

# Relevance of Experimental Design

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## Abstract

Research methods in the Social Sciences are vital for the sake of knowledge (adding to or improving upon knowledge). The dynamic nature of people, organisations, nations as well as our external environment brings to fore the importance a scientific approach to analysis. There exist various methods of research designs that can be employed by a researcher. For the purpose of this paper, we shall look extensively at the experimental research design, types, pros and cons of each type. Also explained are methods of its application and its uniqueness.

**Keywords:** research design, experimental design, scientific approach, control group, experimental group

## 1. Introduction

In the social sciences, research deals with the quest of a deeper understanding and knowledge of a given matter (Agbonifoh and Yomere, 1999, p 4). The scientific approach is employed in research for the following assumptions (Frankfort-Nachmias and Nachmias, 2009, pp 5-7):

1. Nature is orderly: This assumption asserts that in spite of the dynamic environment in which we live there exist recognizable regularity and order which presupposes that events do not just occur randomly. This basic assumption is the reason why it can be studied to gain understanding of underlying phenomenon.
2. We can know nature: Owing to the fact that humans are part of nature as other tangible and intangible, animate and inanimate objects and phenomenon, we can therefore be understood and explained by the same methods employed in studying natural phenomenon.
3. All natural phenomena have natural causes: It is believed that all events or occurrences can be explained from nature, thus rejecting any other form of abstract explanation even when the immediate cause is yet to be deduced.
4. Nothing is self evident: This implies the objective expression of claims of truth. Skepticism and criticality thinking is engaged in verification of scientific knowledge. This precludes intensive reliance on custom, prejudice or bias and common sense.
5. Knowledge is derived from the acquisition of experience: This presupposes reliance on insight, know-how and scrutiny. Hence, to comprehend the real world the scientific way the above three must be empirical.
6. Knowledge is superior to ignorance: Scientists assume that knowledge is provisional and altering and as a result what we did not know before we know now and present knowledge can be adapted in the future. The pursuance of knowledge for its sake and for improving human condition indicate the fact that proof, techniques as well as theories can be subjected to modification.

Agbonifoh and Yomere, 2009,p 12 summarizes the scientific method of knowing the following way:

- i. Objectivity (efforts to reduce bias).
- ii. The quest for precision.

- iii. Verification (confirmation or rejection by others).
- iv. Empiricism (observation or collection of data from the real world) and
- v. Theory construction.

The scientific research operates basically at two levels and Bhattacharjee, 2012, pp 7-8 explains them thus:

- I. Inductive research: Here the researcher aims at inferring theoretical concepts and patterns from observed data.
- II. Deductive research: This involves the researcher testing with new empirical data concepts and patterns which are known from theory.

He also asserts that a complete researcher is one who has a grip on both inductive and deductive research.

### 1.1 Research Designs

Research design here refers to any investigation of the empirical world that bears upon a proposition's truth value – its degree of truth or probability of truth, which we called accuracy. How do we know that a given proposition is true or false? How will we go about demonstrating (i.e., verifying, falsifying, proving) its truth? These are the central questions of research design

Source: John Gerring, *Social Science Methodology: A critical framework*, p 155

The purpose of a research design is to make sure that the facts acquired facilitate our answering the research question (s) as explicitly as possible.

Agbonifoh and Yomere aptly defined research design as a blue print which serves as a guide to the researcher through the different phases of the research process.

The authors above also clearly explained the various types of research designs according to their scientific connotation as follows:

- A. Exploratory Research Designs:
- B. Descriptive Research Designs:
- C. Causal Research Designs:
- D. Correlational Studies:

It is important that the above is mentioned in order to enhance clearer understanding; however the focus of this paper is on causal research design – specifically the experimental research design.

#### 1.1.1 Experimental designs

An experiment is a research design in which the researcher manipulates or varies an independent variable in a controlled setting an independent variable in a controlled setting to allow observation or measurement of the impact of the variation or manipulation on another variable called the dependent variable. (Agbonifoh and Yomere, 1999).

An experiment is a process or study that results in the collection of data. The outcomes of experiments are not known in advance. It is a study in which interference is intentionally introduced to observe its effects. Usually, researchers are able to manipulate the conditions of the experiment and can deal with the factors that are extraneous to the research objectives (Design Institute of Six Sigma, n.d).

Experiments has been captured expressively by the following authors who highlighted on its relevance

If experiments are less able to provide this highly-prized explanatory causal knowledge, why are experiments so central to science, especially to basic social science, in which theory and explanation are often the coin of the realm? ... Experiments help to test the links in

each chain. Second, experiments help distinguish between the validity of competing explanatory theories, for example, by testing competing mediating links proposed by those theories. Third, some experiments test whether a descriptive causal relationship varies in strength or direction under Condition A versus Condition B (then the condition is a moderator variable that explains the conditions under which the effect holds). Fourth, some experiments add quantitative or qualitative observations of the links in the explanatory chain (mediator variables) to generate and study explanations for the descriptive causal effect. Experiments are also prized in applied areas of social science, in which the identification of practical solutions to social problems has as great or even greater priority than explanations of those solutions.

Source: Shadish, R.W, et al, *Experimental and quasi-experimental designs for generalized causal inference*, p,11

Experimental design is the process of planning a study to meet specified objectives. Planning an experiment properly is very important in order to ensure that the right type of data and a sufficient sample size and power are available to answer the research questions of interest as clearly and efficiently as possible.

Source: Design Institute for Six Sigma at SAS, n.d

James P. key (1997) opines that research method is a blueprint of the procedure that allows the researcher to test his hypothesis by realization of valid conclusions about relationships among independent and dependent variables. It refers to the conceptual structure within which the experiment is conducted.

“An experimental design is a plan for assigning experimental units to treatment levels and the statistical analysis associated with the plan” Kirk, 1995 in R.E. Kirk (n.d)

In order to adequately execute an experiment successfully, the researcher must undergo a series of procedures or activities. According to (Cooper and Schindler 2006), the following seven steps have been outlined as the necessary to follow:

- I. Select relevant variables: This entails selection of most appropriate operational representations of the original concept.
- II. Specify the treatment levels: This refers to treatment levels of the independent variables which are the random or natural groups the researcher makes within the independent variable of an experiment.
- III. Control the experimental environment: This is usually done in a bid to ensure the prevention of extraneous variables as they could influence the effect of the treatment on the dependent variable; hence they are either controlled or eliminated. Another form of control exists when the subjects do not know they are receiving experimental treatment (they are thus said to be blind). Also when the experimenter does not know whether he is giving treatment to the experimental or control groups (referred to as double blind).with the aim of ensuring unwanted complications are eradicated.
- IV. Choose the experimental design: The goal of the research determines the appropriate design that could be employed. Proper selection of the design improves the chance that the observed change in the dependent variable was caused by the exploitation of the independent variable and not a different factor.
- V. Select and assign the subjects: The aim of the research is to be able to make generalizations

about the population of interest based on results obtained or findings. In order to achieve this aim, participants should therefore be representative of the population of interest to the researcher.

- VI. Pilot test, revise, and test: This is done so as to reveal possible errors in the design, inappropriate control of the extraneous variables/ experimental conditions. Pretesting instruments allows for refinement to be carried out before the final test.
- VII. Analyze the data: The researcher could achieve this by means of observational techniques and control schemes, paper and pencil test, self-reporting instruments with open-ended or closed questions, scaling techniques and physiological measures.

In experimental designs there exist two important terminologies used to express the validity of finding which varies from high to low. However, it suffices to say at this point that they are referred to as:

- a. External validity: It is the extent to which the treatment effect can be generalized across populations, treatment variables, and measurement instruments. External validity refers to the degree to which the results of an empirical investigation can be generalized to and across individuals, settings, and times. (Michael. S.R, n.d)
- b. Internal validity: It is the extent to which the experimental treatment makes a difference in (or causes change in) the specific experimental settings. According to Casady R, (2005), opines thus “internal validity in a research study is what gives the researchers the confidence to conclude that what they did in the study caused what they observed to happen, i.e., the outcome is the result of the treatment”.

At this juncture it is important that the researcher is well aware of the benefits and flaws associated with the experimental designs and also with each specific type of experimental design he/she may wish to engage. Thus below are explained advantages and disadvantages of the experimental design as well as the advantages and disadvantages of the various types of experimental designs.

### 1.1.2 Advantages and Disadvantages associated with Experimental Design

It becomes expedient at this point that we clarify the fact that every research technique as good and as suitable as it might seem to a particular research investigation is not devoid of drawbacks. The researcher must therefore be aware of its benefits and loopholes in order to make a decision as to which technique to use as well as d level of validity or generalization that can be made using the research technique. Hence, below are outlined the pros and cons of experimental design

Advantages of experimental design

- I. Experiments aid researchers to exert a great deal of control over extrinsic and intrinsic variables thus strengthening the validity of causal inferences.
- II. Control over elimination extraneous variables is greater than in other types of research method.
- III. Experiments allow researchers to control the introduction of the independent variable so as to determine the direction of causation.
- IV. The existence of strict control and conditions of the experiment, the researcher can set up the experiment again in order to verify the results or findings.
- V. The above advantage is vital as arriving at same or similar results gives greater confidence in the research findings.

Disadvantages of experimental design

- I. This design does not allow researchers to replicate real-life social situations thus resulting in a weak external validity.
- II. The sample gotten may not be representative of the population of interest because researchers usually rely on volunteer or self selected subjects for their samples.
- III. As a result of the above flaw researchers are therefore not able to make generalizations about

the population thus limiting the scope of the findings.

IV. The issue of ethics in experimentation

V. Experiments are expensive to carry out and sometimes impossible to embark upon.

### 1.1.3 Types of Experimental Designs

There are 3 broad types of research designs as asserted by J.P Key, 1997; Cooper R.D and Schindler .S. P (2006)

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

#### 1. True experimental designs

Yount .R (2006) opined that Experimental designs are said to be true experiments when they utilize randomization in the selection of their samples and control for extraneous influences of variation on the dependent variable. The following here listed are very useful tools for experimental dissertation:

- a. Pre test- Post test control group design: Cooper et al, 2006 asserts that it entails adding a control group to the one-group pretest- posttest design then assigning the subjects to either of the groups via a random procedure.
- b. Post test only control group design: Here, the pretest measurements are omitted, thus the participants are measured only once and random assignment is used.(Cooper et al, 2006)
- c. Solomon four group design: This design is an experimental design that evaluates the plausibility of pretest sensitization effects, that is, whether the mere act of taking a pretest influences scores on subsequent administrations of the test. (Clark, H. M & Shadish, R. W, 2008). Trochim, W.M.K (2006) aptly puts it as being designed to deal with potential testing threats.

#### 2. Quasi –experimental designs

Yount. R (2006) asserted that when a random sample of participants cannot be taken because of practical or ethical reasons in such a case pre-existing or naturally occurring units are used. This type of research still has all the other components of an experiment except for randomization hence it is referred to as quasi-experimental design. This type of Experiment is one in which units are not assigned to conditions randomly. Listed below are some types of quasi-experimental design:

- a. Time series design: It introduces repeated observations before and after the treatment as well as allowing subjects to act as their own controls. The single treatment group design has before and after measurements as the only controls while the multiple design have two or more comparison groups as well as the repeated measurements in each treatment group.(Cooper et al, 2006)
- b. Non – equivalent control group designs: Here, the membership of the experimental and control groups is naturally assembled. Volunteer subjects are used as the experimental and non-volunteer subjects are used as the control. (Cooper et al, 2006)
- c. Counter balanced control designs: It is a technique used when you intend to manipulate two or more independent variables within-subjects, while on the other hand not wanting to use all possible combinations of the variables for every subject.

#### 3. Pre-experimental designs

The author above also posits that this type of test employs a single group on which treatment is administered. It does not have a control group thereby giving room for further research.

- a. One shot case study: This involves the treatment or manipulation of the independent variable followed by the observation or measurement of the dependent variable.(cooper et al,2006)
- b. One –group pretest/posttest design: This entails a pre-test followed by manipulation and post-test.(cooper et al,2006)
- c. Static- group comparison design: This design make available two groups of which one receives the experimental stimulus while the other serves as a control.(cooper et al, 2006)

#### 1. Advantages of True Experimental Designs

- I. It gives room for greater internal validity.
- II. Claims of causality can be investigated.
- III. It represents the population appropriately because its employs random selection.

#### Disadvantages of True Experimental Designs

- I. Reduced external validity as it does not employ real world conditions.
- II. It is not very practical.
- III. High risk of researcher bias.

#### 2. Advantages of Quasi- Experimental Designs

- I. There exists greater involvement with real world conditions hence superior external validity.
- II. It is more feasible owing to time and logistics constraints.
- III. Simulation of experiment is possible.

#### Disadvantages of Quasi-Experimental Designs

- I. Less control of variables.
- II. Difficulty in justifying causal claims.
- III. Non –random selection of sample from the population of interest thus affecting generalizations about the population of interest.

#### 3. Advantages of Pre-Experimental Designs

- I. It is very practical or realistic.
- II. It sets the stage for more research.

#### Disadvantages of Pre-Experimental Designs

- I. Rare use of random selection.
- II. There is no involvement of a control group.
- III. There exists lower validity of findings.

#### 1.1.4 Conclusion

Research methods in social and management sciences engage scientific procedures in arriving at conclusions empirically via data collection, presentation, analysis and interpretation of findings. Worthy of note is the fact that the experimental design is the most reliable form of research having the highest level of validity amongst other types of research.

Having outlined the various types of experimental designs the researcher has therefore been given a brief exposition as to which designs to engage and how to go about its usage. Also, the researcher can now know what problems or challenges are inherent with the various types and how to spot the one suitable for the kind of experiment to be carried out.

However, it is important that the researcher properly evaluates each of the types of experimental



designs against his/her various constraints in terms of resources (could be financial, time, manpower, etc) to decipher whether it is feasible to embark upon.

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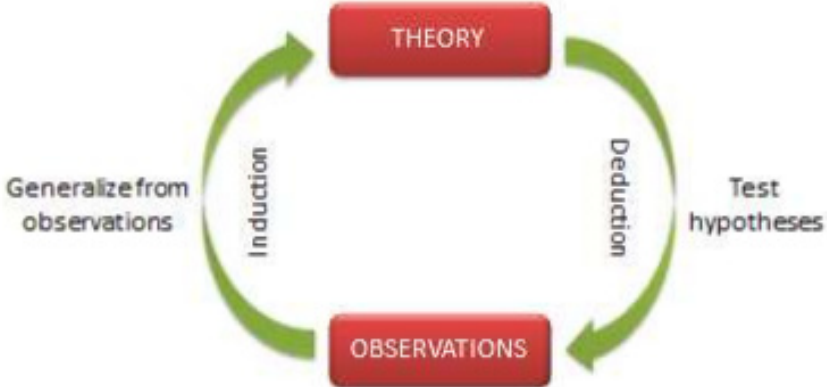


Figure 1: the cycle of research