

RESEARCH DESIGN PART 2

Experimental Research Design

Purpose

The aim of the experimental research is to investigate the possible cause-and-effect relationship by manipulating one independent variable to influence the other variable(s) in the experimental group, and by controlling the other relevant variables, and measuring the effects of the manipulation by some statistical means. By manipulating the independent variable, the researcher can see if the treatment makes a difference on the subjects.

If the average scores of two groups prove to be significantly different, and if there are not any explanations for this difference, then it can be concluded that the effect of the treatment caused this difference. This is where experimental research differs from correlational research. For instance, correlational studies only describe or predict the strong *relationship* between socioeconomic level and the academic achievement but cannot prove the direct cause-and-effect relationship between these two variables. It is the experimental research which can demonstrate that by changing the independent variable, a change is possible on the dependent variable.

In educational research the most frequently studied dependent variables are achievement, motivation, attention, interest in learning, participation and attitudes. The common independent variables that are manipulated are teaching methods, types of assignments, types of teaching materials such as text books and visual aids, types of rewards, types of questions used by the teacher, and evaluation techniques. There are however, some independent variables such as age and gender that cannot be manipulated. When the independent variable that is chosen cannot be manipulated, either a comparative research is conducted, or a second independent variable is chosen for manipulation in order to conduct an experimental study.

The following are some examples to illustrate the experimental research (Isaac & Michael, 1977):

- To investigate the effects of two methods of teaching a twelfth-grade history program as a function of class size (large and small) and levels of student intelligence (high, average, low), using random assignment of teachers and students-by-intelligence-level to method and class size.
- To investigate the effects of a new drug abuse prevention program on the attitudes of junior high school students using experimental and control groups who are either exposed or not exposed to the program respectively, and using a pretest-posttest design in which only half of the students randomly receive the pretest to determine how much of an attitude change can be attributed to pretesting or the educational program.
- To investigate the effects of two methods of pupil evaluation on the performance of children in the twenty-three elementary schools of a given

suburban district. 'N' in this study would be the number of classrooms, rather than children, and the method would be assigned by stratified random techniques such that there would be a balanced distribution of the two methods to classrooms across grade levels and socio-economic locations of schools. (p. 24)

Types

Different types of experimental research can be conducted depending on the nature of subjects and the instruments, and the way data are collected and analyzed. Answers to the following questions would determine what type of experimental design to follow:

- Will there be a control group?
- How many subjects will there be?
- Will the subjects be randomly selected?
- Will each group be pretested?
- How will the obtained data be analyzed?
- What factors may affect the internal validity?
- What factors may affect the external validity?

Experimental investigations can be conducted on groups or individuals. Accordingly, the structure of the design changes as group experimental design, or single-subject experimental design.

Group Experimental Design

Group experimental designs can be of different forms. If there is only one independent variable that can be manipulated, then a *single-variable design* is used. If there are two or more independent variables, and at least one can be manipulated, then a *factorial design* should be chosen.

Single-variable designs. These studies are classified under three main headings depending on the degree of control maintained on other variables:

1. Pre-experimental designs (low degree of control)
 2. True experimental designs (high degree of control)
 3. Quasi-experimental designs (medium degree of control)
1. *Pre-experimental designs* are classified depending on whether there is an involvement of one or two groups, and whether the groups are posttested only, or both are pretested and posttested:
 - *One-shot case studies:* One group is exposed to the treatment, and only a posttest is given to observe or measure the effect of the treatment on the dependent variable within the experimental group. Since it is applied on a single group, there is no control group involved in this design. As seen in Table 6.2, first of all, the chosen group is exposed to the treatment ,

and then it is tested only once for the purpose of measuring the degree of change on the dependent variable after the treatment.

- *One-group pretest-posttest design:* One group is pretested and exposed to the treatment, and then posttested. This is called a one-group pretest-posttest design because the two tests are administered to the same group. As seen in Table 6.3, the first one is administered at the beginning of the treatment and the second one at the end. This design is better than the one-shot case study design but it still has some weaknesses because no proper selection is made taking the other possible dependent variables into consideration.

Table 6.2

Example of a One-shot Case Study Design

STEPS	PROCEDURE (on single group)	AIM
Step 1	TREATMENT Ten weeks of instruction on reading with a new technique	To influence the dependent variable (reading comprehension skill)
Step 2	POSTTEST a reading test or a questionnaire	To measure the degree of change on the dependent variable

Table 6.3

Example of a One-group Pretest-posttest Design

STEPS	PROCEDURE (on single group)	AIM
Step 1	PRETEST (Reading test)	To measure the degree of the dependent variable before the treatment
Step 2	TREATMENT (Ten weeks of instruction on reading with a new technique)	To influence the dependent variable
Step 3	POSTTEST (Reading test)	To measure the degree of change on the dependent variable

- *Static-group comparison design*: At least two groups are involved. After one group receives the treatment, all groups are posttested. For example, two groups that have already been formed are chosen; one is given a treatment different from the regularly applied one. As seen in Table 6.4, an experiment is conducted on Group 2; therefore, Group 2 is given the treatment before being posttested. Although Group 2 receives no treatment, the posttest is administered to these subjects as well in order to see the relative effect of the treatment. This design has better control over most of the variables.

Table 6.4

Example of a Static-group Comparison

STEPS	P R O C E D U R E		A I M
	GROUP 1	GROUP 2	
Step 1	No new treatment (Regular Instruction)	Treatment (A new technique)	To influence the dependent variable
Step 3	POSTTEST (Reading test)	POSTTEST (Reading test)	To measure the degree of change on the dependent variable

2. *True experimental designs* have the highest level of control among the three single-variable experimental designs because the subjects within the groups are randomly assigned for each group. When subjects are randomly assigned, there is higher control of the internal validity as well as the external validity. Moreover, there is always a control group to compare the results of the subjects in the experiment with other subjects of similar status that have not been exposed to the treatment.

True experimental research may be designed with or without a pretest on at least two groups of randomly assigned subjects. The classification of true experimental designs is made accordingly (see Tables 6.5 - 6.7):

1. The posttest-only control group design
2. The pretest-posttest control group design
3. Solomon four-group design

Table 6.5

The Posttest-only Control Group Design

STEPS	P R O C E D U R E		AIM
Step 1	Random assignment for Control Group	Random assignment for Experimental Group	To control subject characteristics threat to internal validity
Step 2	No treatment	Treatment	To observe any possible change on dependent variable
Step 3	POSTTEST	POSTTEST	To measure the degree of change

Table 6.6

Pretest-posttest Control Group Design

STEPS	P R O C E D U R E		AIM
Step 1	Random assignment for Control Group	Random assignment for Experimental Group	To control subject characteristics threat to internal validity
Step 2	PRETEST	PRETEST	To measure the degree of the dependent variable before the treatment
Step 3	No treatment	Treatment	To influence the dependent variable
Step 4	POSTTEST	POSTTEST	To measure the degree of change

Table 6.7

Solomon Four-group Design

Step	G1 Exp.	G2 Control	G3 Exp.	G4 Control
1	Random assignment	Random assignment	Random assignment	Random assignment
2	PRETEST	PRETEST		
3	Treatment	-----	Treatment	-----
4	POSTTEST	POSTTEST	POSTTEST	POSTTEST

Solomon four-group design takes the effect of pretest and posttest sensitization into consideration. It is the combination of pretest-posttest control group (G1 and G2) and posttest only control group (G3 and G4) designs. In this case, - subjects are randomly selected and placed into four groups;

- the first and the second groups are pretested;
- the first and the third groups are exposed to the treatment, and the second and the fourth groups are taken as control groups;
- all four groups are posttested.

This design provides the best result but it requires a large sample so that enough subjects could be assigned to four groups. When the sample is large, administering the tests becomes difficult, time and energy consuming.

3. *Quasi-experimental designs* may be conducted in three different forms:
- Non-equivalent control groups design
 - Time-series design
 - Counterbalanced design

All three categories of quasi-experimental design are similar to some extent to the true experimental design. However, they differ in the following aspects:

- Non-equivalent control group design is similar to pretest-posttest control group design except that no randomization is required. The groups are generally chosen from clustered units such as classrooms or counseling groups. The major drawback of this design is that since there is no randomization, variables related to history, maturation or testing may interfere with the effect of the treatment.
- Time-series design is an elaborated version of the one-group pretest-posttest pre-experimental design in the sense that subjects are repeatedly pretested and posttested before and after the treatment rather than being tested once at the beginning and a second time at the end of the treatment.
- Counterbalanced designs are used to equate the experimental and control groups. In this design, the treatments are given to all the groups in a different order, and the number of groups should be equal to the number of treatments (see Table 6.8). In other words, if there are two different treatments, there should be two groups.

Table 6.8

An Example of a Counterbalanced Design

Week	Session One		Session Two	
	Group 1	Group 2	Group 1	Group 2
1-4	Technique X	Technique Y	Technique X	Technique Y
	TEST Mean = 75	TEST Mean = 55	TEST Mean = 70	TEST Mean = 40
5-8	Technique Y	Technique X	Technique Y	Technique X
	TEST Mean = 50	TEST Mean = 75	TEST Mean = 50	TEST Mean = 85

Factorial designs. These are applied to determine if the effects of the independent variable can be generalized. A factorial design, in this sense, indicates relationships between variables. It may be that while one variable increases, the other one decreases, or an increase in one gives rise to the other variable.

These designs are the modified forms of either the posttest-only control group or pretest-posttest control group designs with or without random assignment. They also allow the investigation of additional independent variables. Moreover, they enable the researcher to study the interaction of the independent variable with one or more other variables, which are called *moderator variables*. A moderator variable could be a treatment variable or a subject characteristic variable. For instance, aside from finding the effect of different methods of teaching on students' success level, the researcher might want to look into the effect of the class size in the application of these two methods. Under these conditions, the researcher has to design a 2 by 2 factor design (see Table 6.9.)

Table 6.9

An Example of a Factorial Design

Step	G1 Exp.	G2 Control	G3 Exp.	G4 Control
1	Random assignment	Random assignment	Random assignment	Random assignment
2	PRETEST	PRETEST	PRETEST	PRETEST
3	Treatment 1	Treatment 2	Treatment 1	Treatment 2
	Class size 1	Class size 2	Class size 2	Class size 1
4	POSTTEST	POSTTEST	POSTTEST	POSTTEST

Single-subject Experimental Design

These designs are applied when only one subject is involved in the study. They aim at studying the behavioral changes of different individuals as a result of some intervention or treatment. Gay, (1987, p. 323) mentions three types of single-subject experimental design:

1. A-B-A withdrawal design
2. Multiple-baseline design
3. Alternating treatments design

A-B-A withdrawal design. These designs are basically of three types: (a) the *A-B design*, (b) the *A-B-A design*, and (c) the *A-B-A-B design*. In the A-B design, similar to counterbalanced design, the subject is exposed to a non-treatment condition (A) as well as to a treatment (B) in order to study the difference of behavior within the subject. Clinical studies frequently make use of this technique. In order to find out if the improvement is really due to the treatment or due to some

other factors, the A-B-A design is applied. In making final judgments on the effect of the treatment, this time the A-B-A-B design is applied.

Multiple-baseline designs. These are used when the A-B design is used, and the conditions cannot be reversed. In this design, the treatment can be withdrawn but the effects of the treatment continue, and it is impossible to go back to the nontreatment condition.

Alternating treatments. These are used to determine the relative effects of two or more treatments within a single-subject. This design is preferred because no withdrawal is necessary. The treatments are alternated on a random basis with no interval in between. However, it has one major drawback. The effect of one treatment may persist while the second treatment is being given.

In the A-B-A withdrawal design, the analysis and interpretations are made by studying the graphic representations of the results or simply by visual inspection. The primary criterion of making generalizations is the "clinical significance of the results rather than the statistical significance" (Gay, 1987, p. 325). The statistical results obtained from tests (e.g. t-test) may support the clinical generalizations.

In arriving at a reliable decision, the results need to be replicated. Direct replication is done by the same investigators using the same or different subjects in a specific setting. Simultaneous replication is done at the same time and at the same location on a number of individuals that have the same problem. When the investigators, behaviors, or settings are differed, then it is called "systematic replication." "Clinical replication involves the problem of a treatment package, composed of two or more interventions which have been found to be effective individually, designed for persons with complex behavior disorders" (Gay, 1987, p. 326).

During the manipulation of the independent variable, it is difficult to keep the other variables under control. This control can be maintained by eliminating or removing their influence that would affect the performance. For instance, in investigating the effect of one teaching technique on students, two groups of students are chosen, and the experimental group is exposed to the treatment but the control group is not. Meanwhile, these students continue with the instruction. If only one teacher teaches both the experimental group and the control group, the teacher factor as a possible threat to the internal validity of the study would be eliminated. Otherwise, any positive or negative effect might be attributed to the teacher as well as the teaching technique itself.

When the difference of behavior (dependent variable) observed in the experimental group is directly the result of the application of the technique (manipulation of the independent variable), and not of any other variable, this condition is referred to as *internal validity*. It is difficult to maintain internal validity, because, during the period of treatment, similar factors mentioned below may affect the performance of the dependent variable (see also Table 6.10):

- The occurrence of any event which is not part of the treatment (history threat)
- The mental and physical changes that occur within subjects (maturation threat)
- Subjects getting familiarized with test items after having taken the pretest (testing threat)

- Assessment of performance by unreliable measures (instrumentation threat)
- Selection of subjects on the basis of their extreme scores (This leads the subjects with the highest scores on a pretest to score lower on a posttest or vice-versa.) (Regression threat)
- Not choosing groups of the same level (The initial difference between the groups may still be reflected on the posttest results.) (Subject characteristics threat)
- The loss of subjects for some reason during the study (mortality threat)
- The unintended outcomes of the location the treatment of the study takes place (Location threat).
- The treatment of the experimental group in an unplanned way (Implementation threat)
- Collecting data without giving sufficient orientation to the data collectors (Data collector characteristics).

Table 6.10

Threats to Internal Validity and the Degree of their Control

		Different Types of Experimental Designs											
Threats	1	2	3	4	5	6	7	8	9	10	11	12	
S	-	-	-	**	**	*	**	**	**	**	**	**	
M	-	*	-	*	*	*	**	**	-	**	**	**	
L	-	-	-	-	-	-	-	-	*	-	*	*	
I	NA	-	*	*	*	*	*	*	-	**	-	-	
D	-	-	-	-	-	-	-	-	*	-	*	*	
T	NA	-	*	*	-	*	**	-	-	*	**	**	
H	-	-	*	*	*	*	*	*	**	*	**	**	
Mat.	-	-	*	**	**	*	**	**	*	**	*	*	
A	-	-	-	-	-	-	-	*	-	-	-	-	
R	-	-	-	**	*	**	**	**	**	**	*	*	
Im.	-	-	-	-	-	-	-	-	-	-	-	-	

Key:

Degree of control over the threats.:

- (**) = Strong control, threat is not likely to occur
- (*) = Some control, slight possibility of threat
- (-) = Weak control, high possibility of threat
- (N/A) = Not applicable

Threats : S = Subject, M = Mortality, L = Location, I = Instrument Decay, D = Data collector characteristics, T = Testing, H = History, Mat. = Maturation, A = Attitudinal, R = Regression, Im. = Implementation

Designs: 1 = One-shot case study, 2 = One-group pretest-posttest, 3 = Static group comparison, 4 = Posttest-only control group, 5 = Pretest-posttest control group,

6 = Matching only pretest-posttest control group,
 7 = Solomon four-group, 8 = Counterbalanced, 9 = Time-series, 10 = Factorial design, 11 = A-B-A-B, 12 = Multiple baseline

Some suggestions can be offered as how to avoid some of these threats. In order to control the possible threats, the researcher tries to

- control the research conditions strictly;
- collect more information on subjects;
- check the details more carefully;
- find a suitable design (see Table 6.11)

Table 6.11
Suggested Techniques to Avoid Threats to Internal Validity

Threats	Suggested Techniques			
	Control the conditions strictly	Collect more information	Check the detail carefully	Find a suitable design
S		*		*
M		*		*
L	*		*	*
I	*		*	*
T				*
H			*	*
Mat.				*
R				*
Im.	*		*	

The extraneous variables in a group experimental design can be controlled if

- the subjects are selected randomly;
- the pairs are matched from experimental and control groups;
- homogeneous groups or subgroups are compared;
- analysis of covariance is applied when necessary;
- the same group is exposed to two different treatments.

In experimental research, if the obtained results can be generalized or applied to other groups or environments, the treatment is said to have *external validity*. Aside from the above mentioned factors, there are other issues that affect the external validity:

- Exposure of the group to the treatment prior to the intended experiment (thus it is difficult to observe the effect of the later treatment.)
- The characteristics, personality or bias of the experimenter (One experimenter cannot conduct the same experiment in all settings.)

- *Hawthorne effect* (Students may be negatively or positively involved, thinking that they are involved in an experiment or getting special attention.)
- *Novelty effect* (Students are interested and motivated due to getting involved in a different activity, which indirectly affects their performance positively.)
- Characteristics of the subjects which are termed as *organismic variable* (For instance, subjects may perform differently depending on their sex.)
- Intervening variables such as boredom and anxiety

Basic Steps

Isaac and Michael (1977) report the seven steps in experimental research as outlined by Van Dalen and Meyer (1966) :

1. Survey the literature relating to the problem.
2. Identify and define the problem.
3. Formulate a problem hypothesis, deducing the consequences, and defining basic terms and variables.
4. Construct an experimental plan.
 - a. Identify all non-experimental variables that might contaminate the experiment, and determine how to control them.
 - b. Select a research design.
 - c. Select a sample of subjects to represent a given population, assign subjects to groups, and assign experimental treatments to groups.
 - d. Select or construct and validate instruments to measure the outcome of the experiment.
 - e. Outline procedures for collecting the data, and possibly conduct a pilot or "trial run" test to perfect the instruments or design.
 - f. State the statistical or null hypothesis.
5. Conduct the experiments.
6. Reduce the raw data in a manner that will produce the best appraisal of the effect which is presumed to exist.
7. Apply an appropriate test of significance to determine the confidence one can place in the results of the study. (p. 25)

Whatever research method is chosen, it is generally advised by scholars (Allen 1987; Gay 1987; Isaac & Michael 1977) to evaluate the work undertaken at every stage (introduction, review of literature, data analysis etc.) of the research in order to avoid or detect any shortcomings or faulty applications that may appear in the study. Researchers are advised to ask themselves questions, such as the ones presented below in order to be able to conduct the study according to the required norms (see also Appendices 3 and 4).

TITLE

1. Have I precisely identified the problem area with sufficient clarity?
2. Have I included the specifications of the independent and the dependent variables?

3. Have I arranged the words in the title effectively?
4. Have I tried to avoid using irrelevant expressions, unqualified nouns, quotations and underlinings?
5. Have I identified the target population?
6. If I am writing a thesis or dissertation, have I typed the required information on the title page?

INTRODUCTION

1. Have I defined the problem accurately, clearly focusing on the basic difficulty?
2. Have I presented the background of the study by giving a careful analysis of what is known about the problem, and what the suspected facts are? In other words, have I demonstrated the relevance of the existing knowledge to the problem?
3. Have I stated the educational significance of the problem in either basic or applied research by stating clearly the major points to be resolved and/or the objectives to be investigated?
4. Have I mentioned the variables or factors to be studied or investigated; and have I indicated the relationship between these variables or factors?
5. Have I directly or operationally defined the technical terms that may sound unfamiliar to my readers?
6. Have I stated the problem, the question, and the approach to be adopted in a logical and internally consistent manner?
7. Have I defined the scope of the study by mentioning what aspects to include, and what to exclude, regarding the topic and the problem area? Have I given justification for the inclusions and the exclusions I have made ?

REVIEW OF LITERATURE

1. Are the investigations and studies cited in this section adequate and relevant to the problem under investigation?
2. Have I compiled a comprehensive review of literature?
3. Have I critically analyzed the studies I have cited, and have I compared and contrasted these results?
4. Have I avoided reviewing these studies only in the form of abstracts and annotations?
5. Have I developed an appropriate rational or theoretical framework from these cited research studies by concluding the chapter with a brief summary on the implications of these studies for the problem I have been investigating?

HYPOTHESES

1. Have I clearly specified the questions that I am seeking answers for? In other words, have I clearly stated my assumptions and the specific hypotheses that I aim at testing?
2. If I have deduced any consequences of the research or have made predictions regarding the outcome of the research, are they consistent with my hypotheses?
3. Am I sure that the hypotheses I have specified are testable?

PROCEDURES

1. Have I given the size of the sample and the major characteristics of my subjects?
2. Have I indicated whether I have studied the entire population?
3. Have I clearly explained my method of selecting the sample?
4. Have I clearly explained my method of sample selection (e.g. random assignment, matching, voluntary, etc.)?
5. Am I sure that I have not been biased in the selection of my subjects?
6. Is the number of my subjects sufficient to apply the research method I have adopted?
7. Do my subjects really represent the whole population?
8. Have I given sufficient information about the reliability, validity, and standardization properties of the instruments I have used for testing purposes?
9. Have I described the procedure I have applied in a logical sequence?
10. Have I clearly demonstrated the relationship between the method adopted and the research questions formulated?
11. Have I appropriately discussed the way I will conduct the method and the way I will keep the procedure under control so that another researcher who wants to replicate my study can make use of it properly?
12. Have I specified how the null (statistical) hypotheses relate to my research hypotheses?
13. Were there any uncontrollable instances? If so, have I clearly stated them; and have I indicated my assumption for the appearance of such uncontrollable factors?

These questions serve as confirmation prompts to guide researchers while conducting their research. Questions not relevant to the content of the chapters are excluded in this volume. For questions relevant to data analysis and the other steps to follow, reference can be made to Volume 2 of this book.