Analytical Research Design

Analytical Research designs can be experimental or observational and each type has its own features. A study design is critical to the research study because it determines exactly how we will collect and analyze our data. If we aim to study the relationship between two variables, then an analytical study design is the right choice.

But how do we know which type of analytical study design is best for our specific research question? It's necessary to have a clear plan before we begin data collection. Lots of researchers, sadly, speed through this or don't do it at all .Analytical study designs can be experimental or observational and each type has its own features.

When are analytical Research designs used?

A study design is a systematic plan, developed so you can carry out your research study effectively and efficiently. Having a design is important because it will determine the right methodologies for your study. Using the right study design makes your results more credible, valid, and coherent.

Descriptive vs. analytical Research

Study designs can be broadly divided into either descriptive or analytical.

Descriptive studies describe characteristics such as patterns or trends. They answer the questions of what, who, where, and when, and they generate hypotheses. They include case reports and qualitative studies.

Analytical study designs quantify a relationship between different variables. They answer the questions of why and how. They're used to test hypotheses and make predictions**.**

Experimental and observational

Analytical study designs can be either experimental or observational. In experimental studies, researchers manipulate something in a population of interest and examine its effects. These designs are used to establish a causal link between two variables.

In observational studies, in contrast, researchers observe the effects of a treatment or intervention without manipulating anything. Observational studies are most often used to study larger patterns over longer periods.

Experimental Research Method

The experimental method of research is used as the classical method in physical sciences. It is based on observation or experiments. It deals with actual experiments to determine the relationship between cause and effect of various experimental treatments. It is defined as 'the research method in which a researcher objectively observes phenomenon which is made to occur in a strictly controlled situation where one or more variables are varied and others are kept constant'.

The purpose of experimental research is to investigate cause and effect relationship by exposing one (or more) experimental groups to one (or more) treatment conditions & comparing the result to one (or more) control groups not receiving the treatments. In this method, the researcher undertakes control or manipulation (vary) of various variables under study. The usual approach is to hold all variables constant except one in controlled condition. By varying this one variable, the out puts (the effects) are studied and documented.

Actually, in social sciences, in natural sciences, in biological phenomena and to the human behavior control of variable is hardly possible. However, in physical sciences and experimental technology the investigation in controlled condition is highly acceptable.

Experiment is a test of a casual proposition, such as:

i) Do changes in variable 'A' cause changes in variable 'B' keeping other variables constant?

ii) How the changes in the value of one variable (called independent variable) affect another variable (called dependent variable)?

The mathematical form of the experimental method is given below: If x_1, x2, x3, x4... xn are n independent variables taken as the inputs of the process and y is the output of the process (a dependent variable), then y is defined as a function x and denoted by,

$y = f(x)$

Where,

x means x_1, x_2, x_3, x_4..... x_n and f denotes the function

Suppose for an example, yield (y) of a product in an agricultural field is influenced by the following four different independent variables:

x_1 - seed quality (qualitative variable say, Si, S2),

x_2 - amount of fertilizer (quantitative variable, in kg),

x_3 - irrigation scheme (categorical variable say, I_1, I_2,I_3)

x4 - labor input (quantitative variable say, in number)

The production or yield, which depends upon these four variables, can be related mathematically as

$Y = f(x)$

Or $Y = f(x_1, x_2, x_3, x_4)$

By taking any three (say x_1, x_2, x_3) constant one can observe the effect of x_4 in Y; x_4 may vary as researchers will, so it is said to be a controlled variable.

The various factors in an experiment are divided into two groups: independent variables and dependent variables. The first sets of a factor or factors are called an experimental group and the second sets of factors are called control group. Control group is also known as a group of individuals, items or objects used as a standard for comparison or accepted norm. It is used to compare with or to evaluate the others among which a new process or method has been implemented.

An experimental or independent factor is such a cause, which is freely changed in an experiment; usually, an independent variable consists of a single factor only because an experimenter wishes to study the effect of a cause independent of all other influences. An experimenter tries to stabilize and control all the factors in an experiment; and then takes one of these for study. He varies it to see the effect of variations upon other factors. The variations of an independent variable produce responses in other factors and these responses are actually dependent variables. These responses are subject to the cause, which is being studied.

To make the experimental method of research effective and distinct from normal activity the method of local control (blocking) and statistical control methods are used. Control is necessary to reduce variations. In some experiments, some variables may be eliminated. Undesired variations can be reduced by standardization.

Types of Experiment

Experiment is the scientific investigation in which an investigator manipulates and controls one or more independent variables and observes the dependent variables for variation concomitant to the manipulation of the independent variable. There are four different types of experiments given as follows:

1. Positive and Negative Experiment If the subject of an experiment is such that i) the phenomenon and ii) its cause both are present, the experiment is said to be positive. For example, a bell rings in the air. Here both the sound and cause of its propagation are present; but if, on the other hand, a bell is rung in a vacuum, there will be no phenomenon of a sound because the cause of the propagation, namely air is absent. Such experiment is called negative experiment.

2. Natural Experiment These experiments are to be observed in natural phenomenon. In most of the natural state experiments, the controlling of variable is unnecessary (emphatically avoidable) to obtain. the real information about the phenomena. In such case, the whole phenomenon is divided into control group and experimental group to study the effects of seen and unseen variables.

3. Laboratory Experiment These are the experiments performed in physical sciences with full control of external conditions. A laboratory experiment is an artificially created situation in which the researcher controls one or more variables while manipulating other variable at will. The method of lab experiment is used in the experiments, mainly related to the physical, chemical, microbiological, clinical and such other sciences. If, it is difficult to conduct an experiment out-side or in the field or in the society then one tries to carry out it in the laboratories. In lab experiment, the controlling of the variable as required is possible.

4. Field Experiment Field experiments are the experiments conducted in the field or in natural setting. Research study in a realistic situation in which one or more independent variables are manipulated by the experimenter under carefully controlled conditions as the situation will permit. In the social, managerial, agricultural, environmental researches, the method of field experiment is widely used. In these experiments, the influence of apparently unconnected variables is minimized as possible and experiment is carried out to study the problem in its real setting or at its existence state. Some of the field experiments like agricultural or business field the controlling of the variable is possible but in the careful condition

Purposes of Experimental Method

a. To determine the effect of various treatments and to compare the differences of effects as significant or non-significant.

b. To estimate the interaction effects of various treatments and to compare them

c. To establish the mathematical relationship between various treatments and their effects.

Problem in Experimentation

- To single out one factor from the phenomena

It is always difficult to single out one factor from a social phenomenon for the purpose of measurement, because in any event there may be many factors interacted.

- Controlling the factors

Control of factors sometimes is not possible, because some factors may be unknown and uncontrollable. It is better to select several random samples as experimental and control groups. One solution here is the adoption of the control group technique.

- To get data from the control groups

There are difficulties in getting data from the control groups. The remedy may be found in matching the control and experimental groups on as many points as possible.

- To assign the level of significance

The determination of the required level of significance of the differences between the experimental and control groups is also fraught with difficulty. What difference can be taken as fraught with difficulty? What difference can be taken as significant? There is the problem of value judgment. But the scientific criterion is the determination of the statistical test of significance. However, this requires a reliable and valid socio-metric scale.

- Change in response of people

In field experiment related with human behaviors (society and clinical setup), when data collected through human interaction due to changes in time, situation, environment and types of questions to be asked people often changes their responses.

- Change in theme of trialing

Due to change in behavior of the respondents and unsatisfactory management of the investigator theme of trialing of the area under experiment (in social and clinical setup) may change at the end of the experiment from what it was started. Because of the changes made by experimentation may give different responses which may lead wrong conclusion.

- Problem of handling or operation

In social setup and to the medical trials, if the people under study area is not aware, attentive and responsive about the inquiry, true response cannot be possible; in such situation the problem of data handling (manipulation) or the problem of conducting the study (operation) is come to pass.

Steps in Experimental Methods

Statement of the problem, research questions and the objectives

The first step in the application of field techniques is related in mentioning of problem, research questions and specific objective. The hypothesis, at this stage, should be stated explicitly in general terms.

Examination of possible outcomes and events through literature

The second step consists in setting up the field experiment by thorough reading of the available literature. The factors to be controlled must be assessed; the cooperation between the researcher and the subject must be set up; and scouting for information is required before any choice regarding setting is made.

Design of experiment

The next step is the choice of experimental design regarding its size, material, control groups etc. The choice of material should be based on the criterion of maximum possible accuracy. The basic problem of design relates to control. Control and experimental groups should be matched on all important factors. In cases where conditions cannot be standardized, the significance of the factors can be deducted through various devices of measurement, such as trends, extrapolations etc.

Performing experiment

The next step of this method is to performing experiment in predefined circumstances. The principles of randomization, replication and blocking should be implemented as can as possible. The sensitiveness of experiments can be augmented by neutralizing the biases through random choice, by increasing the replication, y improving the quantitative technique and by refinements of techniques.

Analysis of experimental out comes statistically

The analysis of the experimental data should be done starting from stating the descriptive nature of the data, measuring relationship between them and modeling data into some mathematical models. The analysis of variance permits a study of complex interrelationship, which is not possible by simpler designs. It permits more reliable conclusions about more hypotheses with fewer cases than if hypotheses were tested in separate design. In the experimental designs, it is also possible to achieve a matching of the groups through an analysis of covariance.

Drawing conclusions by measuring reliability

For an experimental research the conclusions are drawn based on the statistical significance testing. The tests can be performed as required level of design by the use of different statistical techniques. The results obtained then are put to test their reliability and the conclusions are made.

Testing the validity of the conclusion

The validity of the results should be measured before disseminating the results and reports. The validity of the experimental results is checked by the comparing with other similar phenomenon or to the standards.

Evaluation of the entire investigation through practice

The success of the experimental study can be measured only through putting into practice the experiments many times. If the repeated experiments give similar or better results, then the experimental results may be considered satisfactory.

Ethical Issues in Experimental Research Design

- The following practices are considered unethical:
- Putting pressure on individuals to participate in experiments through coercion, or applying social pressure.
- Deceiving subjects by deliberately misleading them as to the true purpose of the research.
- Exposing participants to physical or mental stress.
- Not allowing subjects to withdraw from the research when they want to.
- Using the research results to disadvantage the participants, or for purposes not to their liking.
- Not explaining the procedures to be followed in the experiment.
- Not debriefing participants fully and accurately after the experiment is over.
- Not preserving the privacy and confidentiality of the information given by the participants.
- Withholding benefits from control groups.