Chapter Objectives:

- Understand that the purpose of experiments and group quasi-experiments is to investigate differences between groups as the result of an intervention or treatment.

- Understand the terms and procedures used in experimental and quasi-experimental group designs.

- Understand sampling and group assignments in true experimental designs and how they differ from procedures for group assignment in quasi-experiments.

- Understand the types of true experimental designs: pre and post test/control, post-test only control, and factorial designs.
• Understand the types of quasi-experimental group designs: non-equivalent pre and post test/ control, non-equivalent post test only/ control, and repeated measures designs how they investigate cause and effect.

**Purpose and Definitions**

The purpose of experimental research is to demonstrate a causal relationship between an intervention or treatment and measured outcomes. Experimental research is the only research that can establish a cause and effect relationship. It is meant to replicate with human subjects, as much as is possible, the conditions of a laboratory experiment. This chapter focuses on differences in outcomes between and among groups as the result of an intervention or treatment.

**Definitions**

• *A theory* is a coherent set of concepts used to explain other concepts, that is, it explains a connection between cause and effect. The theory is established through a comprehensive review of previous research
and is operationalized though the selection of a treatment and the identification of an outcome and the statement of a hypothesis.

• *An independent variable (IV)* represents the treatment, or the causative aspect of the theory. The IV is what is presumed to be the *cause* of an effect; all experimental research is *interventionist* because it applies a treatment, or intervention, to subjects. A treatment in educational research usually is in the form of an instructional strategy, a curricular approach, a targeted program, or a behavioral intervention.

• *A dependent variable (DV)* represents the outcome, or the *effect* that the theory presumes will occur as a result of the intervention. *The DV* is measured by a valid and reliable instrument.

• A *hypothesis* operationalizes the theory by making a prediction about the effect of the independent variable on the dependent variable. A hypothesis can be stated as either a directional or non-directional hypothesis.
  
  o *A directional hypothesis* predicts that the treatment will result in a change on and that the change will be a positive result of the experiment.
  
  o *A non-directional hypothesis* predicts that a treatment will result in a change in outcomes, but does not predict the direction of the change: whether it will be positive or negative.
Procedures for Group Experiments

Researchers who wanted to investigate the effect of different approaches to math instruction on computation skills would conduct a group experiment. They would review the research to see if there was a theory that supported one particular approach. For example, assuming they found support for the use of math software:

- **IV** = computer math instruction
- **DV** = math computation, measured by scores on a valid and reliable test of reading comprehension

In order to assess the effect of the IV on the DV, the researcher might assign groups to different conditions and manipulate the IV so that one group receives computer software instruction and another group does not.

- *The treatment group (IV)* is the group that receives the new program or approach.
- *The control group (DV)* is the group that continues with business as usual. The researcher does is to select an intervention or treatment that matches the theory and then measure the result.

In this case the researcher would be conducting what is termed a *control group experiment;* an experiment that investigates differences between control and treatment groups.

Most group experiments use control and treatment groups, though some compare groups that receive different treatments with no treatment groups. In this case, the researchers may decide to compare outcomes on two different
treatments; for example two different software programs, or a software program unmediated by the teachers and the same software program with teacher involvement instruction. The graphic below illustrates the process of experimental research in both instances.

Figure 1: Experimental Group Designs
Sampling is very important in experimental research. Sampling has to do with both the selection of the sample and the assignment of the sample to the treatment condition. In terms of selection, the optimal approach is through randomization from an accessible population. Since this is more easily done in large scale and funded experiments than in smaller school and classroom studies, educational researchers often begin with a convenience sample and then assign subjects within the sample to the treatment condition.
How a researcher assigns the sample to the treatment condition defines the experiment as a true or quasi-experiment.

- A *true experiment* uses randomization to assign the sample to the treatment condition.

- A *quasi-experiment* does not randomly assign the subjects in the sample to the treatment group. Instead, it uses intact/ or exiting groups and then assigns a group to the treatment condition.

Measurement is equally important in experimental research. The researchers have to have valid and reliable measures of the dependent variable, and they have to justify the measures they select.

### True Experimental Designs

![Tree Diagram]

More than any other quantitative method, true experiments provide valid inferences about cause and effect relationships. The distinctive feature of true experiments is their use of randomization to assign the sample subjects treatment and control group. Randomized group assignment provides every member of the sample with an equal opportunity to be assigned to the treatment. As a result, it eliminates biases, helps to ensure that the groups under study are
equivalent at the beginning of the experiment, and allows the researcher to make the strongest statistical inferences about cause and effect. There are three true experimental designs that appear most frequently in education: (1) pre-test/post-test/control group design, (2) post-test only/control group design and (3) factorial design. Each is described and illustrated below.

Fig 2. Pre and Post Test/ Control Group Design

In this design, the researcher randomly assigns the sample to control and treatment groups and administers a valid and reliable measure of the dependent variable to both groups at the beginning of the implementation phase. During the implementation stage, the treatment group receives the treatment, and the control group proceeds with business as usual or receives another treatment for comparison. At the conclusion of implementation, each group is administered the same or equivalent measure to determine gains in outcomes. The advantages of the pre-test are that it indicates whether the groups are equivalent at the beginning of the experiment and it provides a way to compare gains. The
The disadvantage of the pre-test is that it sensitizes subjects to the issue and may undermine determining whether the treatment has had its desired effect.

For example, Flynn, Marquis, Paquet, Peeke, and Aubry (2012) conducted a true experiment that used a pre and post test / control group design to test the hypothesis that an individualized direct-instruction tutoring program delivered by foster parents to their primary-age foster children would raise the children’s reading and math achievement. The researchers randomly assigned 77 children from nine local agencies into a control group (n=35) and a treatment group (n=42). The control group was assigned to a waiting list, and the treatment group received the intervention. The children were pre-tested and post-tested on measures of reading comprehension and mathematic and their gain scores were compared and analyzed.

**Post-Test Only/ Control Group Design**

![Post-Test Only/ Control Group Design](image)

This is a simple variation on the pre- and post-test design, the difference being that only a post-test is administered. This design avoids potential sensitizing of the subjects to the nature of the treatment. However, with no pre-test, there is no way to check to ensure that the treatment and control groups are
equivalent at the beginning of the experiment and no way to measure gains in scores over time. Randomized assignment to groups is assumed to have produced equivalent groups.

For example, Spencer and Manis (2010) conducted a true experiment using a post-test only design to test the hypothesis that instruction in fluency will add to gains in reading comprehension in low achieving middle school students. The researchers randomly assigned 60 middle school students who were at the very lowest level of reading achievement to treatment and control groups. The treatment group received instruction using the Great Leaps reading program, a six-month intervention focusing on reading fluency. The control group received the usual reading program. Students were pre- and post-tested for both fluency and comprehension.

**Factorial Designs**

In these designs there is more than one treatment group, meaning there is more than one independent variable acting on the dependent variable. Each variable is called a *factor*. In factorial studies, the researcher may compare
treatment groups to each other, or they may introduce a control group. The simplest design is a two-factor design represented below in which there are two factors and one control group.

Figure 4. Pre and Post Test Factorial Design with Two Factors

This figure shows a factor analysis that studies the effects of feedback. There are two randomly assigned two-treatment groups (one receiving formative teacher feedback only and one receiving formative feedback from the teacher and from peers) and a control group that receives summative feedback the usual way through test scores. This design would allow the researcher to (1) compare the effect of each treatment to control conditions (2) compare the effect of the combined treatments, and (3) compare the treatments to each other. This would yield a main effect and an interaction effect.
• **Main effect** is the effect of the major independent variable on the dependent variable

• **Interactive effect** is the effect of the variables taken together on the dependent variable.

A 2 x 3 factorial design is more complex. Here the researcher would add variations to each of the feedback factors. These variations are called *levels* as shown below.

![Figure 5. 2 x 3 Factorial Design / Post Test only](image)

Here, there are three levels relating to the frequency of feedback and three levels:
Factor A. Teacher feedback  
A.1 = once a week  
A.2 = three times a week  
A.3 = everyday  

Factor B. Teacher and Peer Feedback  
B.1 = once a week  
B.2 = three times a week  
B.3 = everyday  

This researcher randomly assigns subjects to the sample to six treatment groups, each receiving a different combination of factor and level. By using a factorial design, the researcher could combine all the levels of feedback and all levels of frequency and produce all possible outcomes. The advantage of a 2x3 factorial design is that it allows the researcher to test more than one hypothesis, to build confounding variables into the design as factors, and to test interaction effects. The disadvantage is that it requires a large sample and that an equal number of subjects be included in each cell.

As an example, Lim, Lee & Grabowski (2009) conducted a “2 x 3” factorial study of concept mapping strategies. They were interested in the effects of two factors related to concept mapping and their effects on student knowledge of a topic and their interaction with each other. Factor 1 was student self-regulatory learning, divided into two levels: level 1 = high, level 2 = low. Factor 2 was concept generating strategies, divided into three levels (level 1 = expert generated, level 2 = partially student generated, level 3 = totally student generated). Subjects were randomly assigned to one of three treatment groups, each representing a concept mapping strategy. The researchers analyzed the effect of each factor and its levels on knowledge acquisition and also the interaction effect of the two factors.
Quasi-experiments quite literally mean “almost” or “to some degree” experiments because of the absence of randomized assignment. The reason a researcher chooses a quasi-experimental design is quite straightforward. In the real world of schools, it is difficult—if not impossible—to randomize group assignment. However, it is possible to use existing groupings like classrooms within a school and to assign one classroom to the control conditions and the other to the treatment condition. These existing groups are called intact groups.

While not as rigorous as true experiments, quasi-experiments have produced interesting and compelling results and have gained wide acceptance within the research community. There are two quasi-experimental designs that commonly appear in educational research: non-equivalent control group and repeated measures.
Non–Equivalent Control Group Designs

Non-equivalent control group designs are similar to true experiment control group designs with one difference: they do not use randomization to assign subjects in the sample to groups. These are called non-equivalent group designs because in the absence of randomization, there is little likelihood that the groups will be equivalent. Notice that the only way the designs represented in figures 4 and 5 below differ from the true experiments represented in Figures 1 and 2 is the absence of randomization and the use of intact groups.

Figure 6. Pre and Post Test Non-Equivalent Control Group Design

Figure 7. Post-test Only/Non Equivalant Control Group Design
The process of control group experimental research proceeds in three phases: planning and design, implementation, and analysis and interpretation.

Repeated Measures Designs

In repeated measures designs, the researcher uses one treatment group for every aspect of the research. The researcher may choose to study the effects of one treatment on the subjects within the group or to compare the effects of multiple treatments on the subjects within the group.

![Figure 8. Repeated Measures Design: Single Treatment](Image)

This design investigates the effect of one treatment on one group of subjects over time. The researcher administers a reliable and valid measure of the dependent variable as a baseline. The baseline is meant to serve as a proxy for a control group, since it is assumed that another group that did not receive the treatment would stay at the baseline of the treatment group. Subjects within the
group repeatedly receive the treatment and are repeatedly measured over time until a final measurement of the dependent variable is taken.

Figure 9. Repeated Measures: Multiple Groups/Multiple Treatments Baselines

This design compares the effects of multiple treatments on one group of subjects over time. The researcher assigns subjects to multiple treatments and administers a valid and reliable measure of the dependent variable at the end of each treatment.

As an example, Seifert and Espin (2012) compared the effects of three reading strategies (text reading, vocabulary learning, and text reading plus vocabulary learning) on three outcomes (fluency, knowledge and comprehension in reading science texts).
The treatment group was composed of 20 tenth grade students, who received the three treatment conditions plus a control condition in this order.

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Order of Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 5, 9, 13, 17</td>
<td>Text / Vocab / Text &amp; Vocab / Control</td>
</tr>
<tr>
<td>2, 6, 10, 14, 18</td>
<td>Vocab / Text &amp; Vocab / Control / Text</td>
</tr>
<tr>
<td>3, 7, 11, 15, 19</td>
<td>Text &amp; Vocab / Control / Text / Vocab</td>
</tr>
<tr>
<td>4, 8, 12, 16, 20</td>
<td>Control / Text / Vocab / Text &amp; Vocab</td>
</tr>
</tbody>
</table>

Each subject was measured after each condition. The researchers analyzed and compared the effects of the treatments on the dependent variables.
Summary

- Experimental research demonstrates a causal relationship between an intervention or treatment and a measurable outcome.
- Group experiments investigate differences due to an intervention or treatment on groups of subjects.
- In true experiments, there is random assignment to the treatment condition.
- Quasi experiments use intact groups or non-random strategies for assigning groups to the treatment condition.
- True experimental designs include pre and post-test/control, post-test-only/control, and factorial designs.
Quasi-experimental designs include non-equivalent pre and post-test control, non-equivalent post-test only/control, and repeated measures designs.

Terms and Concepts

- theory
- independent variable (IV)
- dependent variable (DV)
- hypothesis
- directional hypothesis
- non-directional hypothesis
- treatment group
- control group
- true experiment
- quasi-experiment
- intact group
- pre and post test control design
- post test only control design
- factorial design
- factor
- level
- 2x3 factorial design
- main effect
- interaction effect
- non-equivalent group design
- repeated measures

Review, Consolidation, and Extension of Knowledge

1. In your own words
   a. describe the purpose of experimental research
b. explain the difference between a true experiment and a quasi experiment of group differences

c. describe the process of designing and implementing an experiment or quasi–experiment on a topic of interest to you.

d. Using an electronic database, search for an experiment or quasi-experiment on a topic of interest. Read the article and answer the questions in the Guide: Part One below.

Guide to Reading and Critiquing an Experimental and Quasi-Experimental Group Study: Part One

Research Review and Theory:

What is the purpose of the research review?

Does it establish an underlying theory (big ideas) for the research?

Purpose and Design:

What is the purpose of the study?

Is there a hypothesis or a research question? If so, what is it? If not, can you infer the question from the text of the article?

What is the basic research design and type?

What are the dependent and independent variables? Identify each type of variable in the study. (IV=, DV=)
Sampling:

How is the sample selected?

How is the sample assigned to the treatment condition(s): random or non-random/intact group?

Who is in the sample? What are the characteristics of the sample?

What is the sample size?

Data Collection:

What measures are used for the dependent variable?

Are these standardized measures? Adapted measures? Newly-created measures?

What is the format of the measure(s)?

Are there indications of validity and reliability of the measures? What are they (r-values)?