequently used in agricultural research. (two-way ANOVA)*

(iv) Factorial designs.

(a) *Simple factorial designs:*

Simple factorial design may either be a 2 × 2 simple factorial design, or it may be, say, 3 × 4 or 5 × 3 or the like type of simple factorial design.

(iii) l.s. design

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FERTILITY LEVEL

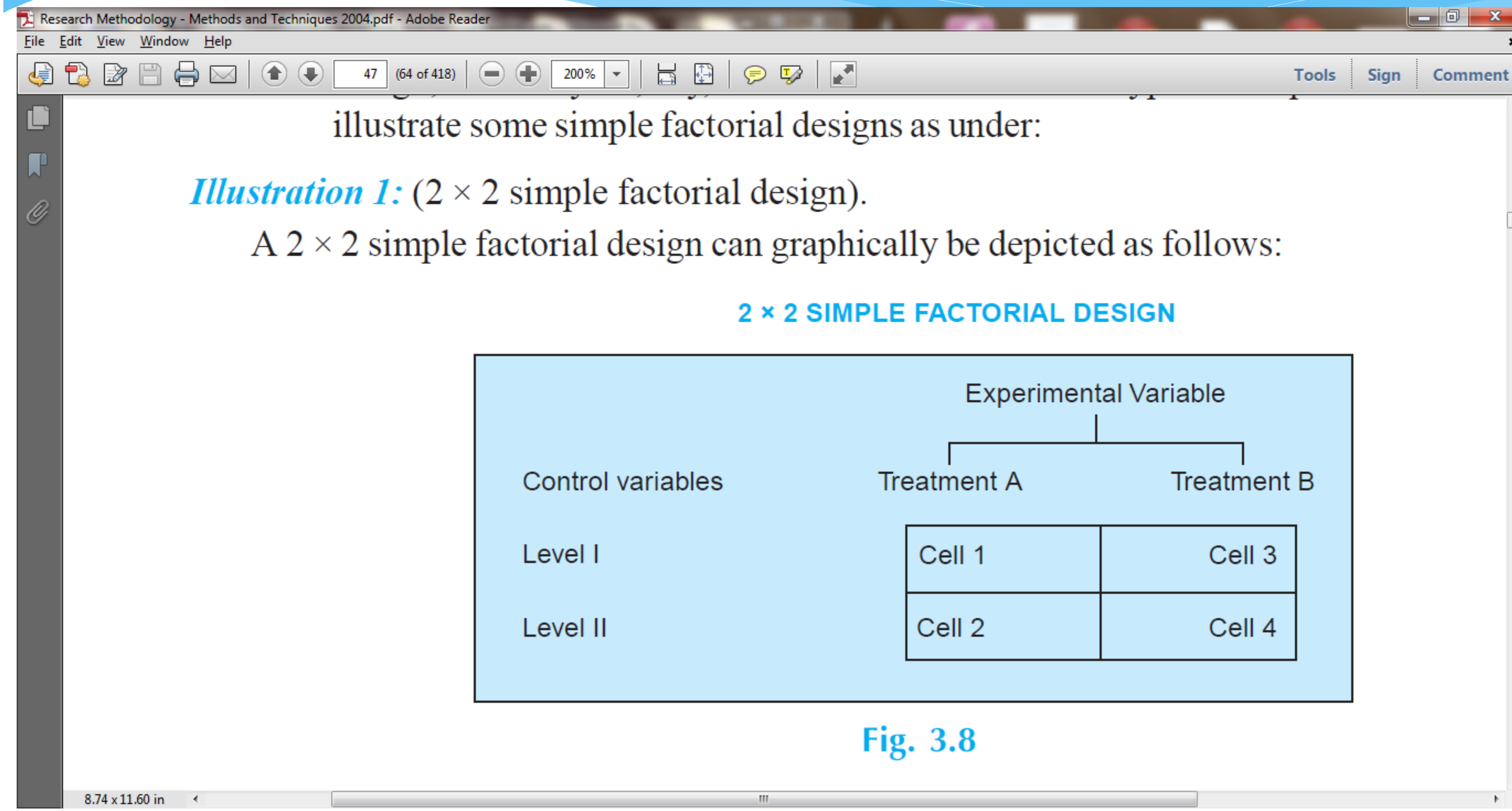
Seeds differences

	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

Fig. 3.7

The above diagram clearly shows that in a L.S. design the field is divided into as many blocks as

(iv) **Factorial designs** Simple Factorial designs



illustrate some simple factorial designs as under:

Illustration 1: (2 × 2 simple factorial design).

A 2 × 2 simple factorial design can graphically be depicted as follows:

Fig. 3.8

The data obtained in case of two (2 × 2) simple factorial studies may be as given in Fig. 3.9.

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STUDY I DATA

		Training		
		Treatment A	Treatment B	Row Mean
Control (Intelligence)	Level I (Low)	15.5	23.3	19.4
	Level II (High)	35.8	30.2	33.0
	Column mean	25.6	26.7	

STUDY II DATA

		Training		
		Treatment A	Treatment B	Row Mean
Control (Intelligence)	Level I (Low)	10.4	20.6	15.5
	Level II (High)	30.6	40.4	35.5
	Column mean	20.5	30.5	

Fig. 3.9

2 × 2 simple factorial design

The 2 × 2 design need not be restricted in the manner as explained above i.e., having on experimental variable and one control variable, but it may also be of the type having two experimenta variables or two control variables. For example, a college teacher compared the effect of the class size as well as the introduction of the new instruction technique on the learning of research methodolog For this purpose he conducted a study using a 2 × 2 simple factorial design. His design in the graphi form would be as follows:

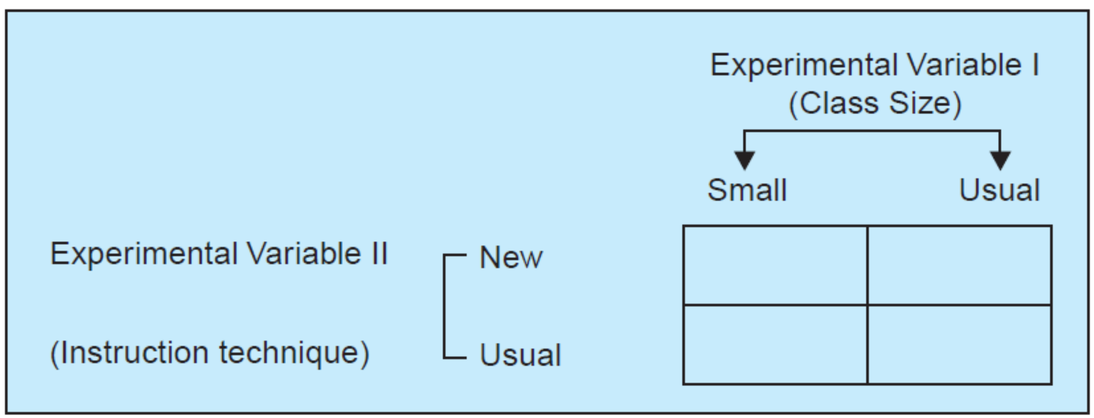


Fig. 3.11

(4 × 3 simple factorial design).

4 × 3 SIMPLE FACTORIAL DESIGN

Control Variable	Experimental Variable			
	Treatment A	Treatment B	Treatment C	Treatment D
Level I	Cell 1	Cell 4	Cell 7	Cell 10
Level II	Cell 2	Cell 5	Cell 8	Cell 11
Level III	Cell 3	Cell 6	Cell 9	Cell 12

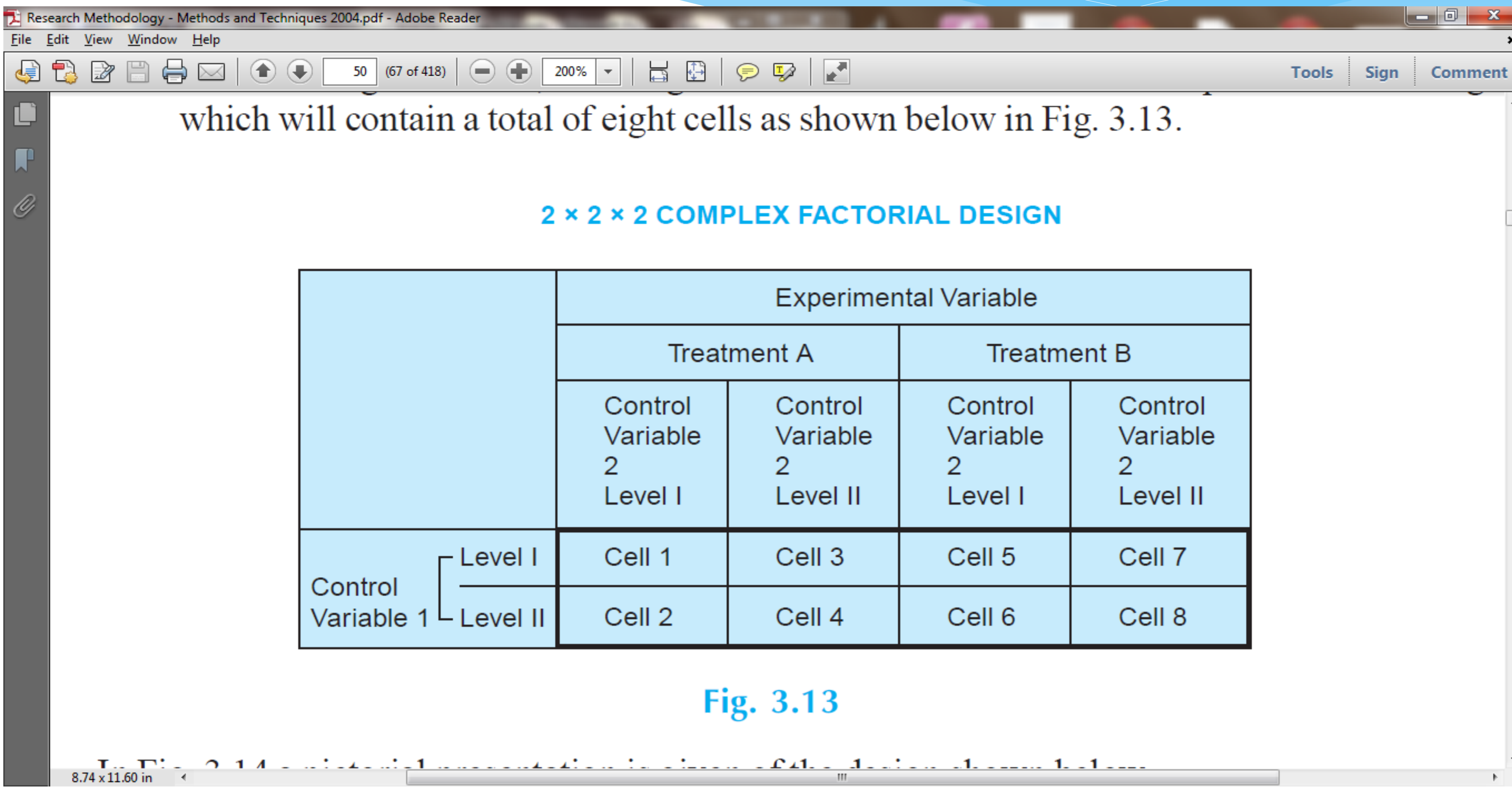
Fig. 3.12

This model of a simple factorial design includes four treatments viz., A, B, C, and D of the experimental variable and three levels viz., I, II, and III of the control variable and has 12 different cells as shown above. This shows that a 2 × 2 simple factorial design can be generalised to any number of treatments and levels. Accordingly we can name it as such and such (–×–) design. In

(b) *Complex factorial designs:*

- Experiments with more than two factors at a time involve the use of complex factorial designs.
- the design used will be termed 2 × 2 × 2 complex factorial design which will contain a total of eight cells

Complex factorial designs:



which will contain a total of eight cells as shown below in Fig. 3.13.

2 × 2 × 2 COMPLEX FACTORIAL DESIGN

		Experimental Variable			
		Treatment A		Treatment B	
		Control Variable 2 Level I	Control Variable 2 Level II	Control Variable 2 Level I	Control Variable 2 Level II
Control Variable 1	Level I	Cell 1	Cell 3	Cell 5	Cell 7
	Level II	Cell 2	Cell 4	Cell 6	Cell 8

Fig. 3.13

n by combining the data of the relevant cells of the latter design as s

		Experimental Variables	
		Treatment A	Treatment B
Control	Level I	Cells 1, 3	Cells 5, 7
Variable 1	Level II	Cells 2, 4	Cells 6, 8

Fig. 3.15

the researcher can determine other first order interactions. The a

CONCLUSION

* **There are several research designs and the researcher must decide in advance of collection and**

* **analysis of data as to which design would prove to be more appropriate for his research project.**