7

EXPERIMENTAL RESEARCH

Unit Structure

7.0 OBJECTIVES :

After going through this module, you will be able to:

(i) Conceptualize experimental method of Educational research;

(ii) Describe the salient features of experimental research; on

(iii) Conceptualize various experimental design

(iv) Conceptualize the internal and external experimental validity

(v) Conceptualize the process of controlling the intervening and extraneous variables; and

(vi) Apply experimental method for appropriate research problem.

7.1 INTRODUCTION :

The experimental method in educational research is the application and adaptation of the classical method of experimentation. It is a scientifically sophisticated method. It provides a method of investigation to derive basic relationships among phenomena under controlled condition or, more simply, to identify the conditions underlying the occurrence of a given phenomenon. Experimental research is the description and analysis of what will be, or what will occur, under carefully controlled conditions.

Experimenters manipulate certain stimuli, treatments, or environmental conditions and observe how the condition or behaviour of the subject is affected or changed. Such manipulations are deliberate and systematic. The researchers must be aware of other factors that could influence the outcome and remove or control them in such a way that it will establish a logical association between manipulated factors and observed factors.

Experimental research provides a method of hypothesis testing. Hypothesis is the heart of experimental research. After the experimenter defines a problem he has to propose a tentative answer to the problem or hypothesis. Further, he has to test the hypothesis and confirm or disconfirm it.

Although, the experimental method has greatest utility in the laboratory, it has been effectively applied non-laboratory settings such as the classroom. The immediate purpose of experimentation is to predict events in the experimental setting. The ultimate purpose is to generalize the variable relationships so that they may be applied outside the laboratory to a wider population of interest.

Characteristics of Experimental Method

There are four essential characteristics of experimental research: (i) Cool, (ii) Manipulationtrn, (iii) Observation, and (iv) Replication.

Control : Variables that are not of direct interest to the researcher, called extraneous variables, need to be controlled. Control refers to removing or minimizing the influence of such variables by several methods such as: randomization or random assignment of subjects to groups; matching subjects on extraneous variable(s) and then assigning subjects randomly to groups; making groups that are as homogenous as possible on extraneous variable(s); application of statistical technique of analysis of covariance (ANCOVA); balancing means and standard deviations of the groups.

Manipulation : Manipulation refers to a deliberate operation of the conditions by the researcher. In this process, a pre-determined set of conditions, called independent variable or experimental variable. It is also called treatment variable. Such variables are imposed on the subjects of experiment. In specific terms manipulation refers to deliberate operation of independent variable on the subjects of experimental group by the researcher to observe its effect. Sex, socio-economic status, intelligence, method of teaching, training or qualification of teacher, and classroom environment are the major independent variables in educational research. If the researcher, for example, wants to study the effect of 'X' method of teaching on the achievement of students in mathematics, the independent variable here is the method of teaching. The researcher in this experiment needs to manipulate 'X' i.e. the method of teaching. In other words, the researcher has to teach the experimental groups using 'X' method and see its effect on achievement.

Observation : In experimental research, the experimenter observes the effect of the manipulation of the independent variable on dependent variable. The dependent variable, for example, may be performance or achievement in a task.

Replication : Replication is a matter of conducting a number of sub-experiments, instead of one experiment only, within the framework of the same experimental design. The researcher may make a multiple comparison of a number of cases of the control group and a number of cases of the experimental group. In some experimental situations, a number of control and experimental groups, each consisting of equivalent subjects, are combined within a single experiment.

Check your progress – 1

Q.1) What are the characteristics of experimental research?

7.2 EXPERIMENTAL DESIGNS :

Experimental design is the blueprint of the procedures that enable the researcher to test hypotheses by reaching valid conclusions about relationships between independent and dependent variables (Best, 1982, p.68). Thus, it provides the researcher an opportunity for the comparison as required in the hypotheses of the experiment and enables him to make a meaningful interpretation of the results of the study. The designs deal with practical problems associated with the experimentation such as: (i) how subjects are to be selected for experimental and control groups, (ii) the ways through which variables are to be manipulated and controlled, (iii) the ways in which extraneous variables are to be controlled, how observations are to be made, and (iv) the type of statistical analysis to be employed.

Variables are the conditions or characteristics that the experimenter manipulates, controls, or observes. The independent variables are the conditions or characteristics that the experimenter manipulates or controls in his or her attempt to study their relationships to the observed phenomena. The dependent variables are the conditions or characteristics that appear or disappear or change as the experimenter introduces, removes or changes the independent variable. In educational research teaching method is an example of independent variable and the achievement of the students is an example of dependent variable. There are some confounding variables that might influence the dependent variable. Confounding variables are of two types; intervening and extraneous variables. Intervening variables are those variables that cannot be controlled or measured but may influence the dependent variable. Extraneous variables are not manipulated by the researcher but influence the dependent variable. It is impossible to eliminate all extraneous variables, but sound experimental design enables the researcher to more or less neutralize their influence on dependent variables.

There are various types of experimental designs. The selection of a particular design depends upon factors like nature and purpose of experiment, the type of variables to be manipulated, the nature of the data, the facilities available for carrying out the experiment and the competence of the experimenter. The following categories of experimental research designs are popular in educational research:

(i) Pre-experimental designs – They are least effective and provide little or no control of extraneous variables.

(ii) True experimental designs – employ randomization to control the effects of variables such as history, maturation, testing, statistical regression, and mortality.

(iii) Quasi-experimental designs – provide less satisfactory degree of control and are used only when randomization is not feasible.

(iv) Factorial designs- more than one independent variables can be manipulated simultaneously. Both independent and interaction effects of two or more than two factors can be studied with the help of this factorial design.

Symbols used :

In discussing experimental designs a few symbols are used.

E – Experimental group

C – Control group

X – Independent variable

Y – Dependent variable

R – Random assignment of subjects to groups

Y_b – Dependent variable measures taken before experiment / treatment (pre-test)

Y_a – Dependent variable measures taken after experiment/ treatment (Post-test)

M_r – Matching subjects and then random assignment to groups.

a. Pre-Experimental design :

There are two types of pre-experimental designs:

1. The one group pre-test post-test design :

This is a simple experimental research design without involvement of a control group. In this design the experimenter takes dependent variable measures (Y_b) before the independent variable (X) is manipulated and again takes its measures (Y_a) afterwards: The difference if any, between the two measurements (Y_b and Y_a) is computed and is ascribed to the manipulation of X.

Pre-test	Independent variable	Post-test
Y_b	X	Y_a

The experimenter, in order to evaluate the effectiveness of computer-based instruction (CBI) in teaching of science to grade V students, administers an achievement test to the whole class (Y_b) before teaching through CBI. The test is administered over the same class again to measure Y_a. The means of Y_b and Y_a are compared and the difference if any is ascribed to effect of X, i.e. teaching through CBI.

The design has the inherent limitation of using one group only. The design also lacks scope of controlling extraneous variables like history, maturation, pre-test sensitization, and statistical regression etc.

2. The two groups static design :

This design provides some improvement over the previous by adding a control group which is not exposed to the experimental treatment. The experimenter may take two sections of grade-V of one school or grade-V of one school or grade-V students of two different schools (intact classes) as experimental and control groups respectively and assume the two groups to be equivalent. No pre-test is taken to ascertain it.

Group	Independent Variable	Post-test
E	X	Y_a
C	-	Y_a

This design compares the post-test scores of experimental group (Y_a E) that has received experimental treatment (X) with that of control group (Y_a C) that has not received X.

The major limitation of the design is that there is no provision for establishing the equivalence of the experimental (E) and control (C) groups. However, since no pretest is used, this design controls for the effects of extraneous variables such history, maturation, and pre-testing.

Check your progress – 2

Q.2) What is pre-experimental design?

b. Quasi-Experimental Design :

Researchers commonly try to establish equivalence between the experimental and control groups, the extent they are successful in doing so; to this extent the design is valid. Sometimes it is extremely difficult or impossible to equate groups by random selection or random assignment, or by matching. In such situations, the researcher uses quasi-experimental design.

The Non-Equivalent Groups Design is probably the most frequently used design in social research. It is structured like a pretest-posttest randomized experiment, but it lacks the key feature of the randomized designs -- random assignment. In the Non-Equivalent Groups Design, we most often use intact groups that we think are similar as the treatment and control groups. In education, we might pick two comparable classrooms or schools. In community-based research, we might use two similar communities. We try to select groups that are as similar as possible so we can fairly compare the treated one with the comparison one. But we can never be sure the groups are comparable. Or, put another way, it's unlikely that the two groups would be as similar as they would if we assigned them through a random lottery. Because it's often likely that the groups are not equivalent, this designed was named the nonequivalent group design to remind us.

Pre-test	Independent Variable	Post-test
Y_b	X	Y_a (Experimental)
Y_b	-	Y_a (Control)

So, what does the term "nonequivalent" mean? In one sense, it just means that assignment to group was not random. In other words, the researcher did not control the assignment to groups through the mechanism of random assignment. As a result, the groups may be different prior to the study. This design is especially susceptible to the internal validity threat of selection. Any prior differences between the groups may affect the outcome of the study. Under the worst circumstances, this can lead us to conclude that our program didn't make a difference when in fact it did, or that it did make a difference when in fact it didn't.

The counterbalanced design may be used when the random assignment of subject to experimental group and control group is not possible. This design is also known as rotation group design. In counterbalanced design each group of subject is assigned to experimental treatment at different times during the experiment. This design overcomes the weakness of non-equivalent design. When intact groups are used, rotation of groups provides an opportunity to eliminate any differences that might exist between the groups. Since all the groups are exposed to all the treatments, the results obtained cannot be attributed to the preexisting differences in the subjects. The limitation of this design is that 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 the administration of one treatment on a group will have no effect on the next treatment. There is possibility of boring students with repeated testing.

Check your progress – 3

How does pre-experimental design differ from quasi experimental design?

c. True experimental design :

True experimental designs are used in educational research because they ascertain equivalence of experimental and control groups by random assignment of subjects to these groups, and thus, control the effects of extraneous variables like history, maturation, testing, measuring instruments, statistical regression and mortality. This design, in contrast to pre-experimental design, is a better and used in educational research wherever possible.

1. Two groups, randomized subjects, post-test only design:

This is one of the most effective designs in minimizing the threats to experimental validity. In this design subjects are assigned to experimental and control groups by random assignment which controls all possible extraneous variables, e.g. testing, statistical regression, mortality etc. At the end of experiment the difference between the mean post-test scores of the experimental and control group are put to statistical test –'t' test or analysis of variance (ANOVA). If the differences between the means are found significant, it can be attributed to the effect of (X), the independent variable.

	Group	Independent Variable	Post-test
R	E	X	Y_a
	C	-	Y_a

The main advantage of this design is random assignment of subjects to groups, which assures the equivalence of the groups prior to experiment. Further, this design, in the absence of pretest, controls the effects of history, maturation and pre-testing etc.

This design is useful in the experimental studies at the pre-primary or primary stage and the situations in which a pre-test is not appropriate or not available.

2. Two groups, randomized matched subject, post-test only design :

This design, instead of using random assignment of subjects to experimental and control group, uses the technique of matching. In this technique, the subjects are paired so that their scores on matching variable(s), i.e. the extraneous variable(s) the experimenter wants to control, are as close as possible. One subject of each pair is randomly assigned to one group and the other to the second group. The groups are designated as experimental and control by random assignment (tossing a coin).

	Group	Independent Variable	Post-test
MR	E	X	Y_a
	C	-	Y_a

This design is mainly used where "two groups randomized subjects, post-test only" design is not applicable and where small groups are to be used. The random assignment of subjects to groups after matching adds to the strength of this design. The major limitation of the design is that it is very difficult to use matching as a method of controlling extraneous variables because in some situations it is not possible to locate a match and some subjects are excluded from the experiment.

3.Two groups randomized subjects, pre-test post-test design :

In this design subjects are assigned to the experimental group and the control group at random and are given a pre-test (Y_b). The treatment is introduced only to the experimental group, after which the two groups are measured on dependent variable. The difference in scores or gain scores (D) in respect of pre-test and post-test (Y_a – Y_b = D) is found for each group and the difference in scores of both the groups (D_e and D_c) is compared in order to ascertain whether the experimental treatment produced a significant change. Unless the effect of the experimental manipulation is strong, the analysis of the differential score is not advisable (Kerlinger, 1973, p-336). If they are analyzed, however, a ‘t’ or ‘F’ test is used.

Group	Pre-test	Independent Variable	Post-test
E	Y_b	X	Y_a
C	Y_b	-	Y_a

The main advantages of this design include:

- Through initial randomization and pre-testing equivalence between the two groups can be ensured.
- Randomization seems to control most of the extraneous variables.

But the design does not guarantee external validity of the experiment as the pretest may increase the subjects’ sensitivity to the manipulation of X.

4. The Solomon three groups design :

This design, developed by Solomon seeks to overcome the difficulty of the design: Randomized Groups, Pre-test Posttest Design, i.e. the interactive effects of pre-testing and the experimental manipulation. This is achieved by employing a second control group (C_2) which is not pre-tested but is exposed to the experimental treatment (X).

Group	Pre-test	Independent Variable	Post-test
E	Y_b	X	Y_a
C_1	Y_b	-	Y_a
C_2	-	X	Y_a

This design provides scope for comparing post-tests (Y_a) scores for the three groups. Even though the experimental group has a significantly higher mean score as compared to that of the first control group ($Y_aE > Y_a C_1$), one cannot be confident that this difference is due to the experimental treatment (X). It might have occurred because of the subjects’ pre-test sensitization. But, if the mean Y_a scores of the second control group is also higher as compared to that of the first control group ($Y_a C_2 > Y_a C_l$), then one can assume that the experimental treatment has produced the difference rather than the pre-test sensitization, since C_2 is not pre-tested.

5. The Solomon four group design :

This design is an extension of Solomon three group design and is really a combination of two two-groups designs: (i) Two groups randomized subjects pre-test post-test design; and (ii) Two group randomized subjects post-test only design. This design provides rigorous control over extraneous variables and also provides opportunity for multiple comparisons to determine the effects of the experimental treatment (X).

In this design the subjects are randomly assigned to the four groups. One experimental (E) and three control (C_l, C_2 and C_3). The experimental and the first control group (E and C_1) are pre-tested groups, and the second and third control groups (C_2 and C_3) are not pre-tested groups. If the post-test mean scores of experimental group (Y_a E) is significantly greater than the post-test mean score of the first control group (Y_a C_1); and also the post test mean score of the second control group (Y_a C_2) is significantly greater than the post-test mean score of the third control group (Y_a C_3), the experimenter arrives at the conclusion that the experimental treatment (X) has effect.

	Group	Pre-test	Independent Variable	Post test
	E	Y_b	X	Y_a
	C_1	Y_b	-	Y_a
R				
	C_2	-	X	Y_a
	C_3	-	-	Y_a

This design is considered to be strong one as it actually involves conducting the experiment twice, once with pre-test and once without pre-test. Therefore, if the results of these two experiments are in agreement, the experimenter can have much greater confidence in his findings. The design seems to have two sources of weakness. One is practicability as it is difficult to conduct two simultaneous experiments, and the researcher encounters the difficulty of locating more subjects of the same kind. The other difficulty is statistical. Since the design involves four sets of measures for four groups and the experimenter has to make comparison between the experimental and first control group and between second and third control groups there is no single statistical procedure that would make use of the six available measures simultaneously.

Check your progress – 4

How does true experimental design differ from quasi experimental design?

7.3 FACTORIAL DESIGN :

Experiments may be designed to study simultaneously the effects of two or more variables. Such an experiment is called factorial experiment. Experiments in which the treatments are combinations of levels of two or more factors are said to be factorial. If all possible treatment combinations are studied, the experiment is said to be a complete factorial experiment. When two independent factors have two levels each, we call it as 2x2 (spoken "two-by-two") factorial design. When three independent factors have two levels each, we call it 2x2x2 factorial design. Similarly, we may have 2x3, 3x3, 3x4, 3x3x3, 2x2x2x2, etc.

Simple Factorial Design :

A simple factorial design is 2x2 factorial design. In this design there are two independent variables and each of the variables has two levels. One advantage is that information is obtained about the interaction of factors. Both independent and interaction effects of two or more than two factors can be studied with the help of this factorial design.

In factorial designs, a **factor** is a major independent variable. In this example we have two factors: methods of teaching and intelligence level of the students. A **level** is a subdivision of a factor. In this example, method of teaching has two levels and intelligence has two levels. Sometimes we depict a factorial design with a numbering notation. In this example, we can say that we have a 2 x 2 (spoken "two-by-two") factorial design. In this notation, the number of numbers tells us how many factors there are and the number values tell how many levels. The number of different treatment groups that we have in any factorial design can easily be determined by multiplying through the number notation. For instance, in our example we have 2x2 = 4 groups. In our notational example, we would need 3 x 4 = 12 groups. Full factorial experiment is an experiment whose design consists of two or more factors, each with discrete possible values or "levels", and whose experimental units take on all possible combinations of these levels across all such factors. A full factorial design may also be called a fully-crossed design. Such an experiment allows studying the effect of each factor on the response variable, as well as the effects of interactions between factors on the response variable.

For the vast majority of factorial experiments, each factor has only two levels. For example, with two factors each taking two levels, a factorial experiment would have four treatment combinations in total, and is usually called a 2×2 factorial design. The first independent variable, which is manipulated, has two values called the experimental variable. The second independent variable, which is divided into levels, may be called control variable. For example, there are two experimental treatments, that is, teaching through co-operative learning and teaching through lecture method. It is observed that there may be differential effects of these methods on different levels of intelligence of the students. On the basis of the IQ score the experimenter divides the students into two groups: one high intelligent group and the other the low intelligent group. There are four groups of students within each of the two levels of intelligence.

	High Intelligence Group	Low Intelligence Group
Teaching Through Co-operative Learning Method	Gain Score on the Dependent Variable	Gain Score on the Dependent Variable
Teaching Through Lecture Method	Gain Score on the Dependent Variable	Gain Score on the Dependent Variable

Since one of the objectives is to compare various combinations of these groups, the experimenter has to obtain the mean scores for each row and each column. The experimenter can first study the main effect of the two independent variables and the interaction effect between the intelligence level and teaching method.

Check your progress – 5

1. How does factorial design differ from true experimental design?

7.4 NESTED DESIGN :

In a nested design, each subject receives one, and only one, treatment condition. In a nested design, the levels of one factor appear only within one level of another factor. The levels of the first factor are said to be nested within the level(s) of the second factor. When variables such as race, income and education, etc. may be found only at a particular level of the independent variable, these variables are called nested variables. In these studies the various nested variables are grouped for the study. For example, a researcher is studying school effectiveness with academic achievement of students as the indicator or criterion variable. In this type of research, school type can be nested within individual schools which can be nested within classrooms. The major distinguishing feature of nested designs is that each subject has a single score. The effect, if any, occurs between groups of subjects and thus the name "**Between Subjects"** is given to these designs. The relative advantages and disadvantages of nested designs are opposite those of crossed designs. First, carry over effects are not a problem, as individuals are measured only once. Second, the number of subjects needed to discover effects is greater than with crossed designs. Some treatments by their nature are nested. The effect of gender, for example, is necessarily nested. One is either a male or a female, but not both. Religion is another example. Treatment conditions which rely on a pre-existing condition are sometimes called demographic or blocking factors.

Crossed Design :

In a crossed design each subject sees each level of the treatment conditions. In a very simple experiment, such as one that studies the effects of caffeine on alertness, each subject would be exposed to both a caffeine condition and a no caffeine condition. For example, using the members of a statistics class as subjects, the experiment might be conducted as follows. On the first day of the experiment, the class is divided in half with one half of the class getting coffee with caffeine and the other half getting coffee without caffeine. A measure of alertness is taken for each individual, such as the number of yawns during the class period. On the second day the conditions are reversed; that is, the individuals who received coffee with caffeine are now given coffee without and vice-versa. The size of the effect will be the difference of alertness on the days with and without caffeine.

The distinguishing feature of crossed designs is that each individual will have more than one score. The effect occurs within each subject, thus these designs are sometimes referred to as ‘within subjects’ designs.

Crossed designs have two advantages. One, they generally require fewer subjects, because each subject is used a number of times in the experiment. Two, they are more likely to result in a significant effect, given the effects are real.

Crossed designs also have disadvantages. One, the experimenter must be concerned about carry-over effects. For example, individuals not used to caffeine may still feel the effects of caffeine on the second day, even though they did not receive the drug. Two, the first measurements taken may influence the second. For example, if the measurement of interest was score on a statistics test, taking the test once may influence performance the second time the test is taken. Three, the assumptions necessary when more than two treatment levels are employed in a crossed design may be restrictive.

Check your progress - 6

1. What is the difference between nested design and crossed design?

7.5 SINGLE FACTOR EXPERIMENT :

Many experiments involve single treatment or variable with two or more levels. First, a group of experimental subjects may be divided into independent groups, using a random method. Different treatment may be applied to each group. One group may be a control group, a group to which no treatment is applied. For meaningful interpretation of experiment, results obtained under treatment may be compared with results obtained in the absence of treatment. Comparison may be made between treatments and between treatment and a control.

Some single factor experiments involve a single group of subjects. Each subject receives treatments. Repeated observations or measurements are made on the same subjects.

Some single factor experiments may consists of groups that are matched on one or more variables which are known to be correlated with the dependent variable. For example IQ may be correlated with achievement.

An example of single factor Experiment :

It is believed that the amount of time a player warms up at the beginning will have a significant impact on his game, lawn tennis. The hypothesis is that if he does not warm up at all or only for a brief time (less than 15 minutes), he will be stiff and his score will be poor. However, if he warms up too much (over 40 minutes), he will be tired and his game score will also suffer. He needs to choose levels of warming up to test this hypothesis that are significantly different enough. The levels he will test are warming up for 0, 15, 30, and 45 minutes.

7.6 INTERNAL AND EXTERNAL EXPERIMENTAL VALIDITY :

Validity of experimentation :

An experiment must have two types of validity: internal validity and external validity (Campbell and Stanley, 1963):

Internal validity :

Internal validity refers to the extent to which the manipulated or independent variables actually have a genuine effect on the observed results or dependent variable and the observed results were not affected by the extraneous variables. This validity is affected by the lack of control of extraneous variables.

External validity :

External validity is the extent to which the relationships among the variables can be generalized outside the experimental setting like other population, other variables. This validity is concerned with the generalizability or representativeness of the findings of experiment, i.e. to what population, setting and variables can the results of the experiment be generalized.

Factors affecting validity of experimentation :

In educational experiments, a number of extraneous variables influence the results of the experiment in way that are difficult to evaluate. Although these extraneous variables cannot be completely eliminated, many of them can be identified. Campbell and Stanley (1963) have pointed out the following major variables which affect significantly the validity of an experiment:

History : The variables, other than the independent variables, that may occur between the first and the second measurement of the subjects (Pre-test and post test).

Maturation : The changes that occur in the subjects over a period of time and confused with the effects of the independent variables.

Testing : Pre-testing, at the beginning of an experiment, may be sensitive to subjects, which may produce a change among them and may affect their post-test performance.

Measuring Instruments : Different measuring instruments, scorers, interviewers or the observers used at the pre and post testing stages; and unreliable measuring instruments or techniques are threats to the validity of an experiment.

Statistical regression : It refers to the tendency for extreme scores to regress or move towards the common mean on subsequent measures. The subjects who scored high on a pre-test are likely to score relatively low on the retest whereas the subjects who scored low on the pre-test are likely to score high on the retest.

Experimental mortality : It refers to the differential loss of subjects from the comparison groups. Such loss of subjects may affect the findings of the study. For example, if some subjects in the experimental group who received the low scores on the pre-test drop out after taking the test, this group may show higher mean on the post-test than the control group.

Differential selection of subjects : It refers to difference between/among groups on some important variables related to the dependent variable before application of the experimental treatment.

Check your progress – 7

1. What is experimental validity?

7.7 CONTROLLING EXTRANEOUS AND INTERVENING VARIABLES :

All experimental designs have one central characteristic: they are based on manipulating the independent variable and measuring the effect on the dependent variable. Experimental designs result in inferences drawn from the data that explain the relationships between the variables.

The classic experimental design consists of the experimental group and the control group. In the experimental group the independent variable is manipulated. In the control the dependent variable is measured when no alteration has been made on the independent variable. The dependent variable is measured in the experimental group the same way, and at the same time, as in the control group.

The prediction is that the dependent variable in the experimental group will change in a specific way and that the dependent variable in the control group will not change.

Controlling Unwanted Influences :

To obtain a reliable answer to the research question, the design should eliminate unwanted influences. The amount of control that the researcher has over the variables being studied varies, from very little in exploratory studies to a great deal in experimental design, but the limitations on control must be addressed in any research proposal.

These unwanted influences stem from one or more of the following: extraneous variables, bias, the Hawthorne effect, and the passage of time.

Extraneous Variables :

Extraneous variables are variables that can interfere with the action of the independent variable. Since they are not part of the study, their influence must be controlled.

In the research literature, the extraneous variables also referred to as intervening variables, directly affect the action of the independent variable on the dependent variables. Intervening variables are those variables that occur in the study setting. They include economic, physical, and psychological variables. Therefore, it is important to control extraneous variables to study the effect of independent variable on dependent variable. We must be very careful to control all possible extraneous variables that might intervene the dependant variable.

Methods of controlling extraneous variables include :

- randomization
- homogeneous sampling techniques
- matching
- building the variables into the design
- statistical control

Randomization : Theoretically, randomization is the only method of controlling all possible extraneous variables. The random assignment of subjects to the various treatment and control groups means that the groups can be considered statistically equal in all ways at the beginning of the experiment. It does not mean that they actually are equal for all variables.

However, the probability of their being equal is greater than the probability of their not being equal, if the random assignment was carried out properly. The exception lies with small groups where random assignment could result in unequal distribution of crucial variables. If this possibility exists, the other method would be more appropriate. In most instances, however, randomization is the best method of controlling extraneous variables.

A random sampling technique results in a normal distribution of extraneous variables in the sample; this approximates the distribution of those variables in the population. The purpose of randomization is to ensure a representative sample.

Randomization comes into play when we randomly assign subjects to experimental and control groups, thus ensuring that the groups are as equivalent as possible prior to the manipulation of the independent variable. Random assignment assures that the researcher is unbiased. Instead, assignment is predetermined for each subject.

Homogeneous Sample : One simple and effective way of controlling an extraneous variable is not to allow it to vary. We may choose a sample that is homogenous for that variable. For example, if a researcher believes that gender of the subject might affect the dependant variable, he/she could select the subjects of the desired gender only. If the researcher believes that socio-economic status might influence the dependant variable, he/she would select subject from a particular range of socio-economic status. After selecting students from a homogenous population the researcher may assign the subjects to experimental and control group randomly.

Matching : When randomization is not possible, or when the experimental groups are too small and contain some crucial variables, subjects can be matched for those variables. The experimenter chooses subjects who match each other for the specified variables. One of these matched subjects is assigned to the control group and the other to the experimental group, thus ensuring the equality of the groups at the outset.

The process of matching is time consuming and introduces considerable subjectivity into sample selection. Therefore, it should be avoided whenever possible. If we use matching, limit the number of groups to be matched and keep the number of variables for which the subjects are matched low. Matching with more than five variables becomes extremely cumbersome, and it is almost impossible to find enough matched partners for the sample. Matching may be used in all research designs when we are looking at certain outcomes and want to have as much control as possible.

Building Extraneous Variables into the Design : When extraneous variables cannot be adequately controlled by randomization, they can be built into the design as independent variables. They would have to be added to the purpose of study and tested for significance along with other variables. In this way, their effect can be measured and separated from the effect of the independent variable.

Statistical Control : In experimental designs, the effect of the extraneous variables can be subtracted statistically from the total action of the variables. The technique of analysis of covariance

(ANCOVA) may be used for this purpose. Here, one or more extraneous variables are measured along with the dependant variables. This method adds to the cost of the study because of the additional data collection and analysis required. Therefore, it should be used only as a last resort.

Check your progress - 8

1. As an experimenter, how will you control the effect of extraneous and intervening variables?

Unit End Exercise:

- Differentiate between the true experimental design and factorial design.
- Differentiate between internal and external validity.
- What is the significance of randomization in experimental research?

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