7

Quantitative Research Methods

Student Learning Objectives

After studying Chapter 7, students will be able to do the following:

1. Describe the defining characteristics of quantitative research studies
2. List and describe the basic steps in conducting quantitative research studies
3. Identify and differentiate among various approaches to conducting quantitative research studies
4. List and describe the steps and procedures in conducting survey, correlational, causal-comparative, quasi-experimental, experimental, and single-subject research
5. Identify and discuss the strengths and limitations of various approaches to conducting quantitative research
6. Identify and explain possible threats to both internal and external validity
7. Design quantitative research studies for a topic of interest

This chapter focuses on research designs commonly used when conducting quantitative research studies. The general purpose of quantitative research is to investigate a particular topic or activity through the measurement of variables in quantifiable terms. Quantitative approaches to conducting educational research differ in numerous ways from the qualitative methods we discussed in Chapter 6. You will learn about these characteristics, the quantitative research process, and the specifics of several different approaches to conducting quantitative research.

Characteristics of Quantitative Research

Quantitative research relies on the collection and analysis of numerical data to describe, explain, predict, or control variables and phenomena of interest (Gay, Mills, & Airasian, 2009). One of the underlying tenets of quantitative research is a philosophical belief that our world is relatively stable and uniform, such that we can measure and understand it as well as make broad generalizations about it. You should note right away the stark contrast between this belief and those of qualitative research—namely, that the world is ever changing and the role of the researcher is to adapt to and observe those constant changes. Gay and colleagues state that, from a quantitative perspective, conclusions drawn about our world and its phenomena cannot be considered meaningful unless they can be verified through direct observation and measurement. Further, quantitative researchers typically base their investigations on the belief that facts and feelings can be separated, and that the world exists as a *single reality*—composed of facts—that can be discovered through observation or other measurements (Fraenkel, Wallen, & Hyun, 2012). Yet again, this belief operates in stark contrast to the assumption held by qualitative researchers that individuals, in essence, are responsible for developing their own separate and unique realities of the same situation.

The goal of quantitative research studies is vastly different from the qualitative goal of gaining a better understanding of a situation or event. When conducting quantitative research studies, researchers seek to describe current situations, establish relationships between variables, and sometimes attempt to explain causal relationships between variables. This type of research is truly focused on describing and explaining—sometimes in a somewhat definitive manner—the phenomenon under investigation (Creswell, 2005). Because of this singular perspective, quantitative research operates under widely agreed-on steps that guide the research process (Fraenkel et al., 2012). The quantitative research process—along with its various designs—is fairly well established; there is little flexibility in terms of the strategies and techniques used. Quantitative researchers believe that nothing should be left to chance; therefore, no aspect of the research design is permitted to emerge during the process, as it is in qualitative research.

The role undertaken by the quantitative researcher is very different from that of his or her qualitative counterpart. One of the goals of qualitative research is for the researcher to become deeply immersed in the setting and among the participants. However, a major goal of quantitative research is for the researcher to remain as *objective* as possible (although, as we have previously discussed, all researchers have biases and it is more important that they recognize those biases and discuss their limitations). The much more linear steps in the quantitative research process—as you will see shortly—constitute the preestablished routines and strategies that help enhance researcher objectivity. This focus on objectivity is what enables the quantitative researcher to *generalize* findings of a research study beyond the particular situation (e.g., setting, school, participants) involved in that study.

Some additional characteristics of quantitative research, summarized below, continue to differentiate its goals and strategies from those of qualitative research (Creswell, 2005).

1. While the *literature review* serves as a justification for the research problem regardless of the research type, its role is much more central to the design of a quantitative study than to that of a qualitative study. Not only does it provide background information for the study, but it serves to inform the methodologies, instrumentation, populations, and analytical techniques to be used in the study.

2. The *purpose* of quantitative studies is typically specific and narrow, focusing on only a handful of measurable variables. This is very different from the holistic perspective of qualitative research.

3. *Data collection* is one of the most thoroughly established aspects of quantitative research. While these strategies may emerge during a qualitative study, they must be well developed prior to beginning a quantitative research study. Furthermore, in a quantitative research study, data collection instruments, procedures, and sampling strategies typically do not change once the study has begun. Quantitative researchers operate in this manner because they believe that it enhances the objectivity of their studies.

4. Quantitative *sampling strategies* differ drastically from those used in qualitative studies. Their focus in quantitative studies is twofold: First, because generalizability of the results is a key aspect of quantitative research, sampling strategies tend to focus on the *random selection* of participants. Second, and again focusing on the idea of generalizing the results, quantitative researchers typically collect data from a large number of individuals in their studies. As you will read in Chapter 12, the reason for using large samples is to collect data from enough individuals that those data mirror the substantially larger population from which the sample was drawn.

5. Techniques for *data analysis and interpretation* are entirely statistical in nature. The focus is on the application of existing indices (e.g., calculating an average score), formulas (e.g., the formula for calculating a standard deviation), and statistical tests (e.g., an independent-samples *t*-test) that are consistent regardless of a particular topic or the variables being studied. In other words, if two researchers are analyzing the same quantitative data set and both are calculating an average score, their calculated score will be identical. The same can be said for interpreting the results of statistical analyses. For example, when interpreting the average test score for two groups of students exposed to different instructional methods, we would naturally interpret the higher average score to mean that *that* group outperformed the group with the lower average score. Of course, this is not the case when analyzing qualitative data, where interpretations can involve a great deal of subjectivity depending on the individual doing the analysis and interpretation. This is yet another aspect of quantitative research methods that introduces objectivity into the overall research process.

6. Finally, *reporting the results* of quantitative research almost always occurs in a standard, fixed format (as you will learn more about in Chapter 14). The results are reported in an extremely objective and unbiased manner, having not been subjected to the inherent biases of the researcher.

The Quantitative Research Process

The general steps involved in the process of conducting any research study—as discussed in Chapters 1 and 2—are typical for quantitative research studies. In nearly every quantitative study, the steps are followed in sequential order. Furthermore, one step is usually completed before the subsequent step begins, especially when it comes to data collection, analysis, and interpretation. Only once data collection has ceased does the analysis begin, followed—upon its completion—by the interpretation of those results. I will briefly reiterate the process, as it was presented in Chapter 2.

1. *Identification of the research problem to be studied*. As you have seen numerous times, clearly identifying a research topic is the first step in any study. Quantitative research studies tend to be narrow in scope, focusing on a handful of key variables. As has been previously noted, the purpose of any given study will often guide choices and decisions about the methodology to be employed in that study.

2. *Statement of one, or several, pertinent research questions and/or hypotheses*. The researcher must ensure that research questions and hypotheses are stated clearly and precisely, as they will guide the remainder of the study. Failure to do so at the outset of the study can lead to problems—that is, misalignment between research questions and necessary data or between collected data and proposed analytical techniques—as the study progresses.

3. *Review of related literature*. Reviewing related literature provides a great deal of guidance in quantitative research studies. Learning what others have done previously can inform decisions regarding research design, sampling, instrumentation, data collection procedures, and data analysis.

4. *Development of a written literature review*. Once the related literature has been collected and thoroughly reviewed, the researcher must synthesize the pertinent body of literature for a prospective reader of the final research report.

5. *Development of a research plan*. Taking what has been gleaned from the literature review, alongside the goals of the researcher, a complete research plan is developed. Included in the plan are strategies for selecting a sample of participants, an appropriate research design based on the nature of the research questions or hypotheses, and strategies for data collection (including procedures, instrumentation, informed consent forms, and a realistic time frame) and data analysis.

6. *Collection of data*. Data collection in a quantitative study tends not to take a great deal of time, depending on the particular design. Data are typically collected directly from participants through the use of instruments, such as surveys, inventories, checklists, tests, and other tools that will generate numerical data.

7. *Analysis of data*. Quantitative data are analyzed statistically, focusing on numerical descriptions, comparisons of groups, or measures of relationships among variables. Because samples tend to be large, data analysis is typically conducted through the use of statistical analysis software programs.

8. *Development of conclusions and recommendations*. Conclusions are drawn directly from the interpretation of results from the statistical analysis. The conclusions, as well as the recommendations for practice and future research, are typically connected back to the body of literature that served as the basis for the earlier literature review.

9. *Preparation of a final research report*. The final step in conducting a quantitative research study is to prepare the final research report. This report summarizes all aspects of the study; in other words, each of the previous eight steps are clearly and thoroughly described in the report.

Approaches to Conducting Quantitative Research

There are several commonly used approaches to conducting quantitative research studies in the field of education. These approaches typically fall into two categories: nonexperimental research designs and experimental research designs. Next, I will provide an overview of these two categories, in addition to descriptions of the specific approaches or designs within each.

Nonexperimental Research Designs

Nonexperimental research designs embody a group of techniques used to conduct quantitative research where there is no manipulation done to any variable in the study. In other words, variables are measured as they occur naturally, without interference of any kind by the researcher. This lack of manipulation may exist because the variable was naturally "manipulated" before the study began or because it is not possible, or feasible, for the researcher to manipulate a particular variable (Mertler, 2014). Three types of nonexperimental research designs are *descriptive research* (which includes *observational research* and *survey research*), *correlational research*, and *causal-comparative research*.

Descriptive Research The purpose of *descriptive studies* is to describe, and interpret, the current status of individuals, settings, conditions, or events (Mertler, 2014). In descriptive research, the researcher is simply studying the phenomenon of interest *as it exists naturally;* no attempt is made to manipulate the individuals, conditions, or events. Two commonly used quantitative, non-experimental, descriptive research designs are *observational research* and *survey research*.

Observational Research. Some of you may be thinking that this sounds more like a qualitative research design than a quantitative one. While observation is certainly important in the realm of qualitative research, we can also design observational research studies that rely on the collection of quantitative data. Quantitative observational studies typically focus on a particular aspect of behavior that can be quantified through some measure (Leedy & Ormrod, 2013). There may still be some confusion between the two observational research approaches, but the *quantification* of observations is the key distinction. For example, we might design a study that focuses on quantifying disruptive classroom behaviors demonstrated by a particular student or group of students. The teacher may notice that the behaviors occur sporadically throughout the day and may want to discover if there are particular times or activities during which the disruptive behavior arises. We might develop an instrument—essentially, a simple tally sheet—to record the number of times the disruptive behavior occurs during specific intervals throughout the day. We might include on the tally sheet a section to indicate the specific activity in which the student is engaged and any other students involved when disruptive behavior occurs. At the end of predetermined periods of time, we would count (i.e., quantify) the number of tally marks on the sheet (Mertler, 2014).

We might base our quantification in observational study on a number of different criteria (Leedy & Ormrod, 2013). In the previous example, we saw how the occurrence of behavior is *counted* to determine its overall *frequency*. However, in other situations, we might be concerned with the *accuracy*, *intensity*, *proficiency*, or *mastery* of a particular behavior. In these cases, our instrument would not be restricted to a simple set of tally marks. The researcher would need to design an instrument that allowed for the *rating*—on a continuum—of the particular characteristic serving as the focus of the study. Examples of these different types of instruments and scales will be discussed and presented in Chapter 12.

A strength of observational research is that it can yield data that depict the complexity of human behavior. With respect to some situations and research questions, it may provide a quantitative option to qualitative approaches such as ethnography and grounded theory research (Leedy & Ormrod, 2013). However, observational research is not without its limitations. An observational study tends to require considerable advanced planning, attention to detail, and often more time than other descriptive approaches to conducting quantitative research (Leedy & Ormrod, 2013).

Survey Research. A second approach to conducting descriptive research is survey research. The central purpose of **survey research** is to describe characteristics of a group or population (Fraenkel et al., 2012). It is primarily a quantitative research technique in which the researcher administers some sort of survey or questionnaire to a sample—or, in some cases, an entire population—of individuals to describe their attitudes, opinions, behaviors, experiences, or other characteristics of the population (Creswell, 2005).

In most cases, it is not possible or feasible to survey an entire population; therefore, a sample of **respondents** must be selected from the population. Since the purpose of survey research is to describe characteristics of a population, it is imperative that the sample be selected using a probability sampling technique to ensure more accurate representation of the population. No sampling technique will *guarantee* perfect representation, but probability techniques improve the odds. Accurate representation is necessary because the survey researcher is attempting to describe an entire population by collecting and analyzing data from a smaller subset of the larger group. If the sample does not approximate the larger population, then the inferences drawn about that population will be erroneous to some degree. (Probability sampling techniques will be discussed in Chapter 12.)

Survey research can be used in a descriptive manner, as has been explained; however, it may also be used to investigate relationships between variables (Fraenkel et al., 2012; McMillan, 2012). This process involves a combination of survey research and correlational research design (which you will learn more about shortly). Educational researchers use this approach when the purpose of their study is to describe the relationships between variables within a given population. Similarly, survey research may also be used in a comparative research design (McMillan, 2012). For example, if a researcher wished to examine the differences in attitudes between two or more subgroups of a population (e.g., based on gender, ethnicity, years of teaching experience, or school level), survey research would be an appropriate methodology to use. For these reasons, there is sometimes disagreement among educational research experts as to whether survey research should be categorized as a *separate approach* to conducting quantitative research or as a particular *data collection technique* to be employed when using other approaches to quantitative research.

When conducting survey research, the researcher can choose among several modes of data collection, including direct administration of surveys, mail surveys, telephone surveys, interviews, e-mail surveys, and web-based surveys (Creswell, 2005; Fraenkel et al., 2012; Mertens, 2005). **Direct administration** is used whenever the researcher has access to all, or most, members of a given group who are located in one place. The researcher administers the survey instrument in person to all members of the group, usually at the same time. This typically results in a high rate of response (also known as **return rate**), often near 100 percent. The cost of this mode is lower than most others; however, its main disadvantage is that gathering an entire group together in the same location at the same time is not always possible.

Mail surveys involve administering or distributing the survey instrument to the sample by sending a hard copy to each individual and requesting that it be returned by mail before a certain date. While the cost can be a bit prohibitive, the researcher does gain access to a wider sampling of individuals than through the use of direct administration. The trade-off, however, is that the response rate is typically much lower. Additionally, it is not possible to encourage participation when the researcher is not face-to-face with the respondents.

Telephone surveys can be quite expensive because they must be administered individually, as opposed to the simultaneous administration of direct and mail surveys. These surveys essentially require the researcher (and any assistants, who must receive training) to read each survey question to individual respondents. Therefore, data collection can take a good deal of time, depending on the size of the sample. Also, access to some individuals may be substantially limited (e.g., those without telephones, those with unlisted telephone numbers, or those who use only cell phones). However, telephone surveys are especially effective in gathering responses to open-ended questions.

Interviews are the most costly type of data collection in survey research, largely because they must be conducted individually and face-to-face. This usually means that either the researcher or the respondent (or possibly both) must travel to the interview location. It is easier in interviews to enlist the participation of respondents and probe for clarification of their answers, due to the more conversational style of data collection. Somewhat similar to telephone surveys, interviews require that any assistants or staff be trained in the administration of the interview protocol. This requires additional time and expense on the part of the researcher.

Finally, the rise of the Internet has resulted in a substantial increase in the use of *electronic surveys*. An electronic survey is distributed to potential respondents, usually as attachments to e-mail messages or as standalone webpages, each with its own unique URL or web address. **E-mail surveys** are delivered to potential respondents via e-mail and require an e-mailed set of responses in return. Individuals who complete **web-based surveys** are typically directed to a website through initial contact via e-mail. They complete the survey online and submit their responses via the Internet. The cost and time requirements for these electronic modes of data collection are low; however, both modes require access to technology—e-mail surveys require an active e-mail account, which must also be accessible to the researcher through some sort of existing database, and web-based surveys require access to the Internet via a web browser. Additionally, other limitations of electronic surveys include the fact that databases of current e-mail addresses often do not exist for larger populations (e.g., all teachers in a given state) and many people are not comfortable using websites or sending personal information via the Internet. Mertler (2002) has outlined some of the technological limitations of web-based and other electronic surveys, in addition to providing some guidelines for their use. These limitations include

- compatibility issues (e.g., older computers or web browsers that will not allow the respondent to view or complete the online survey),
- e-mails not delivered to potential respondents because they are sent to multiple recipients (and thus categorized as "spam"), and
- representativeness of the resulting sample (and, ultimately, generalizability of the study's findings).

The above concerns aside, the use of web-based technology for the collection of research data has exploded over the past decade. Below is a listing of several websites where researchers can develop surveys, have them published online, and use them to collect data efficiently. Most of these sites charge fees for hosting the survey and for storing data on their web servers, although the fees vary widely. These sites have many interesting features, and I encourage you to investigate them.

- KwikSurveys (www.kwiksurveys.com)
- Murvey (www.murvey.com)
- Qualtrics (www.qualtrics.com)
- QuestionPro (www.questionpro.com)
- SurveyGizmo (www.surveygizmo.com)
- SurveyGuru (www.surveyguru.com)
- SurveyMonkey (www.surveymonkey.com)
- Zoho Survey (www.zoho.com/survey)
- Zoomerang (www.zoomerang.com)

Table 7.1 presents a summary of the relative advantages and limitations of these various survey data collection modes.

Types of Surveys. There are three basic types of surveys: descriptive, cross-sectional, and longitudinal. It is important to note that a given research topic may be studied using any of the three types of surveys, as you will see in a moment, depending on the purpose of the research. Mertens (2005) explains the **descriptive survey** approach as a one-shot survey for the purpose of simply describing the characteristics of a sample at one point in time. In research of students' reading attitudes and behaviors, a descriptive survey study might be structured as follows: The researcher would randomly select students—possibly elementary or middle school students—and survey them in an attempt to describe their attitudes toward reading as well as their reading behaviors.

A **cross-sectional survey** involves the examination of the characteristics of—and possibly differences among—several samples or populations measured at one point in time. Using the same topic discussed above, an example of a cross-sectional survey study might involve the examination of—and comparisons among—the reading

TABLE 7.1 ● Relative Advantages and Limitations of Different Modes of Survey Delivery

Characteristic	Mode of Survey Delivery					
	Direct Administration	Mail Surveys	Telephone Surveys	Interviews	E-Mail Surveys	Web-Based Surveys
Comparative cost	Lowest	High	High	Highest	Low	Low
Data collection time	Shortest	Short	Long	Longest	Very short	Very short
Response rate	Highest	Low	High	High	Low	Low
Group administration	Yes	Yes	No	Possibly	Yes	Yes
Permit follow-up questions	No	No	Yes	Yes	No	No
Permit random sampling	Possibly	Yes	Yes	Yes	Yes	Yes
Facilities required	Yes	No	No	Yes	No	No
Technology required	No	No	No	No	Yes	Yes
Training required	No	No	Yes	Yes	No	No

Source: Adapted from Fraenkel et al. (2012).

attitudes and behaviors of third-, fifth-, and seventh-grade students. All the students making up the sample would be surveyed at the same point in time. If a cross-sectional survey is conducted for an entire population, the resulting survey is known as a **census**.

Finally, in a **longitudinal survey**, individuals in one group or cohort are studied at different points in time. In other words, the same group of participants is studied over an extended period of time, which typically involves the administration of several surveys at particular time intervals. The longitudinal version of our hypothetical study would look somewhat similar in purpose but would address somewhat different research questions. The purpose would again be to examine the reading attitudes and behaviors of students, but this time the researcher would follow the same students over an established period of time. For example, the attitudes and behaviors of third-grade students would be measured. Two years later, the same group of students would again be measured as fifth-graders. Two years later, they would again be surveyed as seventh-graders.

Generally speaking, there are three main types of longitudinal surveys: trend, cohort, and panel studies (Creswell, 2005). A **trend study** is a longitudinal survey study that examines changes within a specifically identified population over time. An example might be a survey study of ninth-graders' attitudes toward and use of illegal substances for the 5-year period between 2010 and 2014, in an attempt to identify trends in those attitudes and behaviors. Different ninth-grade students would be surveyed each year; however, they would all represent the same population (i.e., ninth-grade students).

In a **cohort study**, the researcher studies within a specified population a subgroup (called the "cohort") whose members share some common characteristic. This subgroup, as defined by the characteristic, is then surveyed over time. Let us now extend our example of studying attitudes toward and use of illegal substances and apply a cohort design to it. If the researcher wanted to begin by studying ninth-graders (i.e., "ninth grade" would be the defining characteristic) in 2010, this same cohort (but not *necessarily* the same people) would be studied as tenth-graders in 2011, eleventh-graders in 2012, and so on. It is important to note that the group studied each year may or may not be the same individuals that began the study in 2010; remember, they are *selected* from and are *representing* a particular subgroup of a much larger population. To be a part of the group studied in each subsequent year, participants must have been in the ninth grade in 2010.

Finally, a **panel study** is most closely aligned with the fundamental description of a longitudinal survey. In a panel study, the researcher examines the exact same people over a specified length of time. In applying this design to our current example, the researcher would select and survey a group of ninth-graders in 2010, survey the same students in 2011, again in 2012, and so on. Therefore, a panel study is somewhat analogous to a cohort design that studies the same people throughout the length of the longitudinal study. The advantage of this type of design is that you are studying the same individuals; the limitation is that some of them may relocate and be difficult, if not impossible, to find. This tendency will likely result in an ever-decreasing sample size throughout the course of the study.

Cross-sectional survey designs are the most commonly used survey design method, especially when compared with longitudinal designs (Creswell, 2005). This is largely because they can be conducted in a shorter amount of time. Some researchers argue that a longitudinal study provides more meaningful information (i.e., *changes* in reading attitudes and behaviors can be examined for the *same* students). The trade-off, however, is the amount of time required for data collection in this type of survey study.

The Survey Research Process. As previously mentioned, the basic steps in conducting a quantitative research study are fairly consistent across different types of quantitative research. The steps in conducting a survey research study are no exception, although there are unique aspects to the process:

1. *Identification of the topic to be studied*. As with any type of research study, the topic for investigation should first be identified. The topic is often refined and narrowed during the next step.

2. *Review of related literature*. As you have learned, related literature is reviewed to identify useful strategies for conducting the study, as well as to see what has already been discovered about the topic of interest. Also, in survey research, related literature can be used to guide the development of survey or interview questions, as well as data collection protocols.

3. *Identification and selection of participants*. In survey research, the initial activity in the selection of participants is to identify the **target population**. This is the larger group of people to whom the researcher would like to generalize the results of the study. From that list of people, individuals are randomly selected for inclusion in the sample, using a probability sampling technique.

4. *Determination of the mode of data collection*. The researcher must determine the most appropriate method for collecting data—whether it be direct administration of a survey, a mail survey, a telephone survey, interviews, e-mail surveys, or web-based surveys—focusing on the advantages and limitations of each.

5. *Drafting the cover letter and instrument*. A **cover letter**, which will accompany a written survey or precede the interview process, explains the purpose of the study and describes what will be asked of participants. In addition, this letter also describes the potential benefits of the study. The survey instrument or interview questions must be developed based on the guidelines previously discussed. A sample cover letter used in a web-based survey study, along with the survey it accompanied, is presented in Chapter 12.

6. *Pilot test of the instrument*. For a researcher conducting a survey study, there is probably nothing more frustrating than sending out a survey only to discover later that participants did not understand the directions or the questions to which they were supposed to respond (Gay et al., 2009). A **pilot test** is a trial run of the data collection process to determine if any revisions should be made before *actual* data collection occurs. Using a small group—perhaps 15 to 20 individuals—selected from the population of interest, the cover letter and survey are distributed and completed. Upon completion, the researcher seeks feedback from the participants. This process gives the researcher an idea of how long it might take individuals to complete the instrument. It also provides feedback about specific questions that may need revision prior to actual data collection.

7. *Collection of data*. Data are collected through the administration of the survey instrument or by interviewing participants.

8. *Analysis of data*. Most analyses of survey data will involve the use of statistical procedures. These analyses may involve simple frequency distributions, descriptive statistics, correlations, or group comparisons.

9. *Answering research questions and drawing conclusions*. The results of the analyses should permit the researcher to answer the guiding research questions for the study. Once this has been done, inferences about the population may be drawn and conclusions about the study stated.

Strengths and Limitations in Survey Research. As with any research methodology, survey research has its advantages and its limitations. Among its advantages, survey research enables data collection from a large number of people (and can typically do so efficiently), allows for generalizability of results to large populations, and is versatile both in terms of what can be investigated and how (i.e., the various modes of data collection). As you read in this chapter, the wide variety of design options allows the researcher to "customize" survey research to meet the needs and goals of a given study (and its associated questions).

Limitations include issues related to low response rates as well as the time and financial requirements of some modes of data collection. Low response rates are always a potential concern in conducting survey research. Unfortunately, there is no single, widely accepted standard for the rate of survey response; it often depends on the nature of the survey study, the length of the survey instrument, and the population being studied. In some studies (such as those using a direct administration mode of delivery), the survey can be expected to receive nearly a 100% return rate. However, when using mail, e-mail, or web surveys as the mode of delivery, response rates of 50% to 75% may be acceptable. Even in these situations, characteristics of the population may result in response rates below this range. For example, some people (and, therefore, some populations) are constantly inundated with requests to complete surveys; educators are not immune to this experience. It is always advisable to "oversample" from the population (i.e., select substantially more individuals for potential participation than what you are hoping to get), anticipating some degree of nonresponse. Additionally, follow-up mailings or e-mails for requests to complete the survey are nearly always necessary and will result in improved rates of response. Of course, doing this may add to the monetary cost of implementing the survey study. That being said, Dillman (2000) has stated that repeated contact with respondents is the single most effective technique for increasing survey response rates.

The final limitation—or at least consideration—is that we are relying on *self-reported data* (Leedy & Ormrod, 2013); that is, people are telling us what *they* believe is true or what *they* have experienced. On the surface, this sounds like exactly what we want. However, researchers need to remember two important things when it comes to self-reported data:

- Even though people believe they are being accurate, they may in fact not be. Essentially, we are collecting information on their *perceptions* of what they believe to be accurate.

- Sometimes respondents to a survey will indicate answers they *think* we want to hear—especially if they are being asked questions of a sensitive nature; these are known as *socially acceptable responses*. Although this issue is unavoidable when conducting survey research, at a minimum, researchers have an obligation to recognize and acknowledge that respondents *may* be providing socially acceptable responses.

Correlational Research The purpose of *correlational studies* is to discover, and then possibly measure, relationships between two or more variables. From a research perspective, the word *relationship* means that an individual's status on one variable tends to reflect (i.e., is associated with) his or her status on another variable. Correlational research in education seeks out traits, abilities, or conditions that *covary*, or *co-relate*, with each other. Understanding the nature and strength of the relationship between two or more variables can help us

- comprehend and describe certain related events, conditions, and behaviors (correlational studies with this goal are typically referred to as **explanatory correlational studies**);
- predict future conditions or behaviors in one variable from what we presently know of another variable (these studies are generally referred to as **predictive correlational studies**); and
- sometimes obtain strong suspicions that one variable may be "causing" the other.

For example, we know that high school grade point average is correlated with subsequent student success in college. The correlation is far from perfect; in fact, perfect correlations are virtually nonexistent in education. Nevertheless, we can predict, with some degree of accuracy, a person's future college success by the grades he or she earns in high school.

In a correlational study, the researcher examines whether and to what degree a statistical relationship exists between two or more variables. Such a study is typically used to measure or describe existing conditions or something that occurred in the past (Johnson, 2008). The basic design for correlational research involves a *single* group of people who are quantitatively measured on *two* (or more) characteristics (i.e., variables) that have already happened to them. For example, we might be interested in measuring *if* there is a relationship—and if so, *how strong*—between the number of hours students spend studying independently and their scores on a unit test (Mertler, 2014). It is important to realize that, at the time we would collect data on these variables (i.e., "amount of time spent studying" and "test score"), they would have already occurred. Additionally, it is usually the case in a correlational study that the variables measured occur naturally. In our example, students would "naturally" study and they would "naturally" take a unit test. Therefore, when a correlational research design is used, there is no manipulation of any of the conditions being measured in the study.

The relationships investigated during a correlational study are measured statistically by calculating a *correlation coefficient* (symbolized by an italicized, lowercase r), which measures two aspects of the relationship between variables: the *direction* of the relationship and the *strength* of the relationship. You will learn more about correlation coefficients—along with their interpretations—in Chapter 12. However, a word of caution is warranted here. It is critical that the correlation coefficients—and, therefore, the results of a correlational study—not be misinterpreted. Proper interpretation of correlation coefficients allows the researcher to conclude that the relationship has a certain magnitude and direction. There is a common misconception—especially among laypersons and the public—that correlational research also implies causation between the two variables. This could not be further from the truth, and it is crucial to remember the following:

Correlation ≠ Causation

This misconception seems to play out quite frequently in the mass media, particularly on television news programs. It is not uncommon for a newscaster, in reporting the results of a study that undoubtedly was focused on measuring the degree of association between two variables, to imply causation between those variables.

A research is not permitted to conclude, simply because two variables are related, that one variable causes the other (Mertler, 2014). The reason for this is that there are likely to be *additional* variables—perhaps *numerous* additional variables—that have causal influences but were not included in the study at hand. Let us imagine for the sake of illustration that, in our example study above, the result was a *strong positive relationship* (i.e., as one variable increases, so does the other) between the "amount of time spent studying" and "scores on the unit test." It would then be accurate to say that increased time studying is *associated with* higher scores on the test. However, it would be completely inaccurate to conclude that studying for a longer period of time *will cause* improved test performance—although students have been trying to prove this one for years! There could certainly be numerous other variables that might influence higher test scores, such as the quality of time spent studying, the level of conceptual understanding of the material being tested, or perhaps even whether the student had a good night's rest before the test.

Although we cannot and should not use the results of correlational research to try to explain causal relationships between variables, we can certainly use them for prediction purposes. The basis for our ability to predict the value on one variable if we know the value on another variable is that we are capitalizing on the quantitative measure of the relationship that exists between the two (Mertler, 2014). If we know what the measure of the relationship is—as indicated by the direction and value of the correlation coefficient—and we know the number of hours a student has spent studying, then we can predict the test score the student will receive. There will typically be some degree of error inherent in our prediction; only in situations where the relationship is perfect (i.e., the correlation coefficient is equal to –1.00 or +1.00) will we be able to predict the value of the second variable with 100% accuracy. However, when studying human beings in educational settings, there is an infinitesimal chance of obtaining a perfect correlation between two variables. The degree of predictive accuracy is determined by the magnitude of the correlation coefficient; the greater the absolute value of the coefficient (i.e., the closer the $|r|$ is to 1.00), the more accurately the value of one variable can be predicted from the other. Still, it is important to keep in mind that this is *not* a prediction of causation but, rather, a prediction of association.

The Correlational Research Process. Similar to survey research and most any other quantitative research study, the basic steps in conducting a correlational research study are fairly straightforward:

1. *Identification of the topic/problem to be studied*. Since correlational studies are designed either to measure relationships between variables or to test hypotheses about predictions, the variables should be selected based on some *logical* rationale. Correlational research where the researcher attempts to correlate a large number of variables just to "see what turns up" is strongly discouraged (Fraenkel et al., 2012; Gay et al., 2009). This is more like a "fishing expedition" than a research study. Also important to note, when stating research questions or hypotheses, it is appropriate to use the terms *relationship* or *prediction* (e.g., *What is the relationship between chronological age and mathematical ability?* or *Can mathematical ability be predicted from chronological age?*). Researchers sometimes use these terms in research questions for other types of research; however, their use will clearly imply that a correlational design is being implemented.

2. *Review of related literature*. Reviewing the related literature is again useful to identify strategies for conducting a correlational study, as well as to provide guidance about what has previously been learned about the relationships between the variables of interest. As you will discover in Chapter 13, related literature can also help appropriately contextualize interpretations of correlation coefficients.

3. *Identification and selection of participants*. In correlational research, participants are selected through the use of an appropriate sampling method. The *minimally* acceptable sample size for correlational studies is 30 participants. If there is concern about the validity and reliability of the variables being measured, however, it is advisable to use a larger sample (Gay et al., 2009).

4. *Specification of the design and procedures for data collection*. The basic design of a correlational study is straightforward. Scores on two or more variables of interest are collected for *each* member of the sample. The pairs of scores making up the data set are then correlated, meaning a correlation coefficient is computed for the two sets of scores.

5. *Collection of data*. Data are collected in a manner appropriate for the variables of interest. For example, in the hypothetical study we have been using to examine correlational research, the researcher would ask students to report how many hours they studied and would then collect the actual test scores from the teacher. Care would need to be taken to ensure that, when the data were compiled into a database or spreadsheet, the scores were paired accurately for each participant. In other words, the number of hours Kate spent studying would need to be paired with *her* test score. If the scores were randomly mixed in the data file, the resulting correlation coefficient would be entirely inaccurate.

6. *Analysis of data*. The analysis of correlational data involves calculation of a correlation coefficient. You will learn in Chapter 13 that there are many different types of correlation coefficients, depending on the level of measurement for each variable.

However, the processes of data collection and analysis are essentially the same for any correlational research study.

7. *Answering research questions and drawing conclusions*. The results of the correlational analyses should permit the researcher to answer the guiding research questions, or address the hypotheses, for the study. Once this has been done, inferences about the nature of the relationship between the variables of interest within the population can be drawn and appropriate associational—but not causal—conclusions about the study asserted.

Strengths and Limitations in Correlational Research. Among the strengths of correlational research is the simplicity of its design. In its simplest form, data for only two variables are required. Again, depending on the variables being studied, this may be a relatively simple and straightforward task. Because of its somewhat simpler design, correlational research is often appropriate for novice researchers, provided they heed the warnings put forth earlier regarding correlational research and the dangers of inappropriately implying causation.

While the design is simple, researchers must ensure that the limited data they are collecting exhibit the qualities (i.e., sound validity and reliability) necessary to draw generalizable conclusions about the relationships between variables. Of course, a correlation coefficient can be calculated regardless; unfortunately, failure to ensure that the data are of high quality will likely result in the inaccurate interpretation of the calculated correlation coefficient. This can lead to erroneous and misleading conclusions for the research study.

Causal-Comparative Research Sometimes researchers are interested in exploring the reasons behind existing differences between two or more groups. Such studies are known as *causal-comparative studies*. In a sense, this type of research is similar to correlational research in that it intends to study conditions that have *already* occurred. Data are collected to try to determine why one group is different from another (Johnson, 2008; Mertler, 2014). Causal-comparative research designs are also referred to as *ex post facto*—or "after-the-fact"—designs. The reason for this is that the study first observes a difference that exists within a group of people, for example, and then looks back in time to determine possible conditions that might have resulted in this observed difference. The researcher is looking for a possible cause "after the fact," since both the precursory conditions *and* the resulting differences have already occurred; that is, the study is taking place retrospectively (Gay et al., 2009). Two or more groups are compared to find a "cause" for—or consequences of—existing differences in some sort of measurement or score (Fraenkel et al., 2012; Johnson, 2008). However, it is once again important to note that causal-comparative research cannot establish true cause and effect—as experimental research can—because no variables are being manipulated.

The most common situation appropriate for causal-comparative designs is one in which the presumed cause, or *independent variable*, has already occurred. The variable of ultimate interest is the *dependent variable*. The independent variable—also referred to as the *grouping variable* (Gay et al., 2009)—defines group membership, because these are typically naturally occurring conditions or ones that have already occurred as part of some process external to and preceding the research study at hand (Mertler, 2014). For example, researchers may informally observe that the range of scores on an annual standardized test of reading is quite large. In trying to identify possible causes for the differences in these scores—perhaps gender, single-parent versus two-parent homes, or school attended—they could use a causal-comparative design to explore differences in test scores between students belonging to the different groups. The main reason a causal-comparative design is appropriate in this situation is that none of those independent variables can be manipulated. In other words, as a researcher, I cannot assign students to different gender categories (other than the ones to which they naturally belong), nor can I assign them to live in a single-parent or two-parent home. Similarly, I cannot assign students to attend different schools just for the purposes of my research study. Those actions would not be ethical, nor would they be practical or feasible.

As another example, consider a situation where researchers want to know how effectively a new self-esteem program, being piloted in numerous schools throughout a large urban district, is working (Mertler, 2014). This study uses scores from a self-esteem inventory (i.e., the dependent variable) administered to students in schools throughout the district—some of which are piloting the program and some not (i.e., the independent variable). In this example, it is important to realize that the independent variable is a *preexisting condition*; that is, the program was already being implemented in some schools and not in others. The researchers are studying the effect of the program on students' self-esteem after the fact (i.e., after the program has already been implemented). Once the researchers administer the self-esteem inventory, scores are collected. The scores from students who have been exposed to the pilot program are then compared with scores from students in schools that do not have the pilot self-esteem program. If the scores on the inventory are significantly higher for the students who have been exposed to the program than for those students who have not participated in the program, the researchers will conclude that the new program is effective. In contrast, if the inventory scores are lower for the students exposed to the new program or if there is no difference in the scores between the two groups, the researchers will conclude that the new program has a negative effect or no noticeable effect, respectively.

Researchers must exhibit caution because interpretations of the results of causal-comparative research are limited; researchers cannot say conclusively whether a particular factor is a cause, or a result, of the behaviors observed (Fraenkel et al., 2012). The distinct value of causal-comparative studies is that they are capable of identifying *possible* causes of variations in behaviors, academic performance, and the like.

The Causal-Comparative Research Process. Similar to correlational research, the steps in conducting a causal-comparative research study are fairly simple. One of the substantive differences is that analysis of causal-comparative data can involve a wider variety of statistical techniques (Gay et al., 2009). The steps in conducting a causal-comparative research study are as follows:

1. *Identification of the topic/problem to be studied*. Problem identification in a causal-comparative study begins by identifying a phenomenon of interest and then considering possible causes for, or consequences of, that phenomenon (Fraenkel et al., 2012). Once possible causes have been identified, they are typically incorporated into a formal problem statement and research questions or hypotheses. Similar to the process in correlational studies, possible causes or consequences should be identified based on some *logical* rationale. Again, research attempting to investigate a large number of variables just to "see what turns up" should be avoided entirely. Potential research questions are stated in terms of group differences (e.g., *How does teacher training—traditional versus alternative—affect empathy in the classroom?* or *Does gender have an effect on mathematical problem-solving skills?*).

2. *Review of related literature*. Conducting a literature review in a causal-comparative study can provide guidance in the identification of possible causes or consequences of a particular phenomenon. Related literature may also aid the researcher in making methodological decisions, including those related to methods and instrumentation for data collection and data analysis.

3. *Identification and selection of participants*. One of the most important factors in selecting a sample in this type of study is to carefully define the characteristic(s) that will serve as the grouping variable(s), and then be sure to select groups that differ specifically and measurably on the characteristic(s). Further, and beyond consideration of the grouping variable, it is important to select groups that are as homogeneous on *other* factors as possible. Of course, this is impossible to accomplish with respect to all the other factors that can influence human behavior, but measures should be taken to try to control these other influences. Often, the success of a causal-comparative study depends largely on how carefully the comparison groups have been defined (Fraenkel et al., 2012). Typically, the groups will differ in one of two ways: (1) One group will possess a characteristic that the other group does not, or (2) both groups will possess the same characteristic(s) but to differing degrees or amounts (Gay et al., 2009). Since there is only limited control within a causal-comparative design, it is best to select participants randomly from the two (or more) well-defined populations, or groups. It is advisable to have a minimum of 30 participants in each group.

4. *Specification of the design and procedures for data collection*. At this point, I will introduce some common notation used to depict research designs. The symbols are as follows:

T = Treatment condition

O = Observation or measurement

EXP-GRP = Experimental group

CO-GRP = Control or comparison group

GRP = Nondescript group

GRP_1, GRP_2, . . . = Subscripts denote different groups

Using this notation, the basic causal-comparative design appears in Figure 7.1. In this design, two groups are determined based on the presence or absence—or differing

FIGURE 7.1 ● The Basic Research Design for a Causal-Comparative Research Study

Group	Dependent Variable
GRP_1	O
GRP_2	O

degree—of the characteristic of interest. Each group is then measured on the dependent variable, and the subsequent scores are statistically compared by group.

5. *Collection of data*. There are essentially no limits to what can be used as instrumentation or sources for data collection in causal-comparative studies, provided that the resulting data are quantitative.

6. *Analysis of data*. The analysis of causal-comparative data involves calculation of both *descriptive* and *inferential* statistics, as well as the statistical comparison of two or more groups on some quantitative variable. In Chapter 13, you will learn that there are numerous methods for conducting statistical group comparisons. They vary depending on the number of groups being compared, the number of dependent variables being measured, and the underlying purpose of the causal-comparative research study.

7. *Answering research questions and drawing conclusions*. The results of the causal-comparative analyses should permit the researcher to answer the guiding research questions, or address the hypotheses, of the study. However, it is critical to remember that interpreting the findings of a causal-comparative study requires a good deal of caution on the part of the researcher. Even when taking measures to ensure that the groups being compared are relatively equivalent—with the exception of the grouping variable—it is difficult to establish any sort of cause-and-effect conclusions with any degree of confidence.

Strengths and Limitations of Causal-Comparative Research. Gay and colleagues (2009) discuss one of the major strengths of causal-comparative research. Even though true cause-and-effect relationships can be determined only through the application of experimental research (as you will read about shortly), an experimental study is often inappropriate, unethical, or impossible to conduct in many educational settings. Causal-comparative research is an effective alternative to experimental designs, particularly in situations where the independent/grouping variable cannot or should not be manipulated. The main limitation or weakness of causal-comparative research is that, because the cause under investigation has already occurred, the researcher has no control over it. This is incredibly limiting in situations where researchers are trying to conclude cause-and-effect relationships.

Consider a situation where researchers want to study the effect of drinking large amounts of soda on frequency of childhood obesity. They design the study comparing the frequency of childhood obesity in two groups of children—ones who drink soda daily and ones who do not drink soda at all. Realize that the researchers have no control over the participants in terms of soda consumption; these are preexisting conditions that defined the two groups. If it turns out that the group of children who consume soda on a daily basis experience a much higher rate of childhood obesity, the researchers cannot conclude that obesity is directly attributable to soda consumption. Since there was no control over the grouping variable, it is likely that numerous other conditions contributed to the occurrence of obesity, such as eating habits, environmental factors, and genetics. In situations such as these, it is impossible to identify a definitive cause-and-effect association.

Experimental Research Designs

The second category of quantitative research designs is collectively known as *experimental research*, a group of techniques where the researcher establishes different treatments or conditions and then studies their effects on the participants. It is because of this ability to manipulate the treatment conditions and control for many extraneous factors that experimental studies are the most conclusive of all research designs. There are four general categories of experimental research, with each category containing multiple designs: *preexperimental research designs*, *quasi-experimental research designs*, *true experimental research designs*, and *single-subject research designs*.

As has been mentioned, experimental research studies can demonstrate cause and effect the most convincingly of any research design. However, there are trade-offs for this desirable outcome. Students often ask, if experimental research can be so conclusive, why would we conduct any other type of research? The answer lies in the strict requirements of experimental research designs and the fact that many educational problems, settings, and situations do not lend themselves to these requirements. *Generally speaking*, the broad category of experimental research design requires the following components:

- A sample of participants who are *randomly* selected and/or *randomly* assigned to an experimental group(s) and control group(s), more appropriately referred to as a **comparison group**
- An independent variable—which, in experimental studies, can be referred to as the *treatment variable*, the *causal variable*, or the *experimental variable*—that can be selectively applied to the experimental group
- A dependent variable—which, in experimental studies, can be referred to as the *criterion variable*, the *effect variable*, or the *posttest variable*—that can be measured in an identical manner for all groups in the study

As you will see in a moment, there is some variation to these requirements, depending on the specific design we are examining. For example, if we wanted to conduct an experiment on sixth-grade classroom discipline, we would need to randomly select and randomly assign sixth-grade students to two or more classes, at least one of which would receive the experimental treatment while another, serving as a comparison group, would not receive the treatment. The experimental treatment (i.e., the manipulated independent variable) might be a new system of discipline. The dependent variable (which would be measured in both groups) might be the incidence and severity of student misbehavior. If, after the new discipline system had been in effect for a while, the experimental group exhibited behavior significantly different from that of the comparison group, we could conclude that a cause-and-effect relationship existed (provided we accounted for some other control measures, which we will discuss more extensively in Chapter 12). We could then conclude—with some degree of confidence—that the discipline system had caused better, or perhaps worse, student behavior.

It is important at this point to discuss the distinction between *random selection* and *random assignment*. Random selection of samples and random assignment of sample members to experimental and comparison groups are essential and distinguishing features of experimental design. The only exception occurs in single-subject designs, usually conducted on an individual diagnosed as having significant personal problems—for example, obsessive eating or uncontrolled outbursts. **Random selection** is the process of choosing, in random fashion, individuals for participation in a research study, such that every member of the population has an equal chance of being selected to be a member of the sample. Some of the random sampling techniques we will look at closer in Chapter 12 include *simple random sampling*, *stratified random sampling*, and *cluster sampling*. Once participants have been randomly selected to participate in a study, they undergo **random assignment** to groups (usually treatment and comparison groups). Random assignment means that every individual who has been randomly selected to participate in the experiment has an equal chance of being assigned to any of the groups (i.e., experimental or comparison groups) being compared in the study. Both random selection and assignment help ensure equivalence of groups, and control for many extraneous variables that might otherwise contaminate the results of the research study. When it is not possible to randomly select a sample of participants—this is typically difficult, if not impossible, in school settings—one must, if possible, randomly assign students to experimental and comparison groups. It is not always feasible to randomly assign students to treatment conditions in school settings; when random assignment is not possible, the result is a quasi-experimental study, rather than experimental research. To summarize,

Random selection* + *Random assignment* = *Experimental research

Random selection (only)* = *Quasi-experimental research

It is important to note here that, in experimental or quasi-experimental designs, there may be a need or desire to have multiple (i.e., more than two) groups. Clearly, in these cases, the researcher must be able to structure some sort of "alternative" treatment group. This means that there will typically be an experimental or treatment group (receives the treatment condition), a control group (receives nothing), and a third comparison group (receives *something* but not the treatment of interest).

For example, suppose a researcher wanted to investigate the impact of an Internet-based study site on student performance on a standardized achievement test. The treatment group would receive structured time to work with the online study site. The control group would not receive any form of direct study support in preparation for the achievement test. In addition, the researcher might hypothesize that *any* sort of supplemental study time or effort would be beneficial to student performance and may want to compare the effectiveness of this other type of study support against the online site (i.e., the treatment condition), as well as against the complete lack of support (i.e., the control condition). Therefore, the researcher may establish a third, "alternative treatment" group that receives a limited amount of study support supplied by the teacher. This group is sometimes referred to as the *comparison group*, although it is usually the case that any nonexperimental group may be referred to as the comparison group. The benefit of including an additional comparison group is that it can provide the researcher an additional level or type of comparison to better explain the effectiveness of the treatment condition.

There are two major classes of experimental research design: single-variable designs and factorial designs (Gay et al., 2009). **Single-variable designs** are those that involve only one manipulated independent variable. In contrast, **factorial designs** involve two or more independent variables, at least one of which is manipulated. Most of our discussion here will focus on single-variable experimental research designs. Single-variable designs fall into three of the four categories previously listed: preexperimental, quasi-experimental, and true experimental designs. The designs differ in their degree of control over extraneous variables that can jeopardize validity. Each of these three types of experimental designs is discussed below.

Preexperimental Research Preexperimental designs do not do a very good job of controlling for extraneous variables and should be avoided. Gay and colleagues (2009) have asserted that the results of a preexperimental study are so questionable that they may be useful only to provide a *preliminary* investigation of a problem. The first example of a preexperimental design is a **one-shot case study** (see Figure 7.2), involving a single group that is exposed to a treatment condition and then posttested. For example, researchers want to know if a new lab kit will improve student performance in science. The researchers select science teachers, all of whom use the kits with their science classes, and then administer an examination. The resulting exam scores are higher than normal, so the researchers conclude that the new lab kits are effective in helping students learn more.

The essential problem with this design is that even if the participants score high on the posttest, we have no idea what we should attribute their performance to, because we do not know what happened to them or with them before the treatment was administered. The students may have performed better with *any* set of lab materials or even *without* any lab materials, perhaps because they are naturally bright, among a variety of other possible reasons. Gay and colleagues (2009) offer the following advice: "If you have a choice between using this design and not doing a study, don't do the study. Do a different study with a better control design" (p. 253).

A second preexperimental design is known as a **one-group pretest–posttest design** (see Figure 7.3). While still not a strong design, it offers an improvement over the previous one. In this design, we still have only one group—so we have no "other" group for comparison purposes—but a pretest is added prior to the introduction of the treatment. Returning to our previous example, this would involve the administration of a pretest to the students prior to exposing them to the new lab kits. Lessons would then be taught by the teachers using the lab kits, followed by the administration of the posttest to the students. The success of the treatment would essentially be determined by comparing pretest and posttest scores (Gay et al., 2009). This design represents an improvement over the one-shot case study because the researcher will, at a *minimum*, know if some sort of change (i.e., an increase or decrease in scores) has occurred (Leedy & Ormrod, 2013). However, there could most certainly be other explanations for the change in scores, and these possible explanations are not accounted for in the design.

A third and final example of preexperimental design is the **static-group comparison design** (see Figure 7.4). This design offers a slight improvement, in that it introduces a second comparison group; however, the pretesting is not included. Additionally, the members of both groups have been selected in a nonrandom manner; they are in essence existing, intact groups—hence the use of the term *static group*. In this design, the experimental group is exposed to some sort of treatment or condition, and the comparison group is not. The purpose of the comparison group is essentially to demonstrate what the performance by the members of the experimental group *would have been* had they not received the treatment; however, this can happen only to the degree that the design ensures the comparison group is equivalent to the experimental group (Gay et al., 2009). This design is still weak, because no attempt is made to ensure that the groups are equivalent at the outset of the study or

FIGURE 7.2 ● The One-Shot Case Study Preexperimental Research Design

Group	Time →	
EXP-GRP	T	O

FIGURE 7.3 ● The One-Group Pretest–Posttest Preexperimental Research Design

Group	Time →		
EXP-GRP	O	T	O

to determine what the groups may have been exposed to prior to the study; therefore, we have no way of knowing if the treatment resulted in any observed differences between the groups (Leedy & Ormrod, 2013).

Strengths and Limitations of Preexperimental Research. As you can see from our discussion, these preexperimental designs leave a lot to be desired. They are not strong in terms of their control over extraneous variables; either the "independent variable" doesn't vary (due to the fact that there is only one group), or the equivalency of the experimental and comparison groups cannot be established, or individual participants were not randomly selected. Therefore, these designs are very weak in terms of enabling the researcher to draw definitive conclusions about cause-and-effect relationships among variables in the study. These preexperimental designs should be used only as preliminary studies and followed up by more stringent designs (Leedy & Ormrod, 2013), which we will talk about next.

Quasi-Experimental Research Quasi-experimental research designs come the closest to true experiments; however, there is still no random assignment of the participants to groups, which weakens the ability to control for extraneous influences. Random assignment to groups is the aspect of experimental research design that ensures that the groups being compared are relatively similar. Since random assignment of students to groups is typically impractical—due largely to the fact that students are already "assigned" to numerous preexisting and intact groups, such as classes, grade levels, and so on—quasi-experimental designs are often appropriate for research in school settings.

The first quasi-experimental design we will discuss is the **matching posttest-only control group design** (see Figure 7.5). This design uses two groups of participants from the same population, such as two intact classrooms in the same school system. Since random assignment to treatment conditions is not possible in this scenario, students are matched on certain variables in an attempt to make them more equivalent (Fraenkel et al., 2012). In Figure 7.5, *M* signifies that the members of the groups have been matched on one or more variables. This design represents a slight

FIGURE 7.4 ● The Static-Group Comparison Preexperimental Research Design

Group	Time →	
EXP-GRP	T	O
CO-GRP	—[a]	O

[a]The dashed line indicates that the comparison group either receives nothing or receives an alternative treatment or condition.

FIGURE 7.5 ● The Matching Posttest-Only Control Group Quasi-Experimental Research Design

Group	Time →		
EXP-GRP	M	T	O
CO-GRP	M	—[a]	O

[a]The dashed line indicates that the comparison group either receives nothing or receives an alternative treatment or condition.

FIGURE 7.6 ● The Matching Pretest–Posttest Control Group Quasi-Experimental Research Design

Group	Time →			
EXP-GRP	O	M	T	O
CO-GRP	O	M	—[a]	O

[a]The dashed line indicates that the comparison group either receives nothing or receives an alternative treatment or condition.

improvement over the static-group comparison preexperimental design, in that attempts—albeit weak attempts—have been made to establish the equivalency of the groups. Members of the groups are matched, one group is exposed to the experimental treatment or condition, both groups are given a posttest, and then those scores are compared to see if the groups differ on the dependent variable.

A variation of this design is the **matching pretest–posttest control group design** (see Figure 7.6). This is a slightly improved design because not only is a pretest administered, but the pretest scores serve as the basis for matching participants across the groups. In other words, a pretest is administered to all participants and, based on the results of the pretest, each participant is matched with another participant who has a relatively similar pretest score. Groups are then created by putting each person from the pair into a separate group (i.e., one into the experimental group and one into the comparison group; Johnson, 2008). The result is two groups that are relatively similar on the variable of interest, as measured by the pretest.

A **counterbalanced design** is the third type of quasi-experimental research design we will examine. In this research design (see Figure 7.7), each group is exposed to each treatment—however many there may be—but in a different order than are the other groups (Fraenkel et al., 2012). This design is another technique used for equating experimental and comparison groups. The only restriction on the design is that the number of groups must be equal to the number of treatments, although the order in which the groups receive treatment is randomly determined (Gay et al., 2009). Although the diagram in Figure 7.7 shows three groups and three treatments in the study, any number of group treatments may be studied.

A final type of quasi-experimental design is the **time-series design**. This design (see Figure 7.8) is essentially an elaboration of the one-group pretest–posttest design (Gay et al., 2009). In that design, observations in the form of pretests and posttests are taken immediately before and after exposure to the treatment. In a time-series design, however, an extensive amount of data is collected on one group by first pretesting the participants repeatedly until the pretest scores become stable. The group is then exposed to a treatment condition and then posttested repeatedly. If the group performs essentially the same on repeated pretests but then significantly improves on the posttests, the researcher can be more confident about the effectiveness of the treatment, compared with a situation where only one pretest and one posttest are administered (Gay et al., 2009). The effectiveness of the treatment is determined by analyzing the test scores to see if patterns exist; however, the typical statistical analyses appropriate for this type of design tend to be quite advanced (Gay et al., 2009).

Strengths and Limitations of Quasi-Experimental Research. In situations where random assignment is not feasible, quasi-experimental research designs are advantageous. They represent a vast improvement over preexperimental designs, which we identified as being extremely weak. While they allow for conclusions that may provide some degree of confidence, they still do not control for all extraneous and influential variables; therefore, researchers cannot completely rule out some

FIGURE 7.7 ● The Counterbalanced Quasi-Experimental Research Design

Group	Time					
GRP_1	T_1	O	T_2	O	T_3	O
GRP_2	T_2	O	T_3	O	T_1	O
GRP_3	T_3	O	T_1	O	T_2	O

FIGURE 7.8 ● The Time-Series Quasi-Experimental Research Design

Group	Time →									
EXP-GRP	O_1	O_2	O_3	O_4	O_5	T	O_6	O_7	O_8	O_9	O_{10}

alternative explanations for the results they may obtain in quasi-experimental studies. The only solution to these concerns is to use true experimental research designs.

Experimental Research True experimental research designs share one important characteristic in common: They all involve the *random assignment* of participants to treatment conditions (Gay et al., 2009). Random assignment is one of the most powerful techniques for controlling for extraneous threats to validity (Fraenkel et al., 2012). An additional characteristic these designs share is that they all have at least one comparison group. The simplest experimental design is the **posttest-only control group design** (see Figure 7.9). This design closely resembles the static-group comparison design, with one exception: The participants have been randomly assigned—signified by *R* in the figure—to the experimental and comparison groups. The combination of random assignment and a comparison group controls for nearly all threats to validity. The one thing missing in this particular experimental design is use of a pretest as a means for providing additional control.

This missing element is addressed in the second experimental design, the **pretest–posttest control group design** (see Figure 7.10). This design requires at

FIGURE 7.9 ● The Posttest-Only Control Group Experimental Research Design

Group	Time →		
EXP-GRP	R	T	O
CO-GRP	R	—[a]	O

[a]The dashed line indicates that the comparison group either receives nothing or receives an alternative treatment or condition.

FIGURE 7.10 ● The Pretest–Posttest Control Group Experimental Research Design

Group	Time →			
EXP-GRP	R	O	T	O
CO-GRP	R	O	—[a]	O

[a]The dashed line indicates that the comparison group either receives nothing or receives an alternative treatment or condition.

least two groups, each of which comprises randomly assigned participants. All groups are administered a pretest, receive some sort of treatment condition (or, perhaps, the absence of a treatment condition), and are posttested at the end of the study. The combination of (1) random assignment, (2) the use of a pretest, and (3) the presence of comparison group(s)—in a minimal two-group design—makes this the most powerful experimental research design.

The final experimental design is actually a combination of several designs we have looked at thus far. The **Solomon four-group design** is a combination of the posttest-only control group design and the pretest–posttest control group design; therefore, this design provides the benefits of both wrapped into one. The Solomon four-group design (see Figure 7.11) first involves the random assignment of participants to one of four groups. Two groups are pretested, and two are not; one of the pretested groups and one of the non-pretested groups receive the experimental treatment. The other two groups receive nothing or an alternative treatment. Finally, all four groups are posttested using the same measure. As you can see in Figure 7.11, the benefit of this design is that numerous group comparisons are possible, allowing for determination of the effect of the pretest as well as that of the treatment. This design is actually stronger than the pretest–posttest control group design; however, it requires a substantially larger sample due to the inclusion of a third and fourth group.

The Experimental Research Process. The steps in conducting any type of experimental research study (i.e., preexperimental, quasi-experimental, or true experimental) essentially mirror the process for conducting causal-comparative research, as presented earlier in the chapter. The primary exception is the inclusion of random assignment in experimental studies. Those steps are as follows:

1. *Identification of the topic/problem to be studied*. Problem identification in an experimental research study begins by selecting a treatment condition and then considering ways to measure its effect. As in both correlational and causal-comparative

FIGURE 7.11 ● The Solomon Four-Group Experimental Research Design

Group	Time →			
$EXP\text{-}GRP_1$	R	O	T	O
$CO\text{-}GRP_1$	R	O	—[a]	O
$EXP\text{-}GRP_2$	R		T	O
$CO\text{-}GRP_2$	R		—[a]	O

[a]The dashed line indicates that the comparison group either receives nothing or receives an alternative treatment or condition.

studies, any possible cause-and-effect relationship should be determined based on some *logical* or *empirical* rationale.

2. *Review of related literature*. Reviewing related literature can provide guidance in the identification of key variables that should be measured and ways to control for extraneous influences within an experimental study. This review may also aid the researcher in making methodological decisions, including those related to experimental design, as well as methods and instrumentation for data collection and data analysis.

3. *Identification and selection of participants*. As you undoubtedly know by now, random selection and/or random assignment of participants is key in any sort of experimental research study. Decisions must be made about the feasibility of both random selection and random assignment. If random assignment is not possible, other mechanisms (e.g., matching) for establishing the equivalency of the groups involved in the study must be considered, and the appropriateness of their use must be evaluated. As with causal-comparative research, it is advisable to have a minimum of 30 participants in each group.

4. *Specification of the design and procedures for data collection*. Of course, specifying the design in any sort of experimental research study is of the utmost importance so that the various requirements, respective of a particular design, can be appropriately and ethically incorporated into the study.

5. *Collection of data*. There are no limits to what can be used as sources for data collection in experimental studies, provided the resulting data are, of course, quantitative in nature.

6. *Analysis of data*. Similar to causal-comparative data, the analysis of experimental data involves the calculation of both *descriptive* and *inferential* statistics, as well as the statistical comparison of two or more groups on the quantitative variable (i.e., the posttest). Again, these statistical techniques for conducting group comparisons will be presented in Chapter 13.

7. *Answering research questions and drawing conclusions*. The results of the statistical analysis should permit the researcher to answer the guiding research questions, or address the hypotheses, for the study. However, it is critical to remember that researchers must be extremely cautious when interpreting the findings of an experimental study. Even when taking measures to ensure that the groups being compared are relatively equivalent, researchers must factor into their conclusions the various threats to validity.

Strengths and Limitations of Experimental Research. The clear strength of experimental research designs is their capacity to draw strong cause-and-effect conclusions in a research study. As has been mentioned numerous times throughout this chapter, experimental research designs are the only type of study that can establish cause-and-effect relationships. However, these designs are not without their limitations.

The requirements for designing and conducting true experimental studies are extremely stringent and, in some cases, prohibitive. In addition, researchers must go to great lengths to ensure that their designs, data, and conclusions do not fall victim to the variety of threats to validity, which we will discuss momentarily.

Single-Subject Research As we have seen thus far, most experimental research is accomplished through the study of participants in groups. However, experimental-type studies can be conducted on individual participants. These types of designs are known as **single-subject experimental research designs**. Single-subject designs are typically used to study and promote a change in behavior as exhibited by an individual. Generally speaking, a participant is exposed to a nontreatment phase and a treatment phase, and performance is measured during each phase (Gay et al., 2009). Typically, the nontreatment phase is symbolized by A, and the treatment phase is symbolized by B. Suppose that researchers were asked to study a student who chronically misbehaved and did not respond to the disciplinary techniques used with other students. The researchers might decide to conduct a single-participant experiment to see if the student's behavior could be improved.

In such a study, the researchers would need to make accurate measurements of the student's behavior before applying an experimental treatment. Over a period of a week or two, the number of times the student exhibited various misbehaviors—such as shouting out, getting up and wandering around the room, provoking confrontations with other students, and refusing to comply with the teacher's directions—would be recorded. These data would serve as a baseline measurement against which to compare the student's behavior during and after receiving the experimental treatment. The researchers would then implement the experimental treatment, perhaps a special system of behavior modification. After implementation and at a designated time, the student's misbehaviors would again be recorded over a period of days. This process could be repeated several times.

There are various types of single-subject research designs. The simplest form is known as the **A-B design** (see Figure 7.12). In this design, baseline measures (A) are obtained over time and then a treatment (B) is implemented, during which time additional measures are recorded. If there is a change in behavior, then the treatment is said to have had an effect. Although this is a straightforward design, its results may be subject to numerous competing explanations, making it a weak design in the long run. As we have already seen with both experimental and quasi-experimental designs, other variations of this simple design introduce ways to control for the possibility of alternative explanations.

The **A-B-A design** (see Figure 7.13), also known as the **reversal design** or measurement-treatment-measurement design, is a much-improved single-subject design when compared with the A-B design. The A-B-A design begins in similar fashion by establishing the baseline (A) and then introducing a treatment (B). However, in the third phase (the second A), the treatment is reversed or, in actuality, removed or withdrawn. If the negative behavior returns after removing the treatment, this tends to show that the treatment had an effect. The substantial limitation of this design is

FIGURE 7.12 ● The A-B Single-Subject Research Design

Time →											
Baseline Phase (A)				Treatment Phase (B)							
O	O	O	O	X	O	X	O	X	O	X	O

FIGURE 7.13 ● The A-B-A Single-Subject Research Design

Time →															
Baseline Phase (A)				Treatment Phase (B)								Baseline Phase (A)			
O	O	O	O	X	O	X	O	X	O	X	O	O	O	O	O

that many interventions cannot, or perhaps should not, be withdrawn. This may be due largely to ethical reasons (e.g., involving self-injurious behavior) or perhaps even some practical reasons (e.g., the intervention cannot be unlearned, like a skill).

A third single-subject design is the **alternating-treatment design**. This design is used to investigate and explain the comparative effect of two treatments. In the application of this design, two treatments are alternated in quick succession and changes in the participant's behavior are plotted on a graph to facilitate informal comparisons. Finally, in the **multiple-baseline design**, two or more (often three) behaviors, people, or settings are plotted in a staggered graph, where a change is made to one but not the other two, and then to the second but not the third behavior, person, or setting. Differential changes that occur to each behavior or person, or in each setting, help strengthen what is essentially an A-B design, with its problematic competing explanations for behaviors, by providing opportunities to examine those alternative explanations.

Strengths and Limitations of Single-Subject Research. The strength of single-subject research is its ability to focus on a single participant and study the effectiveness of treatment on *only* that participant. By focusing on one individual, one behavior, and one treatment, it is possible to scientifically impact and correct negative or undesirable behaviors. The limitations of this focused research effort lie in the fact that there will always be alternative explanations for *why* a behavior was corrected, or why it *failed* to be corrected. Effectively factoring out alternative explanations for the results of any sort of experimental study will always be a challenge for the educational researcher.

Threats to Validity in Quantitative Designs

"Validity of research" refers to the degree to which research conclusions can be considered accurate and generalizable. All types of quantitative research designs are subject to *threats to validity*, both internal and external. These threats must be controlled, or otherwise accounted for, so the potential error they might introduce into the research study does not jeopardize the legitimacy and accuracy of the research findings and conclusions.

Internal validity is the degree to which measured differences on the dependent variable are a direct result of the manipulation of the independent variable, and not some other variable or extraneous condition or influence (Gay et al., 2009). Researchers have an obligation to examine threats to internal validity that might negatively influence the outcome of an experimental study. The degree to which the conclusions drawn from experimental research studies are directly attributable to the independent variable and not some other explanation determines the degree to which the study is internally valid (Gay et al., 2009). There are eight main threats to internal validity, described below:

1. History. When experimental treatments extend over longer periods, such as a semester or a year, factors other than the experimental treatment have time to exert influence on the results.

2. Maturation. If treatments extend over longer periods, participants may undergo physiological changes that produce differential effects in the dependent variable. For example, they may become stronger, better coordinated, better able to do abstract thinking, or better readers.

3. Differential selection of participants. In some studies, selected participants already possess differences that may account for potential variations on a posttest. This is often the case when participants are not selected or assigned randomly.

4. Testing (also known as **pretest sensitization**). If pretests and posttests are used, participants may learn enough from the pretest to improve performance on the posttest, even when the experimental treatment has no effect. If equivalent forms of a test are used, despite their being considered equal, one form may in fact be easier than the other.

5. Instrumentation. Sometimes the instruments we use to measure performance in experimental studies (e.g., pretests and posttests) are unreliable or lack consistency in their ability to measure variables of interest. Clearly, the result in these cases is inaccurate data.

6. Statistical regression. This threat occurs in studies where participants are selected based on their extremely high or extremely low scores on some measure. Statistical regression is the tendency for participants who score very high on one test (e.g., a pretest) to score lower on a second, similar test (e.g., a posttest), or for participants who score very low on a pretest to score much higher on a posttest. In both cases, the extremely high scorers and extremely low scorers will regress toward the mean, or average score, of the posttest. In essence, they have either "topped out" or "bottomed out," respectively.

7. Attrition (also known as **mortality**). While the experiment is in progress, there may be a loss of participants for reasons such as illness, dropping out, or moving elsewhere. Of course, this is unavoidable, but it may influence the resulting posttest data for a particular group.

8. Selection-maturation interaction (as well as other possible interactive effects). The effects of differential selection of participants may also interact with other threats, such as history, maturation, or testing. Certain intact groups selected to participate in a study may perform better (or worse) or gain a greater (or lesser) advantage from a particular treatment.

Table 7.2 presents these various threats to internal validity and the extent to which they may be controlled in the various types of designs we have discussed in this chapter.

TABLE 7.2 ● Threats to Internal Validity in Various Types of Experimental Designs

Threat	Type of Research Design			
	Preexperimental	Quasi-Experimental	True Experimental	Single Subject
History	Potential threat	Potential threat	Controlled	Potential threat
Maturation	Potential threat	Potential threat	Controlled	Controlled
Differential selection	Potential threat	Potential threat	Controlled	Controlled
Testing	Potential threat	Potential threat if pretest and posttest used	Potential threat if pretest and posttest used	Controlled
Instrumentation	Potential threat	Potential threat if instrument or observational procedures change	Potential threat if instrument or observational procedures change	Potential threat if multiple interventions are used
Statistical regression	Potential threat	Potential threat	Controlled	Controlled
Attrition	Potential threat	Potential threat	Controlled	Controlled
Selection-maturation interaction	Potential threat	Potential threat	Controlled	Controlled

Source: Adapted from Creswell (2005).

External validity of research refers to the extent to which results of a particular study are generalizable, or applicable, to other groups or settings. As you well know, what works in one setting may not work in another. There are three basic types of threats to external validity:

1. **Population validity**. This refers to the degree of similarity among (1) the sample used in a study, (2) the population from which the sample was drawn, and (3) the target population to which results are to be generalized. The greater the degree of similarity among the three, the greater the researcher's confidence can be in generalizing research findings to the broader, target population. This is the reason behind the importance of selecting a representative sample in quantitative studies.

2. **Personological validity**. A given research finding can apply well to some people and poorly to others. Individuals differ in what they find acceptable, comfortable, and useful. Self-directed learning is an example. Some students prefer to work on their own and can do so effectively. Other equally intelligent students require guidance from a teacher and desire the companionship of their peers.

3. **Ecological validity**. This refers to the situation, physical or emotional, that exists during the experiment. An experimental situation may be quite different from a new setting where results are to be applied. For example, some groups of participants, especially when exposed to innovative treatments or conditions, develop a much higher level of motivation to achieve or otherwise perform. Such groups' results may be quite different from results seen in groups that did not experience this heightened level of motivation.

Developmental Activities

1. Brainstorm a potential topic, appropriate for quantitative research. Do you think this topic would be more effectively investigated using a nonexperimental or an experimental approach? Explain your response.
2. Using the topic you brainstormed in Activity 1 above—or perhaps another topic of your choosing—and the general steps for conducting a quantitative research study, briefly sketch out both a nonexperimental and an experimental study to investigate your topic.
3. Based on your responses to Activity 2 above, do you believe that it is possible to *appropriately* and *accurately* investigate the same topic using both experimental and nonexperimental approaches? Why or why not?
4. Consider the following research question: *What is the effect on students' reading comprehension skills of a software program designed to facilitate annotation skills in reading*? Design a true

experimental study to investigate this question, using one of the designs presented in the chapter. Outline several possible threats to the validity of your design and what actions you might take to address those threats.

5. With a topic of your choosing, design a true experimental study to investigate that topic, using one of the designs presented in the chapter. Outline several possible threats to the validity of your design and what actions you might take to address those threats.

Summary

- Quantitative research relies on the collection and analysis of numerical data to describe, explain, predict, or control variables of interest.
- Quantitative research focuses on objectivity that permits the researcher to generalize findings beyond a particular situation or setting.
- Approaches to conducting quantitative research include nonexperimental and experimental designs.
- Nonexperimental research designs comprise techniques where there is no manipulation of any variable in the study. These designs include descriptive research, correlational research, and causal-comparative research.
- Descriptive research focuses on describing and making interpretations about the current status of individuals and settings, and includes observational and survey research.
- In survey research, data are collected from a sample of respondents selected to represent the larger population.
    - There are multiple modes of delivering surveys, including direct administration, mail surveys, telephone surveys, interviews, e-mail surveys, and web-based surveys.
- While electronic surveys have their advantages, they also have numerous technological limitations.
- Three basic types of survey are descriptive surveys, cross-sectional surveys, and longitudinal surveys.
- Three types of longitudinal surveys are trend surveys, panel surveys, and cohort studies.
- Cross-sectional surveys are the most commonly used survey design among educational researchers.
- In survey research, participants are selected so they represent a target population to whom the researcher would like to generalize the results of the study.
- Surveys should be accompanied by a cover letter, which explains the purpose of the study and describes what will be required of participants.
- A strength of survey research is its collection of data from a large number of people. Limitations include potentially low response rates and the time and financial requirements of some modes of data collection.
- Correlational research is designed to discover and possibly measure the relationships between two or more variables.

- Explanatory correlational studies seek to understand and describe related events, conditions, and behaviors.
- Predictive correlational studies predict future conditions or behaviors in one variable from what is known about another variable.

- The basic design for correlational research involves a single group of people who are quantitatively measured on two or more variables that have already happened.
- Relationships are measured by calculating a correlation coefficient, which indicates the direction and strength of the relationship.
- It is critical to remember that "correlation" is not equivalent to "causation."
- Causal-comparative research focuses on exploring the reasons behind existing differences between two or more groups.
  - The presumed cause is the independent variable (also referred to as the grouping variable), and the variable of interest is the dependent variable.
  - Although causal-comparative research cannot explain true cause-and-effect relationships, it is a viable alternative when variables cannot be manipulated due to impracticality or ethics.
- In most quantitative research designs, it is desirable to have a minimum of 30 participants per group.
- The category of experimental research designs includes preexperimental designs, quasi-experimental designs, true experimental designs, and single-subject research designs.
- Generally speaking, all experimental research designs share commonalities, including participants who are randomly selected and/or randomly assigned to groups, an independent variable that can be manipulated by the researcher, and a common dependent variable that can be measured in all groups in the study.
- Random selection is the process of randomly choosing individuals to participate in a study so that every member of the population has an equal chance of being selected as a member of the sample.
- Random assignment is the process of randomly placing participants in treatment and comparison groups.
- When a study includes random selection *and* random assignment, the study is experimental research; if the study includes *only* random selection, the research is a quasi-experimental study.
- Single-variable designs involve only one manipulated independent variable; factorial designs involve two or more independent variables, at least one of which is manipulated.
- Preexperimental designs are weak and, if used, should be followed by a more stringent research study.
- Quasi-experimental designs come the closest to true experiments, but they still lack random assignment of participants to groups.
- True experimental designs control for nearly all extraneous threats to validity.
- Single-subject research designs are experimental-type studies conducted on individual participants.
- All types of quantitative research designs are subject to threats to validity.
- Internal validity is the degree to which measured differences on the dependent variable are a direct result of the manipulation of the

independent variable and not some other, extraneous condition.

- Threats to internal validity include history, maturation, differential selection of participants, testing effect, instrumentation, statistical regression, attrition, and selection-maturation interaction.

- External validity refers to the extent to which results of a particular study are generalizable to other groups or settings.
  - Threats to external validity include population, personological, and ecological validity.

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