UNIT 7 EXPERIMENTAL RESEARCH-II

Structure

7.1 INTRODUCTION

In the previous unit, you studied that experimentation involves formation of groups by randomly assigning the subjects to the groups, equating the groups on the intervening variables and randomly assigning the treatments to the groups. The purpose of experimentation is to study the effect of manipulated independent variable on the dependent variable. In educational setting, independent variable can be manipulated in different ways. An outline has to be drawn about the way a researcher would like to manipulate independent variable. The main objective of outlining the experimentation is to find out the true effect of manipulated variable. Certain factors creep in while manipulating certain functions. These factors either come from the process of experimentation or from outside. Their presence interferes with the treatment. Under such circumstances true effect of the treatment cannot be achieved. In order to get true effect the researcher has to apply certain checks or controls so as to partial out the effect of intervening variables. Process of applying these controls is basic to the experimental design or lay out of the experimentation. These may serve as the criteria for classification of experimental designs. In this unit, we shall focus on different kinds of experimental designs and the steps of experimental research.

7.2 OBJECTIVES

After going through this unit, you shall be able to:

- classify experimental research on the basis of applying various kinds of controls;
- find out the differences among various experimental designs;
- discuss various kinds of pre-experimental designs;
- discuss various kinds of true experimental designs;
- discuss various types of quasi-experimental design;
- enumerate the steps of experimental research; and
- differentiate between experimental research and descriptive research.

7.3 TYPES OF EXPERIMENTAL DESIGN

We know that the researcher applies certain controls or checks to partial out the effect of intervening variables. In order to apply the controls the reasearcher may:

- Assign subjects randomly to the groups
- Assign treatments to the groups randomly
- Equate the groups to the maximum extent with respect to various intervening variables
- Have post-test of all the groups involved in the experiment.

Those designs where all the above mentioned four criteria are satisfied in toto are termed as 'True Experimental Designs'. These designs are very sophisticated involving rigorous controls and have limited practicability in educational settings. The researcher in educational settings may not be able to apply such rigorous controls. The reason being that the controls may take the researcher away from the reality and in that case the conclusions of the experiment may not be generalizable.

Under such circumstances the researcher may follow some of the above mentioned four criteria in order to apply required controls. Therefore, those experiments where some of the above mentioned four criteria are met are termed as 'Quasi Experimental Designs'. These designs have greater applicability in education.

Further the researcher may some times feel such a situation, where it is difficult to follow even one or two of these criteria. The experimental designs where criterion like post-testing is possible are designated as 'Pre-experimental Designs'. These designs have less scientific value for having inadequate controls.

According to the sophistication and the rigor of controls followed the designs may be arranged as:

1. Pre-experimental designs
2. True experimental designs
3. Quasi-experimental designs

The designs resemble one another from point of view of purpose and their adherence to the principles of experimentation. They differ in the degree of accuracy with which they attack the problem or meet the essential criteria of control, manipulation, observation, and replication. No design solves all the problems. The nature of the problem determines which type of design is most appropriate and applicable and how the design should be used to meet the requirements of the experiment.

Experimental designs are classified on the basis of following four criteria:

- Assigning the subjects to the groups randomly.
- Assigning the treatments to the groups randomly.
- Equating the groups to the maximum extent with the respect to various intervening variables.
- Having post-test of all the groups involved in experiment.

Check Your Progress

Notes: a) Space is given below for writing your answer.

b) Compare your answer with that given at the end of the unit.

1. How are the experimental designs classified into different groups?

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7.4 PRE-EXPERIMENTAL DESIGNS

Pre-experimental designs provide little or no control of extraneous or situation variables. They are, however, still being used in the study of educational problems. Suppose a researcher is interested in finding out the effect of educational television programme on the general awareness of students. The programme is launched as mass media programmes in the public sector with a view to developing general awareness of school students. This programme is available to particular region of the country. In this case, the treatment is television programme that is already operative in the field. The researcher does not have to manipulate this programmme with a special objective and he has no control over this treatment. In order to achieve his research objective the researcher will take a group of students who are being exposed to this television programme. For comparing the effect of this television programme with conventional treatment, the researcher may take another group that has not been exposed to the television programme. Due to the field constraints the researcher will not be able to randomly assign the treatment to the groups. Further, he will be unable to equate the groups on intervening variables. He will be doing only one thing easily, that is he will be able to measure the general awareness (dependent variable) of subjects of both the groups after a particular period of time.

Note that in this experiment, the researcher has not formed the groups randomly, treatments have not been given to the groups randomly and the groups have not been equated on intervening variables. However, both the groups have been post-tested. Thus the experimental designs where only the criterion of 'post-testing of all the groups' is met are called as 'Pre-experimental designs'.

There are three types of Pre-experimental designs. These are One Shot Case Study, One group Pre-test Post-test Design, and Static Group Comparison Design.

7.4.1 One Shot Case Study Design

The researcher wants to study the effect of free lunch programme on disruptive classroom activity. The researcher selects a school. The free lunch programme is launched for a period of six months. At the end of this period the teachers of the school are interviewed about the disruptive classroom activities. In this case, treatment (free lunch programme) is applied to the institution. At the end of the treatment, the dependent variable (disruptive classroom activities) is measured. When such a procedure in experimentation is followed, the design is called as One-Shot Case Study design.

Strengths

In this design —

a) One group of subjects or a single subject or an institution is taken.

b) The treatment is applied for a particular period of time.

c) At the end of the treatment the dependent variable is measured.

Limitations

a) The design is not valid against the criterion of History. For example, on the basis of observations (interview of teachers) made at the end of the treatment the researcher may conclude that disruptive classroom activities curtailed because of the free lunch programme. It is quite possible that curtailment of disruptive activities occurred because of change in administrative policy in the school or examination drawing near or school timings changed etc. In other words such changes or occurrences of events might have affected the dependent variable rather than the treatment, hence the criterion of History is not met.

b) The design is not valid against the criterion of maturation. You know, in the example being discussed the free lunch programme continues for a period of six months. During this period some psychological and biological changes may take place amongst the students. That is students may become aware of the need to pay attention to the teachers' teaching or the students may develop positive attitude towards studying. Such types of psychological changes are called as Maturation and these may influence the dependent variable.

c) The design is not valid against the criterion of Selection. In the example under discussion, the researcher took a school where free lunch programme was launched. It is quite possible that the students in the school were having positive attitude towards studies or they might be the wards of educated parents etc. If such types of factors were existing in the group on which the experiment was conducted, there is every possibility that the findings of the experiment are not true.

d) The design is not valid against the criterion of Mortality. The treatment continued for a period of six months. It is quite possible that some mischievous students might have left the institution during the treatment period. Because of their leaving the institution, disruption in the classroom might have been curtailed. In such a situation if the researcher draws a conclusion on the basis of experimentation that disruption was curtailed due to treatment, it may not be true. The reason being that going away of some mischievous students from the school has affected the dependent variable.

e) The design cannot provide an evidence of causal relationship and it cannot add to the body of knowledge with reliable and valid evidences.

Applicability: The one Shot Case Design can be applied in the following situations:

a) The researcher has to carry out the experiment with one group of subjects or an institution.

b) The researcher takes up a variable or experimentation that has already been launched by some agency say government or any NGO etc.

7.4.2 One Group Pre-test Post-test Design

When an experimenter uses this design, he measures dependent variable, before the independent variable X is applied or withdrawn and then takes its measurement again afterwards. The difference in the measurements of dependent variable, if any, is computed and the amount of change is taken as a result of the application or withdrawing of independent or treatment variable.

The researcher plans a study to investigate the effect of detailed correction on writing efficiency of XII grade students. He takes up a group of students from an institution. He measures the writing efficiency of the students of the group. The scores so obtained are termed as pre-test scores. After the pre-test the researcher gives the students a treatment comprising writing programme in English on various topics and the same being corrected in detail. The treatment of detailed correction goes on for three months. At the end of this treatment, the researcher again measures the writing efficiency of students with the same instrument. The scores so obtained are termed as post-test scores. In this case a single group of students has been taken and the pre-test and post-test has been given.

Table 7.1: One Group Pre-test Post-test Design

Pre-test	Independent Variable	Post-test
T_1	X	T_2
Mean of the criterion test	Detailed correction on students' writing	Mean of the criterion test

Strengths

a) Only one group of subjects has been taken and they measured before and after the treatment.

b) The design is valid against the criterion of Selection and Mortality. In the example under study the researcher measured the writing efficiency at both the pre-test and the post-test stage. Suppose the group taken for experimentation consists of highly intelligent, motivated and creative individuals. These characteristics of the subjects will equally influence the measurement at the pre-test and post-test stages. Similarly, if some students drop out during experimentation, the process will be well taken care of at the pre-test and the post-test stages, that is, at the time of analysis the pre-test scores of the drop outs will not be taken into consideration. Thus, the design is valid against the internal validity criterion of selection and mortality.

Limitations

1. This design does not use any control group and, therefore, the experimenter cannot assume that the difference between the pre-test mean and the post-test mean was brought about by the experimental treatment or by some extraneous variables.

2. History and maturation are two major extraneous variables that are not controlled in this design. History refers to the specific events that can occur between the pre-test and the post-test other than the exposure of subjects to the experimental treatment. In the illustration, for example, the increase in writing efficiency at the post-test stage could be due to the events like practicing by the students at home, or reading extra material etc. Occurrence of such events can increase student achievement in this area. Maturation variable refers to changes in the subjects themselves that occur with the passage of time. For example, it is quite possible that during the period of treatment, subjects might have gained mental maturity, accustomed to writing in English etc. Such biological and psychological factors might have affected writing efficiency along with treatment. Thus in a design like this history and maturation become potent sources of extraneous variance when the time interval between the pre-test and post-test is long.

3. This design does not provide any procedure for evaluating the effect of post-test itself. There is practice effect when the subjects take a test a second time or even take a parallel form of the test. That is, subjects perform better at the post-test stage even without any teaching.

4. There is a problem of reactivity in the design due to a teaching between the subject and pre-test measure. It is this reaction rather than the treatment variable that produces the change in the post-test measures. For example, the novel or controversial content of a pre-test may motivate the subjects to react in a particular manner and it is this reaction that brings about the observed change in subjects at the post-test stage.

5. The instruments used for measuring writing efficiency at the pretest and post-test stage are the same. Various characteristics of the instrument such as interpretation of items, subjects, item difficulty etc. will remain unaltered at both the stages (pre-test and post-test stages). The experience gained in the interpretation of items at pre-test may be carried over to the post-test stage. Thus improvement at the post-test stage may not be due to the treatment only. Therefore it can be said that the design is not valid against the criterion of instrumentation.

6. The design is not valid against the external validity criteria of testing and treatment. In the example under discussion, the exposure to pre-test may make the students aware of the criterion required in writing efficiency like continuity of ideas, use of specific words etc. During the treatment of detailed correction, the same criteria are emphasized. So the students who have been pre-tested become more attentive and responsive to the treatment of detailed correction. This in other words means that exposure of subjects to pre-test has interacted with treatment. This may ultimately affect the post-test performance. The conclusion drawn on the basis of such design therefore cannot be generalized to the group of students who have not been pre-tested.

7. The design is not valid against the external validity criterion of interaction of selection and treatment. It is quite possible that the students selected in the group are highly intelligent, motivated and creative. Because of these characteristics, they may involve themselves more during the treatment of detailed correction. Their remaining active and responsive during the treatment will affect their post-test scores. So the improvement in the post-test may be because of the interaction of selection and treatment. The findings of such a study are limited to particular type of students and these cannot be generalized to the population.

8. This design is weak and cannot provide true evidence of causal relationship among the variables.

Applicability: One group pre-test post-test design is applicable to all those situations where –

a) The interval between pre-test and post-test is of short duration.

b) The equated groups are not available.

c) This design has an edge over the One Shot Case Study design as the pre-test is added to it. The addition of pre-test provides information about the selected subjects.

7.4.3 Static Group Comparison Design

In such designs two groups are selected and one of the groups is exposed to the experimental treatment and the other group is not exposed to any experimental treatment. The group not exposed to any treatment acts as the control group and the students of this group continue their usual classroom studies. The design permits the comparison that is required by a scientific investigation. The experimenter assumes the two groups to be equivalent in all relevant aspects at the start of the experimentation. There is no pre-test and the dependent variable is measured for the two groups after the treatment and then compared (post-test), to determine the effect of independent variable or treatment variable. If the experimental group performs better on the post-test, the experimenter is more confident that the independent variable is more responsible for the change in the dependent variable.

Let us take a study, wherein the effect of supervised library study on achievement of students is investigated. To achieve this the researcher takes two groups of students studying at the same grade level from an institution. These groups are not randomly selected. The groups are comparable with respect to grade level, institution in which they study, age level etc. but do not have equivalence with respect to intelligence, aptitude, study habits, etc. One of the groups is given treatment of supervised library study. The other group is not given treatment but they continue their usual classroom studies. The treatment is not randomly assigned to the groups. The treatment continues for a period of three months. At the end of the treatment both the groups are administered the same test.

Table 7.2: Static Group Design

Group	*Independent Variable*	*Post-test*
Experimental	Supervised Library Study	T_2
Control	Usual Classroom Study	T_2

Strengths

a) The design is valid against the internal validity criterion of History and Testing. Any special event occurring during the treatment will equally effect both the groups. For example, the institution may arrange some lectures by experts or arrange some debate, etc.; all these events will equally effect both the groups. Further since the students have not been exposed to the pre-test, there will be no learning experience to the students before the treatment. Thus the treatment effect will not be mistaken for testing.

b) The design is valid against the internal validity criterion of Instrumentation. Since both the groups have been administered the same achievement test after the treatment of supervised library study, the characteristics of the measuring instrument will have a similar affect on both the groups. So the effect of type of items or difficulty level of items in the test etc. will not change the nature and extent of post-test score.

c) The design has an edge over one group pre-test post-test design because in it control group has been introduced without the pre-test situation.

Limitations

a) Since neither randomization nor matching is used to assign subjects to the experimental and control groups, the experimenter cannot assume that the groups as equivalent with respect to relevant extraneous variables before they are exposed to the experimental treatment. This design, therefore, is also considered to be lacking in the necessary control.

b) The design is not valid against the internal validity criterion of selection. It is quite possible that (in the example being discussed), the subjects of one of the groups are more intelligent and creative than the subjects of the other group. Since all these variables affect the achievement, the differences between the post-test measures of the experimental and control groups may not be entirely due to the treatment.

c) The groups, in the example under discussion, are comparable but not equivalent on the variables of intelligence, aptitude, study habits, etc. If by chance some of the intelligent students of the group remain absent in the study, the post achievement will be affected. Thus the experimental mortality may produce differences in the groups due to differential dropout of subjects from the groups. Therefore, the two groups once equivalent may differ later because of selective dropout of subjects.

d) The design is not valid against the criterion of interaction of Selection and Maturation. In the example given in the box, if by chance one of the groups having more intelligent students is exposed to some special events like lectures by experts or arrangement of excursions etc, there is every possibility that these students will fare better in the post-test than their counterparts in the other group. This means that the design is not valid against the internal validity criterion of selection and maturation.

e) The design is not valid against the external validity criterion of selection and treatment. In the example being discussed here, if by chance one of the groups has subjects with good study habits and this group is given treatment it is quite obvious that such subjects will benefit more from the supervised library study. In other words the characteristics of the subjects will interact with the treatment. Because of this interaction the students of treatment group are apt to achieve more on achievement test than their counterparts. The conclusions based on such a design cannot be generalized to those students who do not have good study habits.

Applicability: The Static Group Comparison Design is applicable in all those situations where:

a) The researcher does not have control over situations and is unable to alter natural settings in an educational institution.

b) The groups are comparable.

c) There are chances that the pre-test will sensitize the group and affect the dependent variable.

To conclude it may be said that you have studied three types of pre-experimental designs. These are One Shot Case Study Design, One Group Pre-test Post-test Design and Static Group Comparison Design. These designs have two basic characteristics. One is that there are no matched groups. Secondly groups are not randomly selected and treatments are not randomly assigned to the groups. Because of these internal weaknesses, the designs lack in internal and external validity. However, applicability of these designs will depend upon objectives of the study and fulfillment of essential requirements of the design. If the major purpose of research is to find out cause and effect relationship, more sophisticated designs should be opted for. In the next section, we will discuss true experimental designs.

Check Your Progress

Notes: a) Space is given below for writing your answer.

b) Compare your answer with that given at the end of the unit.

2. Find out the major differences between one group pre-test and post-test design and static group comparison design.

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7.5 TRUE EXPERIMENTAL DESIGNS

True experimental designs are mostly used for experimental research in education because they seek to control the main effects of history, maturation, testing, measuring instruments, statistical regression, selection, and mortality (Koul, 1988). The researcher may be interested in comparing the self-instructional method with the conventional method in terms of achievement of IX grade students, in science. In order to pursue this objective, the researcher may form two groups of students.

Before proceeding further with the formation of groups he will try to find out those variables that may influence the achievement of students irrespective of the method of teaching. These variables can be – intelligence, motivation, sex, socio-economic status, previous achievement in science etc. The researcher will equate these groups of students on these variables and randomly assign the students to the groups. If the mean scores of students on these variables is computed, it will be found that the means of two groups will not differ significantly. That is to say, that the two groups are equated on the above mentioned intervening variables. After formation of groups, the researcher will administer the achievement test to the students of both the groups. This is termed as the pre-test. The pre-test scores will reveal initial differences, if any, with respect to achievement of students of the two groups. After this the researcher randomly exposes one of the groups to the self-instructional method and the other group to the conventional method. The group exposed to the self-instructional method is designated as the experimental group and the group exposed to the conventional method is termed as the control group. The content of teaching and the time of exposure to treatment to both the groups remain similar.

It may be mentioned here that the experiment is conducted in the same institution, therefore the environmental variables like institutional climate, schedule in the school remain the same for both the groups. At the end of the treatment (teaching) both the groups are administered the same achievement test. The scores of students on this test constitute post-test scores. In this way the dependent variable (achievement of students) has been measured before and after the treatment in randomized equivalent groups. The layout of such designs is as follows:

7.5.1 Pre-test Post-test Control Group Design

This design is also called as 'Randomized Control-group Pre-test-Post-test Design'. From the example cited above, it may be observed that the researcher has undertaken a study with the objective of comparing the self-instructional method with the conventional method for teaching science at IX grade level. In pursuance of this objective two equated groups are formed by randomly assigning subjects to the groups. Both groups are administered a similar achievement test as pre-test. The treatments are randomly assigned to the groups. The duration of the treatment has been similar. At the end of the treatment, both groups are administered the same achievement test. The scores on this test are termed as post-test scores. When a researcher follows this type of procedure during experimentation he employs Pre-test Post-test Control Group design for the research study. In this design the dependent variable (achievement test) has been measured before (pre-test) and after (post-test) the treatment (method of teaching) in the randomized equivalent groups. The difference between means of pre-test and post-test is found in order to ascertain whether the experimental treatment produced a significant effect.

The strengths and limitations of this may be enumerated as follow:

Table 7.3: Pre-test Post-test Control Group Design

Randomly assigned group	*Pre-test*	*Independent Variable*	*Post-test*
Experimental group	T_{1E}	Teaching through Self-instructional Method	T_{2E}
Control group	T_{1C}	Teaching through Traditional Method	T_{2C}

Strengths

The main strengths of this design may be listed as:

1. The strength of this design lies in the random assignment of subjects at the initial stage, which assures equivalence between groups prior to experimentation.
2. The experimenter's control over the pre-test provides an additional check on the equality of the two groups on the dependent variable.
3. This design, with its randomization, seeks to control most of the extraneous variables, like the main effects of history, maturation, pre-testing, differential selection of subjects, statistical regression and mortality that pose a threat to internal validity.

Limitations

The main limitation in using this design is a threat to its external validity due to the following reasons (Koul, 1988).

1. There is interaction between the pre-test and the experimental treatment. This interaction may change or sensitize the subjects in certain ways. Although the subjects of the experimental and control groups take the same pre-test and may experience the sensitizing effect, the subjects of the experimental group because of their increased sensitivity may respond to the experimental treatment in a particular way. For example, if attitudinal change were the dependent variable the problem would have been quite highlighted. When the first attitude scale is administered as the pre-test in such a study, it can sensitize both experimental and control subjects to the issues or the content included in the scale. But the subjects of the experimental group may not respond in the same way to the experimental treatment, given in the form of a lecture, film or the like, as the control group subjects. Therefore, the experimenter may only be able to generalize findings to pre-tested groups and not to pre-tested ones from which the experimental subjects were chosen.
2. There is also interaction of selection of subjects and experimental treatment. The cultural background, or some other characteristics of the subjects, who are selected to participate in an experiment, may make the experimental treatment more effective for them than it would be for the subjects elsewhere.
3. The interaction of experimental variable with other factors, such as history, also makes it impossible to generalize the findings beyond the specific conditions or situations in which the experiment was conducted. To overcome this difficulty, the experimenter should replicate the study in different time and place settings so that generalizations concerning the findings can be made with greater confidence.
4. The reactive effects of the experimental procedures on the subjects of the experimental group or who administer the treatments may also create problems in making generalizations. For example, if the subjects of the experimental group know that they are participating in an experiment, they may not react normally to the experimental treatment. Keeping the experimental group subjects unaware

of the fact that an experiment is being conducted can minimize the reactive effect of the experimental procedures.

7.5.2 Post-test only Control Group Design

In the foregoing paragraph we have studied pre-test—post-test control group design. From this design if we remove pre-test then it takes the shape of post-test only control group design. The illustration given in the box will explain that the available subjects are assigned to two groups through randomization that controls all possible relevant extraneous variables. No pre-test is used and the random assignment of subjects assures that any initial differences between the groups are attributable only to chance. The two random samples from population are obtained in two ways: (i) The subjects may be drawn individually at random and assigned alternatively to the groups; or (ii) Two different random samples may be selected first and the groups assigned randomly to the experimental or control condition. Only the experimental group is exposed to the experimental treatment. At the end of the experiment, subjects of both the groups are measured on the dependent variable. The means of the two groups are compared with the help of an appropriate statistical test of significance.

Suppose an experimenter wants to ascertain whether a new teaching method will increase reading speed of third grade students. He prepares a list of all the elementary schools of a particular city and assigns numbers to the entire third grade students. With the help of random number table he may draw a desired sample of 100 students. Then two random samples of 50 subjects each may be selected from the selected sample in two ways: the researcher may select subjects individually at random and assign them alternately to the groups, or he may first draw two random samples and then assign groups to the experimental or control condition by tossing a coin.

After assigning the subjects to two groups, the experimental group is taught through the new method and the control group through the conventional method, for a fixed period of time. In all other respects, the researcher will treat the groups alike. After the desired period of time, the subjects of both the groups will be administered a reading test. The mean scores of the two groups are compared to determine the effectiveness of new teaching method by using an appropriate statistical test. If the obtained means of the groups are significantly different, the experimenter can be reasonably confident that the use of new teaching method was responsible for the observed difference.

Table 7.4: Post-test only Control Group Design

Randomly assigned group	*Independent Variable*	*Post-test*
Experimental	Teaching through New Method	T_2
Control	Teaching through Conventional Method	T_2

The illustration given in the box shows that dependent variable reading speed has been measured at the end of the treatment (method of teaching) in randomized equivalent groups. Because of these features the design has been termed as Post-test-only Control Group Design.

Strengths

1. The main advantage of this design is randomization, which assures statistical equivalence of the groups prior to the introduction of the experimental treatment.

2. Since no pre-test is used, this design controls for the main effects of history, maturation, and pre-testing. Moreover, there can be no interaction effect of pre-test and independent, or experimental variable. Hence, this design is especially recommended for the experiments in which pre-test sensitization is likely to occur.
3. This design is useful in the experimental studies, especially at kindergarten or primary stages, in which a pre-test is either not available or not appropriate.

Limitations

In spite of all the advantages mentioned above, this design suffers from the following limitations:

1. The use of this design seriously restricts the external validity of the experiment. The experiment can partially overcome this limitation by replicating the experiment with different groups.
2. There are some situations in which it is not possible for the experimenter to select subjects at random from the population of interest. In such cases, Ary et al (1972, p. 243) suggest that the experimenter must begin with available subjects and assign them randomly to the groups.
3. The post-test only control group design can be applied in all those situations where:

a. A large number of subjects are available. From these subjects equivalent groups can be formed by randomly assigning the subjects to the groups.

b. Treatment can be randomly assigned to the groups.

c. The groups can be post-tested with the same instrument.

From the discussion presented in this paragraph it may be said that post test only control group design is very much similar to pre-test post-test control group design but for one difference that pre-test is not held in the post-test only control group design. The design is valid against all criteria of internal validity such as History, Maturation, Testing, Instrumentation, Regression, Selection, Mortality and Interaction of Selection and Maturation. Its findings can be generalized to the population because the design has external validity with respect to interaction of testing and treatment criterion. It has application to those situations where the researcher can afford to have rigorous controls.

7.5.3 Solomon Four Groups Design

Till now you have studied pre-test post–test control group design and post-test only control group design. The main features of these two designs are present simultaneously in the design which is discussed below. To understand this let us study the example given in the box.

> The researcher is interested in comparing the self-instructional method with the conventional method in terms of achievement of IX grade students in science. In order to achieve this objective, the researcher forms four equated groups by randomly assigning subjects to the groups. These groups are equated on the variables like intelligence, motivation, previous achievement in science, sex, socio-economic status, etc. Let these four groups be named as A, B, C, and D. Of these four groups any two groups are randomly selected and pre-tested by administering an achievement test. Let us say these groups are A and C. After this one pre-tested group (say A) and another un-pre-tested group (say B) receives the treatment that they are exposed to self-instructional material. The remaining two groups (say B and D) are exposed to the usual conventional method. Here it may be noted that the treatment is randomly given to the groups. The duration of treatment has been same to both the groups. At the end of the treatment all the four groups are given the same achievement test that was given at the pre-test stage. The scores on this test are termed as post-test scores.

From the illustration given in the box, it may be observed that the dependent variable (achievement test) has been measured at the pre-test stage in case of two groups. All the four groups have been measured for the dependent variable at post-test stage at the end of the treatment. The four groups were randomly formed and treatments were randomly given to the groups.

Table 7.5: Solomon Four Groups Design

Randomly assigned	*Pre-test*	*Independent Variable*	*Post-test*
Experimental group (E)	T_{1E}	Teaching through Self-instructional Method	T_{2E}
Control group (C_1)	T_1C_1	Teaching through Conventional Method	T_2C_1
Control group (C_2)	No pre-test	Teaching through Self-instructional Method	T_2C_2
Control group (C_3)	No pre-test	Teaching through Conventional Method	T_2C_3

Strengths

1. This design provides control over any possible contemporary effects that may occur between pre-testing and post-testing.
2. This design actually involves conducting the experiment twice, once with pre-tests and once without pre-tests. If the results of these two experiments are in agreement, the experimenter can have much greater confidence in his findings.

Limitations

1. The design is difficult to carry out in practical situations. It involves more time and effort to conduct two experiments simultaneously and there is the problem of locating the increased number of identical subjects that would be required in the experiment.
2. Since this design involves four sets of measures for four groups and the researcher has to make comparisons between the experimental and first control group (A and C) and between second and third control groups (B, and D), there is no single elementary statistical procedure that would make use of the six available measures simultaneously. In the light of this difficulty, this design is generally recommended for a more advanced level of research.

Applicability: The design can be applied in all situations where:

a) A large number of subjects are available and from these subjects four equivalent groups can be formed by randomly assigning subjects to the groups.

b) Of the four groups two randomly selected groups can be pre-tested.

c) Treatment can be so assigned to the groups that one pre-tested group and one un-pre-tested group receives treatment randomly.

d) All the four groups are post-tested.

e) The same instrument or parallel form of the instrument can be used at pre-test and post-test stage.

In short, it may be inferred that the main features of Pre-test Post-test Control Group Design and Post-test only Control Group Design are simultaneously present in the Solomon Four Group Design. This design is valid against the criteria of internal validity like- History. Maturation, Testing, Instrumentation, Regression, Selection, Mortality and Interaction of Selection and Mortality etc. The findings obtained by applying this design can be generalized to the population, as it is externally valid against the interaction of testing and treatment criterion.

The Solomon Four Group Design is a powerful experimental design as there is inbuilt mechanism of verification of results. Its main limitation is that it requires a rather large sample, more time and much effort on the part of the researcher.

7.5.4 Factorial Designs

The discussion about the various designs thus far has been confined to classical single variable designs, which require that an experimenter manipulates one independent variable to produce an effect on the dependent variable. Human nature is complex and experimenter in educational situations cannot always fulfil these requirements. One independent variables alone may not produce the same effect as it might in interaction with another independent variable. The findings, therefore, from a one-variable design may be meaningless. For example, the effectiveness of a teaching method depends upon a number of variables such as the intelligence level of students, the type of the teacher teaching the group, and so on. In such type of experiment, a classical one-variable design would not reveal any information about the interactive effect of the method of teaching and intelligence level or any other variable. The example given in the box below will clarify further.

The researcher starts with the objective of finding out the effect of a new method of teaching, intelligence, achievement motivation and their conjoint effect on the science achievement of students of IX grade. Method of teaching, intelligence and achievement motivation are three independent variables and achievement of students in Mathematics is a dependent variable. Also there could be more than one method of teaching say Discussion, Demonstration and Lecture Method. These three types of methods of teaching are said to be three levels. Thus methods of teaching have three levels. Further, the independent variables like intelligence may be categorized by the researcher at two levels viz. high intelligence and low intelligence. So also, achievement motivation may be categorized at two levels say highly motivated and low motivated. In this there could be three levels of methods of teaching, two levels of intelligence and two levels of achievement motivation. Each of the independent variables having different levels is termed as factors.

In such a situation the researcher takes an institution and administers an intelligence test and achievement motivation test to all the IX grade students. On the basis of scores of students on intelligence test and achievement motivation test, they may be classified into four groups that is – (i.) highly intelligent and highly motivated, (ii) highly intelligent and low motivated, (iii) low intelligent and highly motivated, and (iv) low intelligent and low motivated. Students from each of these four categories are divided at random into three groups for exposure to three different methods of teaching. In this way, for each category there are three groups and in all there will be twelve groups. One group from each category is randomly allocated to each of the three treatments (methods of teaching). In other words, each treatment is being administered to group of students belonging to four categories. At the end of the treatment all the students of different groups are administered achievement test.

Thus when different factors having different levels are administered treatments randomly so as to find out the effect of each factor separately and conjointly, such designs are termed as Factorial Designs.

A factorial design enables the experimenter to evaluate or manipulate two or more variables simultaneously in order to study the effects of number of independent factors singly as well as the effects due to interactions with one another. Factorial designs vary according to the degree of complexity depending upon the nature and purpose of the experiment. They include two or more independent variables, and each one is manipulated in two or more ways to assess both their separate (main) and their combined (interaction) effects.

Strengths

1. The differences in the effect of different levels or categories of more than one variable can be studied with factorial designs simultaneously. An experimenter, therefore, can accomplish in one experiment what otherwise might require two or more separate experiments.
2. While studying the significance of the differences in the dependent variable under the effect of the levels of any of the factors the groups become alike with respect to the different levels of other factors and thus the groups get controlled as far as the levels of the other factors are concerned.
3. Besides studying the significance of the differences in the levels of the factors, the factorial designs provide an opportunity to study interactions between the factors.

Limitations

A factorial design may include any number of independent variables with any number of levels of each. However, when the experimenter manipulates or controls too many factors simultaneously, the experiment and the statistical analysis of the data sometimes become unmanageable. Moreover, the combinations of too many variables also become artificial (Koul, 1988).

Applicability: The factorial designs have their applicability in all those situations where:

a) Along with the effect of each of the independent variable on dependent variable, the researcher is interested in finding out the effect of interactions of the factors (independent variables) on dependent variables.

b) The same group of subjects is to be utilized in estimating effects of two or more dimensions of independent variables, thus helping in economizing time and money as well as personnel.

c) The simultaneous use of independent variables makes it possible to bring out interactive effects of treatments and may have an accelerating effect on the action of some other independent variable on dependent variable.

Check Your Progress

Notes: a) Space is given below for writing your answers.

b) Compare your answers with those given at the end of the unit.

3. In what way is true experimental design better than pre-experimental design?

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4. Which true experimental design provides the scope to measure the effect of more than one independent variable?

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7.6 QUASI EXPERIMENTAL DESIGNS

The true experimental designs, as discussed earlier, provide full experimental control through the use of randomization procedures. However, in the field experiments, the researcher may have to take the whole group of subjects in an institution. It may not be possible for him to divide the group or randomly assign the subjects to the groups. He may assign the treatments to the groups randomly. Further he may try to equate these groups up to the maximum extent under the existing circumstances. In such situations, the researcher has to depend upon quasi-experimental designs, that provide as much control as possible under the existing conditions. If an experimenter uses a quasi-experimental design, it is necessary for him to know which of the variables his design may fail to control. He must also be aware of the sources that represent threats to both internal and external validity and consider them while interpreting the results of the experiment. Thus the designs that meet the criteria of random assigning of treatment to the groups, equating the groups to the maximum extent, and administration of the post-test are classified as Quasi Experimental designs or Compromise Designs.

There are a large number of Quasi-experimental Designs. A few of these are explained in the paragraphs to follow.

7.6.1 Non-equivalent Control Group Design

In a school situation, it is sometimes practically not possible to upset class schedules like reorganizing the classes in order to employ randomization procedures for getting equivalent control and experimental groups. Under these circumstances an experimenter may use pre-assembled groups, such as intact classes, for framing experimental and control groups. The pre-assembled groups are selected and are administered pretest. The pretest scores are analyzed to show that the means and standard deviations of the two groups do not differ significantly. After determining the groups the experimental treatment is administered to the experimental group and then the posttest is given to both the groups. The difference between the pre-and post-test scores are compared with the help of appropriate statistical test to ascertain the effect of the independent variable.

Let us say the researcher wants to study the effect of a new teaching method on the achievement of students of VIII grade. For this he takes two groups of students of VIII grade from a school. These groups are comparable on some variables like age, school climate etc. But these groups have not been equated on intervening variables like intelligence, attitude towards study, motivation before starting the experiment. Both these groups are given pre-test to have base line data with respect to achievement. One of these groups is taught by new teaching method and the other group by traditional method for the same duration. At the end of the treatment both the groups are post-tested. The same instrument is used at pre-test and post—test stage. Here two groups of subjects are selected non-randomly. They are non-equivalent. Both the groups are given treatment. At the end of the treatment both the groups are post-tested.

Table 7.6: Non-equivalent Control Group Design

Group	*Pre-test*	*Independent Variable*	*Post-test*
Experimental	T_1	New teaching method	T_2
Control	T_1	Traditional teaching method	T_2

Strengths

1. The design is valid against the internal validity criteria of History. Maturation, Testing, Instrumentation, Selection, and Mortality on the following counts:

   a) If special events like debate, excursions, exhibitions etc. occur during the period of experimentation, these will equally effect both the groups.

   b) The biological and psychological changes like fatigue, loss of interest etc. if any will manifest itself equally in experimental as well as control group. Thus controlling the factor of Maturation.

   c) Both the groups will have similar learning experiences from the pre-test. This experience will affect the post-test performance in a similar manner. So, the testing effect will be controlled.

   d) Whatever way the students respond to the items on achievement test, it will remain similar at both the stages in both the groups. The instrument being fixed, its effect is controlled.

   e) The individual differences if any, will affect the post-test scores in both the groups. The effect due to individual differences will be balanced when the groups are compared. In this way the effect of selection is internally controlled in the design.

   f) In this design the data of all the students who have appeared in the pre-test and post-test are analyzed. The lost cases (Mortality), if any, are not taken up for consideration.

   g) The reactive effects of experimentation are easily controlled. When the pre-assembled groups are used, subjects are less aware of the fact that they are subjected to the experimental treatment than when the subjects are drawn from the class through randomization and put into experimental sessions.

   h) The experiments using this design are conveniently conducted in the school situations where the researcher has no control to manipulate the variables as per his design.

Limitations

1. The selection of subjects for the experimental and control groups may result in interaction effect between selection and certain extraneous variables like selection and maturation and testing and treatment.

   a) It is quite possible that one of the groups taken for study has higher rate of maturation than the other group. Under such circumstances, the treatment given to such a group will show boosted results that may ultimately affect the dependent variable.

   b) When unusual test procedures like pre-test and post-test are used, these affect the mental make up of the subjects about the treatment. This perpetual change due to the pre-test in both the groups may hamper the effect of the treatment. Thus the external validity criterion is vitiated because of the interaction of the testing procedure and the treatment.

Applicability: Non-equivalent Control Group Design can be applied in all those field settings where:

a) Subjects cannot be assigned randomly to the experimental and control groups.

b) The control group receives a conventional or usual treatment rather than no treatment.

c) Two groups of subjects are available.

d) Both the groups can be pre-tested as well as post-tested.

e) The design becomes more powerful when the experimental and control groups are similar with respect to pre-test. This makes the control more effective and provides valid effect of the treatment.

7.6.2 Separate Sample Pre-test Post-test Design

Measurement of dependent variable in two randomly selected equivalent sub-groups where one subgroup is pre-tested and the other subgroup is given the treatment and post-tested is known as separate sample pre-test post-test design.

Suppose a researcher wants to study the effect of specially developed instructional material on the creativity of the students of IX grade. For this he takes one class of IX grade from a school. This class is divided into two subgroups say 'A' and 'B' by randomly allocating the students to the subgroups. In this way two equivalent subgroups are formed. To one of the subgroups say 'A', the researcher administers the test of creativity so as to get pre-test scores on creativity. After this, the researcher administers the treatment i.e. instructional material for developing creativity to the whole group or whole class (including subgroups 'A' and 'B'). At the end of the treatment, only subgroup 'B' is post-tested. The test used for one of the groups as pre-tested and to the other group as post-tested is the same. Here one group of the students has been divided in to two subgroups. One of the subgroups is pre-tested. The treatment is given to the whole group. The other subgroup is post-tested.

Strengths

1. The separate sample pretest post-test design is valid against the internal validity criteria of Testing, Regression and Selection on the following counts:
   a) All the subjects in the group have been exposed to the treatment. But only one subgroup has been pre-tested and the other group has been post-tested. There will not be any carry-over effect of testing, as the group that has been pre-tested has not been post-tested.
   b) The mean pre-test scores of one sub-group and the mean post-test scores of another subgroup are compared. Thus regression effect does not exist in the design.
   c) As only one group of student has been taken, two subgroups form the part of this group. Randomization has been used while forming the subgroups where every student has equal chance of being selected to any of the subgroups. In this way the selection effect is inherently controlled in the design.
2. The design is valid against the external validity criteria of interaction of testing and treatment, interaction of selection and treatment and reactive arrangements.
   a) In this design one of the treatment groups does not have any knowledge of pre-test items. Thus interaction of testing and treatment will not take place.
   b) The two subgroups in the design have random equalization. One of the subgroups is pre-tested and the other subgroup is post-tested. When the pre-test and post-test scores of these separate equivalent subgroups are compared, the effect of the characteristics of selected sub-groups will be balanced. Thus the interaction of selection and treatment will not take place.
   c) In the design the sensitization to pre-test is absent, randomization does not disturb the classroom setting (the whole class is involved in the experimentation process) and the treatment has been given to the whole class. Thus it does not create unusual expectations in the subjects. In this way reactive arrangements do not vitiate the effect of the treatment.
3. The design is specifically useful for the large population that cannot be divided in separate groups for different types of treatments.

4. The design is more powerful than the other designs, as it moves the laboratory to the field situation to which the researcher wishes to generalize the effect of the treatment.

Limitations: The design has the following limitations:

a) The design is not valid against the internal validity criterion of interaction of selection and maturation. It is quite possible that the group so selected is highly creative. The maturation changes like tiredness, frustration etc. may take place and affect the post-test scores. This effect of interaction of selection and maturation will not be balanced out when pre-test and post-test scores are compared because the same subjects have not been post-tested.

Applicability: The design can be applied in those field situations in which:

a) The whole group or class has to be taken in its natural setting.
b) Treatment has to be given to the whole group.
c) Equivalent subgroups can be formed within the class or group.
d) One of the two subgroups can be pre-tested and the other can be post-tested.

You have observed from the above discussion that the design is having maximum external validity. But the design is lacking with respect to internal validity criteria like History, Maturation, Mortality and Interaction of Selection and Maturation. Depending on the field settings, the separate sample pre-test post-test design can be planned in different ways to have maximum controls.

7.6.3 Counter Balanced Design

When the random assignment of subjects to experimental and control groups is not possible, the counterbalanced design may be used. This design also uses intact classes and rotates the groups at periodic intervals during the experimentation. This design is also known as rotation group design, crossover design or switchover design. In this design each group of subjects is exposed to each experimental treatment at different times during the experiment.

Let us say the researcher tries to compare the effect of three different approaches of teaching namely- Modular Approach, Radio-vision approach and Conventional approach to teaching. For this purpose the researcher selects three groups of students say 'A', 'B' and 'C' from three different schools and three chapters from general science. All three groups were taught three chapters using three different treatments. These groups are taken as such from the school. These are comparable groups but not equivalent. These three groups are exposed to three different treatments randomly at one point of time (Let us say group 'A' is exposed to treatment 'X'1', group 'B' is exposed to treatment 'X'2' and group 'C' is exposed to treatment 'X'3 at time 'T'1'). Next time group 'A' is exposed to treatment X_3 and group 'B' is exposed to treatment X1 and group 'C' is exposed to treatment X 1. In this way the treatments are rotated in such a way that each group of subjects is exposed to each treatment at different time during the experiment. It is also important to note that each group of subjects is exposed to a treatment for once and once only. In other words there is no specific link between treatments, groups and time. At the end of each treatment, each group is observed on the dependent variable (achievement) with the help of the same instrument.

In short it can be said that in the counterbalanced experimental design the groups of subjects are taken from different institutions in their natural setting. The number of treatments could be equal to the number of groups. The selected groups are comparable but non-equivalent. The treatments are administered to the groups in such a way that each group of subjects gets each treatment once and for once only at different points of time. The treatments are administered randomly. At the end of each treatment given to each group the dependent variable is measured with the same instrument.

Table 7.7: Counter Balanced Design

Replication	*Modular approach*	*Radio-vision approach*	*Conventional approach*
Chapter 1	Group A	Group B	Group C
Chapter 2	Group B	Group C	Group A
Chapter 3	Group C	Group A	Group B
	Column mean	Column mean	Column mean

Strengths

This design overcomes and eliminates any differences that might exist between the groups. Since all the groups are exposed to all the treatments, the result obtained cannot be attributed to preexisting differences in the subjects.

1. The design is valid against the criteria of History, Maturation, Testing, Instrumentation, Regression, Selection and Mortality as well as Interaction of Selection and Maturation.

   a) If some special event occurs during the treatment at one stage, then each treatment will also be exposed to the impact of that event.

   b) If there are some biological or psychological changes in a particular group, these will be reflected in post-test and when such a group is exposed to another treatment the maturation effect will be taken care of.

   c) Testing effect will be taken care of when different groups are compared as it will be counterbalanced.

   d) Instrument effect, if any, will be equally present in all the groups and will be counterbalanced on comparison.

   e) In this design the subjects are not pre-tested but only post-tested. So there is no question of Regression.

   f) If by chance one group happens to be more intelligent than the other groups, then each treatment will profit from this superiority. The same will be balanced on comparison.

   g) If some mortality occurs during the process of experimentation, it will equally affect all the treatments.

   h) There is a possibility that all groups may get some fatigue when the experimentation is in progress. During replication, the factor of fatigue will affect the mean scores of each group. The counterbalance process implied in the design will take care of this factor.

Limitations

a) The design is not valid against the external validity criteria of multiple treatment interference. There is carry-over effect of the groups from one treatment to the next. Therefore, this design should be used only when the experimental treatments are such that administration of one treatment on a group will have no effect on the next treatment.

b) Since many replications are involved it is not always possible to have equivalent learning material during various replications.

c) There is a possibility of boredom when students are exposed to various replications.

Applicability: This design is applicable to those field researches where-

a) The researcher has little control over the assignment of subjects to the groups and has to use intact classes.

b) The number of treatments is equal to the groups and treatments can be rotated amongst the groups.

c) The interaction between the treatments, occasions and groups is not desired.

d) There is need to achieve consistency in findings by internal replication of the experiment.

7.6.4 Time-series Designs

There are two types of time-series designs.

One-group Time-series Design

This design takes into account a series of measurement on the dependent variable before and after the group is exposed to experimental treatment. The experimenter takes a number of measurements on the independent variable, exposes the group to the experimental treatment, and then again takes additional measurements on the independent variable.

> Suppose the researcher is interested in finding out the effect of 'telling important questions for examination' on the attendance of students in M.A (Education) class. For this he counts attendance for five consecutive days. Then on one day he informs the students that he will be telling important questions from the examination point of view. The attendance is again noted for following five days. The difference in attendance is attributed to the treatment.

Here in this design a single group of subjects has been taken. The subjects are measured periodically on dependent variable before and after the treatment. When such a procedure is followed, the design is called Time Series Design.

Table 7.8: One-group Time-series Design

		Y					Y	
				Experimental Treatment X				
T_1	T_2	T_3	T_4		T_5	T_6	T_7	T_8

Strengths

1. This design is valid against the internal validity criteria of Maturation, Testing, Regression, Selection, Mortality and Interaction of Selection and Maturation.

   a) The changes that occur due to biological and psychological changes in the subjects are easily controlled as the subjects are periodically measured before and after the treatment.

   b) Continuous periodical measurement of the dependent variable controls the effect of testing as it is counted on different occasions.

   c) The interval between different occasion of testing and observation is usually quite small for the regression effect to take place.

   d) Since the testing takes place on many occasions before the treatment and the same measurement is repeated on many occasions after the treatment the effect of selection is automatically taken care of.

   e) The drop out or mortality factor does not affect the findings as the measurement is taken on many occasions before and after the treatment. In case of the example being discussed here, it may be pointed out that the attendance of only those students will be counted who are regular. The attendance of dropouts will not matter as attendance of the students in the class has been counted for five days before the treatment and for five days after the treatment.

f) The interaction of selection and maturation will be balanced as the periodic observations made after the treatment are to be compared with the observations made before the treatment.

g) The multi-testing of students in this design provides more check on some sources of internal validity.

Limitations

1. This design fails to control the effects due to history. For example, the factors such as climatic changes and examinations may contribute to the observed change in the dependent variable. In the example under discussion some other teacher might have announced that the students would be given an internal assessment test and it may affect the attendance of the students.
2. Because of the repeated tests, there may be kind of interaction effect of testing that would restrict the findings to those populations, which have been subjected to repeated testing.
3. The usual statistical tests of significance may not be appropriate with a time design (Koul, 1988).

Applicability: Time series design can be applied to those field situations where:

a) It is not feasible to form a control group.

b) This design is useful in the school settings to study the effects of a major changes in administrative policy upon various issues concerning discipline.

c) It is also useful in the study of attitude change in the students as a result of the effect produced by the introduction of a documentary film designed to change attitudes.

d) There is no carry-over effect of testing.

e) The internal and external controls are not possible during experimentation.

f) The measuring instrument is such that it can be used many times and its repeated use does not affect the variable under study.

Time series design can provide useful information because the use of additional measurements preceding and following the experimental treatment makes the design more powerful.

Control-group Time-series Design

Control-group Time-series Design utilizes a control group. The control group is also an intact class group. The control group like the experimental group is tested on the dependent variable at the same intervals of time, but is not exposed to the experimental treatment.

The researcher is interested in studying the effect of praise on students' participation during discussion. For this purpose he takes students of X grade from two institutions of the same city. He observes student's participation during discussion in both the institutions for five times at fixed intervals. Later to one of the groups the researcher introduces praise. In another institution the discussion is organized in usual manner. Later both the groups are observed periodically for five times for their participation in discussion. In this way two groups of students are taken as intact groups from the field situation. They are non-equivalent groups. Both the groups are observed periodically for the variable under study (dependent variable). One of the groups is given treatment. At the end of the treatment both the groups are again tested on periodic intervals for dependent variable. The observation tool is the same for all the periodic observations. The observation tool is the same for both the groups.

Table 7.9: Control-group Time-series Design

Group		Independent Variable	
Experimental	$T_1\ T_2\ T_3\ T_4$	Experimental treatment	$T_5\ T_6\ T_7\ T_8$
Control	$T_1\ T_2\ T_3\ T_4$	No experimental treatment	$T_5\ T_6\ T_7\ T_8$

Strengths

1. This design is valid against the internal validity criteria of History, Maturation, Testing, Instrumentation, Regression, Selection, Mortality and Interaction of Selection and Maturation.

   a) If any special event like students strike etc. takes place during the observation or treatment period, it will equally affect both the groups. Thus the design will overcome the effects due to history.

   b) The maturation on the part of subjects like interest in studies, liking towards the teacher etc. if any, will be controlled by the presence of control group.

   c) The testing effect if any, will be equally present at all the time intervals in both the groups.

   d) The instrument effect will be controlled because of repeated measurements and the presence of control group.

   e) The dependent variable has been measured at periodic intervals in both the groups. Even if the group comprised some specific subjects who may be more motivated or more intelligent it will be controlled as the repeated measurements have been taken.

   f) The mortality will not affect the dependent variable because the data of only those subjects will be taken into consideration during analysis who are present during periodic observations.

   g) If by chance, one of the groups taken has a higher rate of maturation and this group is given treatment, the effect will be balanced as in the experimental group and there will be general rate of gain that will be projected in the pre-treatment observations.

   h) The inclusion of a control group in this design is useful for the necessary comparison.

Limitations

1. There may be interaction effect due to repeated tests and this would restrict the findings to the populations, which have been subjected to repeated testing. The design therefore is not valid against the external validity criteria of Interaction Testing and Treatment as well as interaction of Selection and Treatment.
2. The usual statistical techniques may not be applicable with such designs.

Applicability: Control Group Time Series Design can be applied to those situations where:

a) Subjects cannot be assigned randomly to different groups.

b) One of the groups receives treatment and the other group is exposed to the usual situation.

c) Both the groups can be repeated measured at different time intervals before and after the treatment.

d) Measuring instrument is such that its repeated use does not affect the dependent variable.

e) The design is particularly useful in institutions where repeated measurements on the part of students are required. Further it is more powerful than the Time Series Design because of the presence of non-treatment group and repeated measurements.

In short it may be said that the experimental designs are basically of three types viz. Pre-experimental designs, True experimental designs and Quasi-experimental designs. They have their own strengths and limitations. It depends upon the researcher and the nature of his research problem that the design can be selected.

Check Your Progress

Notes: a) Space is given below for writing your answers.

b) Compare your answers with those given at the end of the unit.

5. What is the major focus of quasi-experimental design?

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6. What is counter balanced design?

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7.7 STEPS IN EXPERIMENTAL RESEARCH

The steps of the experimental method are not different from those of a scientific method. For the sake of clarification, the major steps as given by Koul (1997) may be described as under:

a) Selecting and Defining the Problem

Experimental research starts with the selection of the problem, which is amenable to experimentation. It needs a rigorous logical analysis and definition of the problem in precise terms. The variables to be studied should be defined in operational terms clearly and unambiguously. It helps the researcher to convert the problem precisely into a hypothesis that can be verified or refuted by the experimental data.

b) Stating of Hypotheses

The stating of problem hypotheses is one of the distinguishing characteristics of the experimental method. Hypotheses are the heart of experimental research. They suggest that an antecedent condition or phenomenon (independent variable) is related to the occurrence of another condition, phenomenon, event, or effect (dependent variable). To test a hypothesis, the researcher attempts to control all the conditions except the independent variable, which he manipulates. Then he observes the effect on the dependent variable presumably because of the exposure to the independent variable. The researcher, therefore, should not only be concerned primarily with experimental plans and statistical procedures, but should give sufficient attention to formulation of hypothesis. The experimental plans and statistical procedures merely help him in the testing of hypotheses and contribute little in the development of theories or advancement of knowledge. The hypotheses developed or derived from existing theories, however, contribute to the development of new theories and knowledge.

c) Constructing the Experimental Design

Experimental plan refers to the conceptual framework within which the experiment is conducted. As per Van Dalen (1973, p. 260) experimental plan represents all elements, conditions or phenomena, and relations of consequences so as to:

- identify all non-experimental variables that might contaminate the experiment and determine how to control them;
- select a research design;
- select a sample of subjects to represent a given population, assign subjects to groups, and assign experimental treatments to groups;
- select or construct and validate instruments to measure the outcomes of the experiment;
- outline procedures for collecting data and possibly conduct a pilot or 'trial run' test to perfect the instruments or design; and
- state the statistical or null hypothesis.

In order to select a suitable research design for conducting the experiment and assign subjects to different experimental treatments to measures the outcomes of experiment, the researcher must be well acquainted with different types of experimental designs.

In the unit on descriptive research you have studied the nature of correlational studies so as to find out the relationship between the variables without considering the influence of intervening variables. In a study of experimental nature, the relationship between the variables is studied by controlling the significant intervening variables. Experimental studies provides for much control, therefore, establishes a systematic and logical association or relationship between the variables (dependent and independent) which is not possible in the studies of descriptive nature.

In common parlance 'correlation' means any type of relationship between phenomena. Statistically, it refers to the quantitative extent of relationship between variables. Very often the researcher in education would like to see whether relationship exists between the variables in the field, viz. between intelligence and achievement, achievement and study habits, study habit and home background, etc. The relationship may be simple and linear or complex and curvilinear.

For example you might have seen that intelligence and achievement are related and this relationship is simple and linear. That is higher the intelligence, greater the achievement. But the relationship between height and weight is not of the same nature. Up to certain age level in children height and weight are related. That is, as the height increases weight also increases. After a particular age this relationship stops. Such types of relationships are called as curvilinear relationships.

The relationship between variables may be statistically established by the use of Pearson's 'r'. Spearman's 'rho', or the coefficients of partial or multiple correlation, according to the nature of data and the objective of investigation. It may be mentioned here that knowledge about the strength and direction of relationship between variables is of utmost importance in the field of education. To take an example from the teaching-learning situations, if several methods of teaching are found to be related to learning outcome of pupils, the one that shows very high positive correlation with learning out come may be prescribed for practice.

Hypothesizing is an important component of the design of correlational studies. A well-formulated set of hypotheses ensures testing of the indices of correlation for their significance. A positive and significant correlation between two variables under investigation indicate that the variables are directly related, that is when one increases in value, the value of the other also will increase correspondingly. Similarly, if the correlation coefficient between two variables comes out to be significantly negative, it means that they are related, that is, when one variable increases in value, the other decreases in value.

Meaningful interpretation of the index of correlation between variables under study would demand that the subjects chosen for measuring the variables are adequately sampled following some dependable technique of sample selection. Random sampling, of course, would be the best choice. But in the educational research situations random sampling is not often possible. In that case some other defensible technique of sampling should be adopted. If care is not taken in the sampling procedure, the value of the index of correlation may give wrong indication of the relationship between the variables under investigation.

Reliability and validity of the measuring instruments

Reliability and validity of the measuring instruments used in the correlational studies are the potent factors that affect the index of correlation between the variables under study. If the reliability and validity indices are not of proper degree, the relationship found out between the variables is quite likely to be mis-represented.

Correlation and causation are different

It must be remembered that the coefficient of correlation obtained in the correlational studies does not imply any cause-effect relationship between variables. It merely indicates that the variables are related or associated. It is possible that the variables are causally related, but this conclusion cannot be drawn from the correlation coefficient alone. This means that correlation obtained through correlational studies is a necessary but not a sufficient condition for causal relation between variables.

In short it may be said that correlational studies help the researcher to understand relationship between and among different variables. But correlation coefficient is not the indicator of causation.

Check Your Progress

Notes: a) Space is given below for writing your answers.

b) Compare your answers with those given at the end of the unit.

7. What is linear correlation?

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8. What is the difference between causation and correlation? Give examples.

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7.8 LET US SUM UP

In this Unit, our major focus was to discuss different types of experimental designs. There are basically three types of experimental designs based on the criteria of randomness. The experimental designs where subjects are randomly selected and treatment is randomly assigned to the groups and these groups are equated to the maximum extent and later post-tested are called True Experimental Designs. However, randomization and controls are not possible in educational research. In such cases the researcher has to depend on Pre-experimental and Quasi-experimental Designs. All these designs have their different applicability. Selection of particular design depends on the nature of the research problem, objectives of the study and manipulation of variables on the part of the researcher. Apart from causal relationship studies, the researcher can go for correlational studies. These studies help the researcher to find out the association between different types of variables for understanding the complex educational phenomenon.

7.9 UNIT-END ACTIVITY

- Plan a study based on your experience as a student or as a teacher to find out causal relationship and correlation between different variables that affect the achievement of students. Plan an experiment accordingly. List in detail the various factors that affect the external and internal validity of the experimental design planned by you.

7.10 POINTS FOR DISCUSSION

1. a) How is experimental method of research different from descriptive research?
   b) What are the important criteria that a researcher must keep in mind while selecting an experimental design for Indian classrooms?
   c) Can an experimental design be totally internally valid and externally valid in education?
   d) Discuss the relative merits of pre-experimental research, true experimental research and quasi-experimental research.

7.11 SUGGESTED READINGS

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- Goode, W.J. and Halt, P.K. (1952): *Methods of Social Science Research*. New York: MacGraw Hill.
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7.12 ANSWERS TO CHECK YOUR PROGRESS

1. Experimental designs are defined into different groups based on the four criteria. These are:

   a) Random assignment of the subjects to the groups.

   b) Random assignment of the treatments to the groups.

   c) Equating the groups to the maximum extent with respect to various intervening variables.

   d) Having post-test of all the groups involved in the experiment.

2. In one group pre-test and post-test design the researcher measures the dependent variable before the treatment variable is applied or withdrawn and again measures after the treatment is over. The difference between the two measurements of dependent variable is due to the effect of independent variable. In static group comparison design, there are two groups, one group is exposed to experimental treatment and the other group is not. At the end of the experiment, the dependent variable is measured for the two groups and then compared to determine the effect of independent variables or treatment variables.

3. Pre-experimental design lacks in internal and external validity. But true experimental design overcomes this problem by controlling the main effects of history, maturation, testing, measuring instruments, statistical regression, selection and mortality Therefore, true experimental design is better than pre-experimental design.

4. Factorial design.

5. The major focus of quasi experimental design is to meet the criteria of random assigning of treatment to the groups, to equate the groups to the maximum extent, and to administer the post-test at the end of the experiment.

6. The counter balanced design is used when the random assignment of subjects to experimental and control groups is not possible. This design uses intact classes and rotates the groups at periodic internals during the experimentation.

7. Correlation means any type of relationship between variables. It refers to the quantitative extent of relationship between variables.

8. Causation refers to cause-effect relationship between and among variables, whereas correlation implies relationship between and among different variables. For example, fatigue may cause poor attention in a classroom situation. It is a case of causation. But, intelligence is highly correlated with student performance in school.