CHAPTER 5

The Hypothesis in Quantitative Research

A hypothesis transforms a general idea into a plan for what to look for.

INSTRUCTIONAL OBJECTIVES

After studying this chapter, the student will be able to:

- **1** Define *hypothesis*.
- 2 Describe the purposes of the hypothesis(es) in quantitative and qualitative research.
- 3 List the criteria of a theory useful for a research study.
- 4 Distinguish between an inductive and a deductive hypothesis.
- 5 State the criteria used to evaluate hypotheses for research.
- 6 Define operational definition and give an example.
- 7 Identify a testable hypothesis from given examples.
- 8 Define *null hypothesis* and explain its purpose in a research study.
- 9 Write a research hypothesis and a null hypothesis for a research study.
- 10 Distinguish between a directional and a nondirectional hypothesis.
- 11 Describe the steps in testing a hypothesis.
- 12 State the purpose of the research plan and list the elements to be included.
- 13 State the purpose of a pilot study.

After stating the research question and examining the literature, the quantitative researcher is ready to state a **hypothesis** based on the question.* This should be done before beginning the research project. Recall that the quantitative problem asks about the relationship between two (or more) variables. The hypothesis presents the researcher's expectations about the relationship between variables within the question. Hence, it is put forth as a suggested answer to the question, with the understanding that the ensuing investigation may lead to either support for the hypothesis or lack of support for it. Note that we use the word *support*, not *prove*. Research may find support for a hypothesis, but it does not prove a hypothesis.

*The role of the hypothesis in qualitative research is discussed in Chapter 15.

A researcher might ask the question, "What is the effect of preschool training on the first-grade achievement of culturally disadvantaged children?" The hypothesis would read "Culturally disadvantaged children who have had preschool training achieve at a higher level in first grade than culturally disadvantaged children who have not had preschool training." You can see that the hypothesis related the variables of preschool training and first-grade achievement. The following are additional examples of hypotheses in educational research:

- 1. Boys in elementary school achieve at a higher level in single-sex classes than in mixed classes.
- 2. Students who complete a unit on problem-solving strategies will score higher on a standardized mathematics test than those who have completed a control unit.
- 3. Middle school students who have previously taken music lessons will have higher math aptitude scores.
- 4. Middle school students who have siblings will be more popular among their peers than students who do not have siblings.
- 5. Students who do warm-up exercises before an examination will score higher on that examination than those who do not.
- 6. Elementary school children who do not get adequate sleep will perform at a lower level academically than will their peers who have adequate sleep.

Although hypotheses serve several important purposes, some research studies may proceed without them. Hypotheses are tools in the research process, not ends in themselves. Studies are often undertaken in areas in which there is little accumulated background information. A researcher may not know what outcome to predict. For example, surveys that seek to describe the characteristics of particular phenomena, or to ascertain the attitudes and opinions of groups, often proceed without hypotheses.

Two reasons for stating a hypothesis before the data-gathering phase of a quantitative study are (1) a well-grounded hypothesis indicates that the researcher has sufficient knowledge in the area to undertake the investigation, and (2) the hypothesis gives direction to the collection and interpretation of the data; it tells the researcher what procedure to follow and what type of data to gather and thus may prevent a great deal of wasted time and effort on the part of the researcher.

PURPOSES OF THE HYPOTHESIS IN QUANTITATIVE RESEARCH

Principal purposes served by the hypothesis include the following:

1. The hypothesis brings together information to enable the researcher to make a tentative statement about how the variables in the study may be related. By integrating information based on experience, related research, and theory, the researcher states the hypothesis that provides the most satisfactory prediction or the best solution to a problem.

- 2. Because hypotheses propose tentative explanations for phenomena, they stimulate a research endeavor that results in the accumulation of new knowledge. Hypothesis testing research permits investigators to validate or fail to validate theory through an accumulation of data from many studies. In this way, knowledge is extended.
- 3. The hypothesis provides the investigator with a relational statement that is directly testable in a research study. That is, it is possible to collect and analyze data that will confirm or fail to confirm the hypothesis. Questions cannot be tested directly. An investigation begins with a question, but only the proposed relationship between the variables can be tested. For instance, you do not test the question, "Do teachers' written comments on students' papers result in an improvement in student performance?" Instead, you test the hypothesis that the question implies: "Teachers' written comments on students' papers result in a meaningful improvement in student performance" or, specifically, "The performance scores of students who have had written teacher comments on previous papers will exceed those of students who have not had written teacher comments on previous papers." You then proceed to gather data about the relationship between the two variables (teachers' written comments and student performance).
- 4. *The hypothesis provides direction to the research*. The hypothesis posits a specific relationship between variables and thus determines the nature of the data needed to test the proposition. Very simply, the hypothesis tells the researcher what to do. Facts must be selected and observations made because they have relevance to a particular question, and the hypothesis determines the relevance of these facts. The hypothesis provides a basis for selecting the sampling, measurement, and research procedures to use, as well as the appropriate statistical analysis. Furthermore, the hypothesis helps keep the study restricted in scope, preventing it from becoming too broad or unwieldy.

For example, consider again the hypothesis concerning preschool experience of culturally disadvantaged children and their achievement in first grade. This hypothesis indicates the research method required and the sample, and it even directs the researcher to the statistical test that would be necessary for analyzing the data. It is clear from the statement of the hypothesis that the researcher will conduct an expost facto study that compares the first-grade achievement of a sample of culturally disadvantaged children who went through a preschool program and a similar group of disadvantaged children who did not have preschool experience. Any difference in the mean achievement of the two groups could be analyzed for statistical significance by the t test or analysis of variance technique. (We discuss these procedures in Chapter 7.)

5. *The hypothesis provides a framework for reporting the findings and conclusions of the study.* The researcher will find it very convenient to take each hypothesis separately and state the conclusions that are relevant to it; that is, the researcher can organize this section of the written report around the provision of answers to the original hypotheses, thereby making a more meaningful and readable presentation.

SUGGESTIONS FOR DERIVING HYPOTHESES

As explained in Chapter 3, a study might originate in a practical problem, in some observed behavioral situation in need of explanation, in previous research, or even more profitably in some educational, psychological, or sociological theory. Thus, researchers derive hypotheses inductively from observations of behavior or deductively from theory or from the findings of previous research. Induction and deduction are complementary processes. In induction, one starts with specific observations and reaches general conclusions; in deduction, one begins with generalizations and makes specific predictions.

DERIVING HYPOTHESES INDUCTIVELY

In the inductive procedure, the researcher formulates an **inductive hypothesis** as a generalization from apparent observed relationships; that is, the researcher observes behavior, notices trends or probable relationships, and then hypothesizes an explanation for this observed behavior. This reasoning process should be accompanied by an examination of previous research to determine what findings other investigators have reported on the question.

The inductive procedure is a particularly fruitful source of hypotheses for classroom teachers. Teachers observe learning and other student behavior every day and try to relate it to their own behavior, to the behavior of other students, to the teaching methods used, to changes in the school environment, and so on. Teachers might observe, for example, that when they present particularly challenging activities in the classroom, some students get motivated and really blossom, whereas others withdraw from the challenge. Some students learn complex concepts best from primarily verbal presentations (lectures), whereas others learn best from discussions and hands-on activities. After reflecting on such experiences, teachers may inductively formulate generalizations that seek to explain the observed relationship between their methods and materials and students' learning. These tentative explanations of why things happen as they do can become the hypotheses in empirical investigations.

Perhaps a teacher has observed that classroom tests arouse a high degree of anxiety and believes this adversely affects student performance. Furthermore, the teacher has noted that when students have an opportunity to write comments about objective questions, their test performance seems to improve. The teacher reasons that this freedom to make comments must somehow reduce anxiety and, as a result, the students score better. This observation suggests a hypothesis: Students who are encouraged to write comments about test items on their answer sheets will achieve higher test scores than students who have no opportunity to make comments.

The teacher could then design an experiment to test this hypothesis. Note that the hypothesis expresses the teacher's belief concerning the relationship between the two variables (writing or not writing comments about test items and performance on the test). Note also that the variable *anxiety* that was part of the reasoning chain leading to the hypothesis is not part of the final hypothesis. Therefore, the results of the investigation would provide information concerning only the relation between writing comments and test performance. The relationships between anxiety and comments, and anxiety and test performance, could be subjects for subsequent hypotheses to investigate. Frequently, an original idea involves a series of relationships that you cannot directly observe. You then reformulate the question to focus on relationships that are amenable to direct observation and measurement.

The following are additional examples of hypotheses that might be arrived at inductively from a teacher's observations:

- Students' learning of computer programming in the middle grades increases their development of logical thinking skills.
- Using advance organizers increases high school students' learning from computer-assisted instruction in chemistry.
- Students trained to write summaries of a lecture will perform better on an immediate posttest on lecture comprehension than will students who simply take notes.
- Children score higher on final measures of first-grade reading achievement when they are taught in small groups rather than large groups.
- The cognitive and affective development of first-grade children is influenced by the amount of prior preschool experience.
- After-school tutoring programs increase the achievement of at-risk students.

In the inductive process, the researcher makes observations, thinks about the problem, turns to the literature for clues, makes additional observations, and then formulates a hypothesis that seeks to account for the observed behavior. The researcher (or teacher) then tests the hypothesis under controlled conditions to examine scientifically the assumption concerning the relationship between the specified variables.

DERIVING HYPOTHESES DEDUCTIVELY

In contrast to hypotheses formulated as generalizations from observed relationships, some others are derived by deduction from **theory**. These hypotheses have the advantage of leading to a more general system of knowledge because the framework for incorporating them meaningfully into the body of knowledge already exists within the theory. A science cannot develop efficiently if each study results in an isolated bit of knowledge. It becomes cumulative by building on the existing body of facts and theories. A hypothesis derived from a theory is known as a **deductive hypothesis**.

After choosing a theory of interest, you use deductive reasoning to arrive at the logical consequences of the theory. If A is true, then we would expect B to follow. These deductions then become the hypotheses in the research study. For example, social comparison theory suggests that students form academic self-concepts by comparing their self-perceived academic accomplishments to some standard or frame of reference. The frame of reference for most students would be the perceived academic abilities of their classmates. If this is true, then one might hypothesize that gifted students would have lower academic self-concepts if they were placed in selective homogeneous groups than if they were in heterogeneous or mixed-ability groups in which they compare themselves to less able students.

One could investigate this hypothesis by examining the change over time in the academic self-concept of gifted students in homogeneous classes compared to that of matched gifted students placed in regular, heterogeneous classes. The evidence gathered will support, contradict, or possibly lead to a revision of social comparison theory.

Another useful theory from which an educational researcher might make deductions is Piaget's classic theory on the development of logical thinking in children. Piaget (1968) suggested that children pass through various stages in their mental development, including the stage of concrete operations, which begins at age 7 or 8 years and marks the transition from dependence on perception to an ability to use some logical operations. These operations are on a concrete level but do involve symbolic reasoning. Using this theory as a starting point, you might therefore hypothesize that the proportion of 9-year-old children who will be able to answer correctly the transitive inference problem, "Frank is taller than George; George is taller than Robert; who is the tallest?" will be greater than the proportion of 6-year-olds who are able to answer it correctly. Such research has implications for the importance of determining students' cognitive capabilities and structuring educational tasks that are compatible with their developmental level.

Piaget's cognitive theory also emphasizes that learning is a highly active process in which learners must construct knowledge. This tenet that knowledge must be constructed by learners rather than simply being ingested from teachers is the basis for much of the research on discovery-oriented and cooperative learning.

In a study designed to test a deduction from a theory, it is extremely important to check for any logical gaps between theory and hypothesis. The researcher must ask, "Does the hypothesis logically follow from the theory?" If the hypothesis does not really follow from the theory, then the researcher cannot reach valid conclusions about the adequacy of the theory. If the hypothesis is supported but was not rigorously deduced from the theory, the researcher cannot say that the findings furnish credibility to the theory. Table 5.1 shows propositions from some well-known theories and a hypothesis based on each theory.

CHARACTERISTICS OF A USABLE HYPOTHESIS

After tentatively formulating the hypothesis, but before attempting any actual empirical testing, you must evaluate the hypothesis. The final worth of a hypothesis cannot be judged prior to empirical testing, but there are certain useful criteria for evaluating hypotheses.

A HYPOTHESIS STATES THE EXPECTED RELATIONSHIP BETWEEN VARIABLES

A hypothesis should conjecture the relationship between two or more variables. For example, suppose you attempt to start your car and nothing happens. It would be unprofitable to state, "The car will not start and it has a wiring system," because no relationship between variables is specified, and so there is

Table 5.1 Well-Known Theories and a Hypothesis Based on Each Theory

Theory

Achievement motivation (McClelland, 1953) People have a tendency to strive for success and to choose goal-oriented, success/failure activities.

Attribution theory (Weiner, 1994) People attempt to maintain a positive self-image; people explain their success or failure in a way that preserves their self-image.

Theory of multiple intelligences (Gardner, 1993) People have a number of separate intelligences that may vary in strength.

Cognitive dissonance theory (Festinger, 1957) People experience discomfort when a new behavior clashes with a long-held belief or with their self-image. To resolve the discomfort, they may change their beliefs or behavior.

Vygotsky's theory of learning (1978) Cognitive development is strongly linked to input from other people.

Maslow's human needs theory (1954). In a hierarchy of needs, people must satisfy their lower level needs (hunger or safety) before they are motivated to satisfy higher level needs (self-esteem or need to know).

Behaviorism (Skinner, 1953) Behavior that is positively reinforced will increase in strength.

Hypothesis

There is a positive relationship between achievement motivation and success in school.

If students are given a task and told that they failed or succeeded (even though all actually succeed), those who are told they failed say it is due to bad luck; those who are told they are successful will attribute it to skill and intelligence.

Teaching science concepts using a variety of approaches will result in greater achievement than when using only linguistic and mathematical approaches.

Requiring middle school students who smoke to write an essay on why young people should not smoke will change their attitudes about smoking.

Tutoring by more able peers will have a positive effect on the learning of at-risk students.

Children from economically disadvantaged homes who are given breakfast at school will show higher achievement than similar students not given breakfast.

On-task behavior will increase when teachers positively reinforce it.

no proposed relationship to test. A fruitful hypothesis would be "The car will not start because of a fault in the wiring system." This criterion may seem patently obvious, but consider the following statement: "If children differ from one another in self-concept, they will differ from one another in social studies achievement." The statement appears to be a hypothesis until you note that there is no statement of an expected relationship. An expected relationship could be described as "Higher self-concept is a likely antecedent to higher social studies achievement." This hypothesis would then be stated as "There will be a positive relationship between self-concept and social studies achievement." If the opposite is predicted—that is, higher self-concept leads to lower social studies achievement—then the hypothesis would be "There will be a negative relationship between self-concept and social studies achievement." Either statement would meet this first criterion.

A HYPOTHESIS MUST BE TESTABLE

The most important characteristic of a "good" hypothesis is testability. A **testable hypothesis** is verifiable; that is, deductions, conclusions, or inferences can be drawn from the hypothesis in such a way that empirical observations either support or do not support the hypothesis. If the hypothesis is on target, then

certain predictable results should be manifest. A testable hypothesis enables the researcher to determine by observation and data collection whether consequences that are deductively implied actually occur. Otherwise, it would be impossible either to confirm or not to confirm the hypothesis. In the preceding example, the hypothesis "The car's failure to start is a punishment for my sins" is obviously untestable in this world.

Many hypotheses—or propositions, as they may initially be stated—are essentially untestable. For instance, the hypothesis "Preschool experience promotes the all-around adjustment of the preschool child" would be difficult to test because of the difficulty of operationalizing and measuring "all-around adjustment." To be testable, a hypothesis must relate variables that can be measured. If no means are available for measuring the variables, then no one could gather the data necessary to test the validity of the hypothesis. We cannot emphasize this point too strongly. Unless you can specifically define the indicators of each variable and subsequently can measure these variables, you cannot test the hypothesis.

The indicators of the variables are referred to as operational definitions. Recall from Chapter 2 that variables are operationally defined by specifying the steps the investigator takes to measure the variable. Consider the hypothesis "High-stressed nursing students will perform less well on a nursing test than will low-stressed students." The operational definition of stress is as follows: One group of students is told that their performance on the nursing test will be a major determinant of whether they will remain in the nursing program (high stress), and the other group is told that they need to do as well as they can but that their scores will not be reported to the faculty or have any influence on their grades (low stress). The operational definition of test performance would be scores from a rating scale that assessed how well the students did on the various tasks making up the test. Or consider the following hypothesis: "There is a positive relationship between a child's self-esteem and his or her reading achievement in first grade." For this hypothesis to be testable, you must define the variables operationally. You might define *self-esteem* as the scores obtained on the Self-Image Profile for Children (Butler, 2001) and reading achievement as scores on the California Reading Test, or as first-grade teachers' ratings of reading achievement.

Make sure the variables can be given operational definitions. Avoid the use of constructs for which it would be difficult or impossible to find adequate measures. Constructs such as *creativity*, *authoritarianism*, and *democracy* have acquired such diverse meanings that reaching agreement on operational definitions of such concepts would be difficult, if not impossible. Remember that the variables must be defined in terms of identifiable and observable behavior.

It is important to avoid value statements in hypotheses. The statement "A counseling program in the elementary school is desirable" cannot be investigated in an empirical study because "desirable" is too vague to be measured. However, you could test the hypothesis "Elementary pupils who have had counseling will have higher scores on a measure of expressed satisfaction with school than will those who have not had counseling." You can measure verbal expressions of satisfaction, but whether they are desirable is a value judgment.