Quantitative Research Methods: Experimental and Nonexperimental Research

The basic building blocks of quantitative research are variables. *Variables* (something that takes on different values or categories) are the opposite of *constants* (something that cannot vary, such as a single value or category of a variable).

Many of the important types of variables used in quantitative research are shown, with examples, in Table 2.2.

Here is that table for your review:

TABLE 2.2 Common Types of Variables Classified by Level of Measurement and by Role of Variable

Variable Type	Key Characteristic	Example
Level of Measurement		
Categorical variable	A variable that is made up of different types or categories of a phenomenon	The variable *gender* is made up of the categories of male and female.
Quantitative variable	A variable that varies in degree or amount of a phenomenon	The variable *annual income* varies from zero income to a very high income level.
Role Taken by the Variable		
Independent variable (symbolized as IV)	A variable that is presumed to cause changes to occur in another variable, a causal variable	Amount of studying (IV) affects test grades (DV).
Dependent variable (symbolized as DV)	A variable that changes because of another variable, the effect or outcome variable	Amount of studying (IV) affects test grades (DV).
Mediating variable (It is also called an intervening variable)	A variable that comes in between other variables, helps to delineate the process through which variables affect one another	Amount of studying (IV) leads to input and organization of knowledge in long-term memory (mediating variable), which affects test grades (DV).
Moderator variable	A variable that delineates how a relationship of interest changes under different conditions or circumstances	Perhaps the relationship between studying (IV) and test grades (DV) changes according to the different levels of use of a drug such as Ritalin (moderator).

In looking at the table note that when we speak of measurement, the most simple classification is between categorical and quantitative variables. As you can see, *quantitative variables* vary in degree or amount (e.g., annual income) and *categorical variables* vary in type or kind (e.g., gender).

The other set of variables in the table (under the heading role taken by the variable) are the kinds of variables we talk about when explaining how the world operates and when we design a quantitative research study.

As you can see, *independent variables* (symbolized by "IV") are the presumed cause of another variable. *Dependent variables* (symbolized by "DV") are the presumed effect or outcome. Dependent variables are influenced by one or more independent variables. What is the IV and DV in the relationship between smoking and lung cancer? (Smoking is the IV and lung cancer is the DV.)

Sometimes we want to understand the process or variables through which one variable affects another variable. This brings us to the idea of *intervening variables* (also called mediator or mediating variables). Intervening variables are variables that occur between two other variables. For example, tissue damage is an intervening variable in the smoking and lung cancer relationship. We can use arrows (which mean causes or affects) and draw the relationship that includes an intervening variable like this:
Smoking---->Tissue Damage----->Lung Cancer.

Sometimes a relationship does not generalize to everyone; therefore, researchers often use *moderator variables* to show how the relationship changes across the levels of an additional variable. For example, perhaps behavioral therapy works better for males and cognitive therapy works better for females. In this case, gender is the moderator variable. The relationship be type of therapy (behavioral versus cognitive) and psychological relief is moderated by gender.

Now, I will talk about the major types of quantitative research: experimental and nonexperimental research.

Experimental Research
The purpose of experimental research is to study cause and effect relationships.
Its defining characteristic is active manipulation of an independent variable (i.e., it is only in experimental research that "manipulation" is present). Also, random assignment (which creates "equivalent" groups) is used in the strongest experimental research designs.

Here is an example of an experiment.

Pretest	Treatment	Posttest
O_1	X_E	O_2
O_1	X_C	O_2

Where:

- E stands for the experimental group (e.g., new teaching approach)
- C stands for the control or comparison group (e.g., the old or standard teaching approach)

Because the best way to make the two groups similar in the above research design is to *randomly assign* the participants to the experimental and control groups, let's assume that we have a convenience sample of 50 people and that we randomly assign them to the two groups in our experiment.

Here is the logic of this experiment. First, we made our groups approximately the same at the start of the study by using random assignment (i.e., the groups are "equated"). You pretest the participants to see how much they know. Next, you manipulate the independent variable by using the new teaching approach with the experimental group and using the old teaching approach for the control group. Now (after the manipulation) you measure the participants' knowledge to see how much they know after having participated in our experiment. Let's say that the people in the experimental group show more knowledge improvement than those in the control group. What would you conclude? In this case, we can conclude that there is a causal relationship between the IV, teaching method, and the DV, knowledge, and specifically we can conclude that the new teaching approach is better than the old teaching approach. Make sense?

Now, let's say that in the above experiment we could not use random assignment to equate our groups. Let's say that, instead, we had our best teacher (Mrs. Smith) use the new teaching approach with her students in her 5th period class and we had a newer and less experienced teacher (Mr. Turner) use the old teaching approach with his 5th period class. Let's again say that the experimental group did better than the control group. Do you see any problems with claiming that the reason for the difference between the two groups is because of the teaching method? The problem is that there are alternative explanations. First, perhaps the difference is because Mrs. Smith is the better teacher. Second, perhaps Mrs. Smith had the smarter students (remember the students were not randomly assignment to the two groups; instead, we used two intact classrooms). We have a name for the problems just mentioned. It is the problem of alternative explanations. In particular, it is very possible that the difference we saw between the two groups was due to variables other than the IV. In particular, the difference might have been due to the teacher (Mrs. Smith vs Mr. Turner) or to the IQ levels of the groups (perhaps Mrs. Smith's students had higher IQs than Mr. Smith's students) We have a special name for these kinds of variables. They are called extraneous variable.

It is important to remember the definition of an *extraneous variable* because they can destroy the integrity of a research study that claims to show a cause and effect relationship. An *extraneous variable* is a variable that may compete with the independent

variable in explaining the outcome. Remember this, if you are ever interested in identifying cause and effect relationships you must always determine whether there are any extraneous variables you need to worry about. If an extraneous variable really is the reason for an outcome (rather than the IV) then we sometimes like to call it a *confounding variable* because it has confused or confounded the relationship we are interested in.

Nonexperimental Research

Remember that the defining characteristic of experimental research was manipulation of the IV. Well, in nonexperimental research there is no manipulation of the independent variable. There also is no random assignment of participants to groups.

What this means is that if you ever see a relationship between two variables in nonexperimental research you cannot jump to a conclusion of cause and effect because there will be too many other alternative explanations for the relationship.

In the chapter, we make a distinction between two examples of nonexperimental research. In the "basic case" of *causal-comparative research*, there is one categorical IV and one quantitative DV.

- Example: Gender (IV) and class performance (DV).
- You would look for the relationship by comparing the male and female average performance levels.

In the simple case of *correlational research*, there is one quantitative IV and one quantitative DV.

- Example: Self-esteem (IV) and class performance (DV).
- You would look for the relationship by calculating the correlation coefficient.
- The correlation coefficient is a number that varies between –1 and +1, and 0 stands for no relationship. The farther the number is from 0, the stronger the relationship.
- If the sign of the correlation coefficient is positive (e.g., +.65) then you have a positive correlation, which means the two variables move in the same direction (as one variable increases, so does the other variable). Education level and annual income are positively correlated (i.e., the higher the education, the higher the annual income).
- If the sign of the correlation coefficient is negative (e.g., -.71) then you have a negative correlation, which means the two variables move in opposite directions (as one variable increases, the other decreases). Smoking and life expectancy are negatively correlated (i.e., the higher the smoking, the lower the life expectancy).

We will show you how to improve on the two basic nonexperimental designs in later chapters, but for now, please remember these important points:

1) You can obtain much stronger evidence for causality from experimental research than from nonexperimental research (e.g., a strong experiment is better than causal-comparative and correlation research).

2) You cannot conclude that a relationship is causal when you only have one IV and one DV in nonexperimental research (without controls). Therefore, the basic cases of both causal-comparative and correlation research are severely flawed!

3) In later chapters we explain three necessary conditions for causality (relationship, temporal order, and lack of alternative explanations)

For a preview of these *three necessary conditions* required to make a firm statement of cause and effect, read this next section. It is provided as supplemental or preview material for this topic which occurs in many chapters of the book. If you have had enough for now, just skip to the next section of this lecture entitled Qualitative Research.

There are three necessary conditions that you must establish whenever you want to conclude that a relationship is causal. They are shown in the following Table:

TABLE 11.1
The Three Necessary Conditions for Causation

Researchers must establish three conditions if they are to conclude that changes in variable A cause changes in variable B.	
Condition 1:	Variable A and variable B must be related (the relationship condition).
Condition 2:	Proper time order must be established (the temporal antecedence condition).
Condition 3:	The relationship between variable A and variable B must *not* be due to some confounding extraneous or "third" variable (the lack of alternative explanation condition).

Our experiment met these criteria quite nicely. That is, we had a relationship between teaching method and knowledge; the manipulation occurred before the posttest; and because we randomly assigned the people to the two groups, there should be no other variables that can explain away the relationship.

On the other hand, in the basic cases of causal-comparative and correlational research, where we only observed a relationship between two variables (we had no manipulation or random assignment), we have only established condition 1. We can only conclude that the two variables are related. In chapter 11 we will show you how to design nonexperimental research that performs better than the basic cases on the three above conditions.

Still, remember, even when these basic cases are improved, experimental research with random assignment is better for studying cause and effect than nonexperimental research.

Another way of saying this is, if you want to show that one thing causes another thing, then, if it is feasible, you will want to CONDUCT AN EXPERIMENT.

Qualitative Research Methods

We describe qualitative research earlier, in Table 2.1. There are five major types of qualitative research: phenomenology, ethnography, case study research, grounded theory, and historical research. All of the approaches are similar in that they are qualitative approaches. Each approach, however, has some distinct characteristics and tends to have its own roots and following.

Here are the definitions and an example of the different types of qualitative research:

- *Phenomenology* – a form of qualitative research in which the researcher attempts to understand how one or more individuals experience a phenomenon. For example, you might interview 20 widows and ask them to describe their experiences of the deaths of their husbands.
- *Ethnography* – is the form of qualitative research that focuses on describing the culture of a group of people. Note that a *culture* is the shared attitudes, values, norms, practices, language, and material things of a group of people. For an example of an ethnography, you might decide to go and live in a Mohawk communities and study the culture and their educational practices.
- *Case study research* – is a form of qualitative research that is focused on providing a detailed account of one or more cases. For an example, you might study a classroom that was given a new curriculum for technology use.
- *Grounded theory* – is a qualitative approach to generating and developing a theory form data that the researcher collects. For an example, you might collect data from parents who have pulled their children out of public schools and develop a theory to explain how and why this phenomenon occurs, ultimately developing a theory of school pull-out.
- *Historical research* – research about events that occurred in the past. An example, you might study the use of corporeal punishment in schools in the 19th century.

Mixed Research Methods

Mixed research is a general type of research (it's one of the three paradigms) in which quantitative and qualitative methods, techniques, or other paradigm characteristics are mixed in one overall study. Earlier we showed it major characteristics of mixed research in Table 2.1. Now the two major types of mixed research are distinguished: mixed method versus mixed model research.

- *Mixed method research* – is research in which the researcher uses the qualitative research paradigm for one phase of a research study and the quantitative research paradigm for another phase of the study. For example, a researcher might conduct an experiment (quantitative) and after the experiment conduct an interview study with the participants (qualitative) to see how they viewed the

experiment and to see if they agreed with the results. Mixed method research is like conducting two mini-studies within one overall research study.

- *Mixed model research* – is research in which the researcher mixes both qualitative and quantitative research approaches within a stage of the study or across two of the stages of the research process. For example, a researcher might conduct a survey and use a questionnaire that is composed of multiple closed-ended or quantitative type items as well as several open-ended or qualitative type items. For another example, a researcher might collect qualitative data but then try to quantify the data.

The Advantages of Mixed Research

First of all, we advocate the use of mixed research when it is feasible. We are excited about this new movement in educational research and believe it will help qualitative and quantitative researchers to get along better and, more importantly, it will promote the conduct of excellent educational research.

- Perhaps the major goal for researcher who design and conduct mixed research is to follow the *fundamental principle of mixed research.* According to this principle, the researcher should mix quantitative and qualitative research methods, procedures, and paradigm characteristics in a way that the resulting mixture or combination has complementary strengths and nonoverlapping weaknesses. The examples just listed for mixed method and mixed model research can be viewed as following this principle. Can you see how?
- Here is a metaphor for thinking about mixed research: Construct one fish net out of several fish nets that have holes in them by laying them on top of one another. The "new" net will not have any holes in it. The use of multiple methods or approaches to research works the same way.
- When different approaches are used to focus on the same phenomenon and they provide the same result, you have "corroboration" which means you have superior evidence for the result. Other important reasons for doing mixed research are to complement one set of results with another, to expand a set of results, or to discover something that would have been missed if only a quantitative or a qualitative approach had been used.
- Some researchers like to conduct mixed research in a single study, and this is what is truly called *mixed research*. However, it is interesting to note that virtually all research literatures would be mixed at the aggregate level, even if no single researcher uses mixed research. That's because there will usually be some quantitative and some qualitative research studies in a research literature.

Our Research Typology

We have now covered the essentials of the three research paradigms and their subtypes. Let's put it all together in the following picture of our research typology:

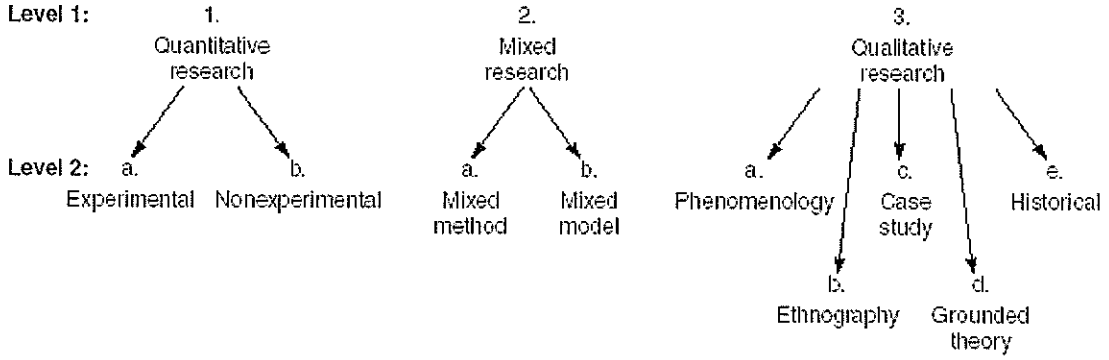

FIGURE 2.3 Research typology (Later chapters will add a third level to this typology.)