CHAPTER 3

The Research Problem

A research problem is not a nuisance; it is a step toward new knowledge.

INSTRUCTIONAL OBJECTIVES

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

1. Define a research problem.
2. Identify potential sources of problems for educational research.
3. State the criteria to use for evaluating a research problem.
4. State the characteristics of a worthwhile theory.
5. Evaluate a given problem for research using the accepted criteria.
6. Take a general problem in an area of interest in education and formulate it in a specific form ready for empirical investigation.
7. Distinguish between the types of problem statements used in quantitative research and qualitative research.
8. Define terms such as *population* and *variables* as used in a quantitative research study.
9. Identify the population and the variables in a given study.

Systematic research begins with a **research problem.** In a classic work, John Dewey (1933) spoke of the first step in the scientific method as the recognition of a felt difficulty, an obstacle, or problem that puzzles the researcher. Your first step in the research process is therefore to select a problem for investigation. Selecting and formulating a problem is one of the most important aspects of doing research in any field. Beginning researchers are often surprised to find that this initial stage can take up a large part of the total time invested in a research project. There is no way to do research until a problem is recognized, thought through, and articulated in a useful way.

A researcher must first decide on the general problem area. This step is often difficult for beginning researchers. The difficulty is not due to a shortage of problems but, rather, to the fact that beginners must select a problem very early, when their understanding of how to do research is most limited. They are uncertain about the nature of research problems and how to go about solving them. Skill in doing research is to a large extent a matter of making wise choices about what to investigate. This skill takes time and repeated effort to develop, but the willing beginner can do it.

In order to ask questions that research can answer, one should have knowledge or experience in an area. We often hear students in difficult courses say, "I don't know enough to ask questions." Similarly, unless a researcher has knowledge or experience in an area, he or she does not know what additional knowledge is needed or how to obtain it through empirical investigation.

Furthermore, the question chosen for investigation should hold deep interest or be one about which the researcher is really curious. The choice must necessarily be very personal or else the researcher may find it difficult to muster the motivation to carry the research through to its end. Find a question that intrigues you and you will enjoy the search for a solution. For example, an elementary school teacher may be interested in finding a more effective way to teach reading. A high school biology teacher may want to know if using computer simulations would improve students' problem-solving skills. An elementary school principal may want to know if a mentoring program would improve the effectiveness of beginning teachers.

After having chosen the general area of investigation, the researcher then narrows it down to a specific statement of the research question. What specifically do you want to know or what do you want to predict? Unlikely as it may seem, once the researcher has selected a problem area and clearly articulated a question or statement, he or she has accomplished one of the most difficult phases of the research process.

SOURCES OF PROBLEMS

The first question most students ask is "How do I find a research problem?" Although there are no set rules for locating a problem, certain suggestions can help. Three important sources for research problems are experience, deductions from theory, and related literature. Noneducation sources may also be useful. These sources are appropriate in both quantitative and qualitative research.

EXPERIENCE

Among the most fruitful sources for beginning researchers are their own experiences as educational practitioners. Teachers have intuitions or hunches about new relationships or why certain things in school happen the way they do. Teachers often question the effectiveness of certain classroom practices that have become routine but that may be based more on tradition or authority than on scientific research. They wonder if alternative procedures would be more effective. A high school teacher might have a question about strategies to improve the achievement of at-risk students, or an elementary teacher may have questions about a new method to teach reading. In this age of accountability in education, teachers want to know if programs and practices they use are the most effective. Research can provide the answers to such questions.

Most graduate students in education have been in the classroom or are currently working full- or part-time in schools. Students who have not had teaching experience can get ideas from discussions and their reading in education courses. We recommend that you make a list of ideas, noting things that you question. By studying these notes, you will soon identify a worthwhile research problem.

THEORIES

Theories are a good source of problems for research. A *theory* may be defined as a set of interrelated statements, principles, and propositions that specify the relationships among variables. The application of the general principles embodied in a theory to specific educational problems is only hypothetical, however, until research empirically confirms them. For example, assume a researcher is interested in how adolescents form their academic self-concepts. 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. One question that might arise is "Would gifted students placed in selective homogeneous classes have lower academic self-concepts over time than equally gifted students in heterogeneous or mixed-ability classes?" This question could be investigated by studying the change over time in the academic self-concept of gifted students in homogeneous classes compared with that of gifted students placed in regular, heterogeneous classes.

Another interesting theory that has implications for education is Erik Erikson's (1967) classic theory of personality development. Erikson describes psychosocial development in terms of stages throughout the life span, each of which involves a critical issue or conflict that the person must resolve. Adolescence, which is one of these stages, has as its major task the development of a positive self-concept or, to use Erikson's term, a strong sense of identity. Forming a strong personal identity is difficult because competing roles and values face the young person. Research shows that adolescents who have achieved a sense of identity are more independent, more socially competent, better able to cope with stress, and have higher self-esteem. However, if the adolescent does not resolve the identity crisis, a sense of inferiority and personal alienation may result. It is interesting that students who have committed violent acts often report feelings of alienation. Erikson's theory could become the foundation for research on school violence. A researcher interested in studying school violence might ask, "Are there school practices that may contribute to feelings of isolation in some students? "What are some positive programs that might help improve students' self-image?" "How does the school deal with reported incidences of physical bullying or cyber-bullying?" and "Would other procedures be more effective?" A qualitative researcher might conduct a case study of an adolescent who has committed an act of school violence or of one who has been a victim of bullying.

Choosing a Theory

Not all theories are equally useful to a beginning researcher. Let us examine some of the characteristics one searches for in a good theory for a research study:

1. *An essential characteristic of a good theory is that it is testable*. The theory chosen should be one from which the researcher can make concise

predictions (hypotheses) about what will happen in new situations and can verify these predictions through empirical observation. As the hypotheses are supported in research studies, they then become part of the theory that adds to the body of knowledge. However, if the theory cannot be tested, it serves no useful purpose.

2. *A good theory is not only testable but also falsifiable*. Being falsifiable means that it is capable of being proven wrong. It is possible to gather evidence that contradicts the theory. A theory that explains why a tornado touched down in a certain area of a town by stating that the people there are being punished for their sins is not a theory that can be proven wrong. Thus, it is not a useful theory.

   Students sometimes find this concept of **falsifiability** difficult to understand. This concept derived from the philosopher Sir Karl Popper, who in *Logic of Scientific Discovery* (1965) argued that claims to knowledge "can never be proven or fully justified, they can only be refuted" (p. 40). A theory cannot ever be proved to be true because theories are generalizations that apply to all possible instances of the phenomena they are trying to explain, and it is not possible to test it against all possibilities. We say only that a theory has been supported; the more support it gets in a variety of research studies, the more confidence we have in the usefulness of the theory. However, it is possible to disprove a theory by gathering negative evidence that contradicts the theory. According to Popper, this is how most scientific progress is achieved. Neuman and Kreuger (2003) give a useful example: "If I want to test the claim that all swans are white, and I find 1000 white swans, I have not totally confirmed the causal law or pattern. All it takes is locating one black swan to refute my claim—one piece of negative evidence" (p. 40). Negative evidence indicates that the theory needs to be rejected or at least revised. To summarize, a good theory is one for which evidence can be gathered that will either support or refute the theory. Both outcomes must be possible.

3. *A good theory deals with some significant phenomenon or behavior that needs explanation, such as learning or motivation*.

4. *A good theory provides the simplest, clearest, and most plausible explanation for the phenomenon*. A good theory follows the principle of parsimony, which states that a theory should explain the largest number of facts with the smallest number of principles.

5. *A good theory has internal consistency*; its propositions do not contradict one another. For example, a "commonsense" theory of human separation may state "Absence makes the heart grow fonder" but also "Out of sight, out of mind." One could find evidence to support both of these propositions; thus, the theory would not be useful for predicting what might happen when people are separated.

In summary, think of an educational, psychological, or sociological theory that you find especially interesting. Read a summary of the theory in journals, textbooks, or primary sources, and then ask a question. A theory-based research question is beneficial because the results can be tied to a body of existing knowledge. The research can verify or fail to verify the theory, and it will most likely suggest other questions for research. You might talk to your professors to find out what they are working on or to get their suggestions.

RELATED LITERATURE

Another valuable source of problems is the published literature in your area of interest. In published research, you will find examples of research problems and the methods used to solve them. A review of related literature may help in the following ways:

1. You may find a study that needs to be replicated. You can repeat someone else's study, not exactly, but with some variation. You might use a different age group, different setting, or a different methodology. A study might even become a cross-cultural one to determine if the conclusions from research in one culture apply in other cultures. You need not be concerned that you are merely replicating a study rather than doing some new, groundbreaking research. Replication is a worthwhile activity because it provides more evidence of the validity of the original findings. As studies are repeated at different times and in different places, with the findings supported in each study, we can have increasing confidence in the scientific validity of the findings.

   For example, researchers have conducted numerous replications of Piaget's famous studies (1999) of the development of moral judgment in children. These studies have used Piaget's basic approach but have investigated the development of moral judgment in children of different socioeconomic classes, in children of the same chronological age but differing in intelligence level, in children differing in the extent of their participation in their own age groups, in children differing in the nature of parental discipline experienced in the home, and in both boys and girls. Recently, other investigators have used techniques that differed from Piaget's in their attempts to confirm his findings and conclusions. In general, the large body of research stemming from Piaget's investigations has supported his original conclusions. Thus, a single research study, if it deals with a significant problem and if its findings are exciting, can inspire many other studies.

2. You may find a question that represents the next logical step in the research on a problem. The outcomes of one piece of research very often lead to new questions. In the concluding sections of their research reports, researchers often describe new questions that have arisen and suggest additional studies that should be done. A productive way to extend studies is to introduce new variables into a research design for further control and for determining interaction effects among variables. Many multivariate studies are extensions of earlier single variable investigations (see Chapter 11).

In conclusion, published research can be a great source of ideas for research. With some critical analysis of the research in your field and a bit of creativity, you should be able to find several potentially researchable problems. Reading research will also help you by showing how previous researchers measured variables, selected samples, analyzed data, and so on.

Reviews of Research

Reviews of research that integrate and summarize studies on specific topics can be very useful for identifying a research problem. Those produced by the American Educational Research Association (AERA) are particularly useful.

The *Review of Educational Research* published quarterly by AERA since 1931 reviews and integrates educational literature on a different topic each volume. For example, the topic of volume 71 (2007) was "Difference, Diversity, and Distinctiveness in Education and Learning."

In 1973, AERA launched the annual *Review of Research in Education* to provide summaries of what research has been done, is being done, and needs to be done in a specific broad topic each year. Volume 82 (2008) focused on "What Counts as Knowledge in Educational Settings: Disciplinary Knowledge, Assessment, and Curriculum."

Approximately every 10 years, AERA publishes the *Handbook of Research on Teaching* (Gage, 1963; Travers, 1973; Wittrock, 1985; Richardson, 2001). These volumes list, summarize, and critically analyze research in the field of teaching. Each edition contains authoritative articles by specialists on selected topics in the field. The fourth edition is composed of 51 chapters from 81 authors, all of whom are experts in their respective fields. Comprehensive bibliographies are included, by selected topics. Among the topics in the fourth edition are policies for licensing and assessment of teachers, special education, middle school teaching, teaching as a moral activity, and the teaching of physical education.

AERA's *Encyclopedia of Educational Research* (2004), designed to present "a critical synthesis and interpretation of reported educational research," contains signed articles with bibliographies providing well-documented discussions of recent trends and developments, as well as traditional topics. This four-volume encyclopedia includes approximately 200 topics. It is a good basic source for preliminary overviews of research in various areas.

Other useful periodicals include *PsycINFO*, *Education Abstracts*, and specialized reviews such as Social Work Abstracts, Historical Abstracts, and MEDLINE (medicine). For more information on related literature, see Chapter 4.

NONEDUCATION SOURCES

You can adapt theories or procedures you encounter in other fields to apply to education. Often, movements that originate outside a profession lead people to new paths of research. The women's movement has led researchers to study gender stereotyping in educational materials, the influence of schools on the learning of sex roles, gender differences in achievement and personality, and so forth. The civil rights movement led to many studies about the education of minority children. The AIDS (acquired immunodeficiency syndrome) epidemic has stimulated a great deal of research on the best procedures and materials to use to acquaint young people in school with the danger of the disease and how best to protect themselves from it. The inspiration for much valuable research in education has come from such noneducation sources.

QUALITATIVE RESEARCH PROBLEMS

Just as is true for quantitative researchers, beginning qualitative researchers can look to their personal experiences and interests, to theory, to the professional literature, or to current social issues and real-world concerns to find a potential problem. You need to identify an area or a topic about which you have a real interest. For example, a beginning researcher might be interested in how learning-disabled students are integrated into regular high school classrooms.

Once researchers have selected the initial focus of inquiry, they need to identify exactly what they want to know about that topic. The focus of inquiry is thus narrowed to the aspect of the phenomenon that will be explored in the research study. The focus of inquiry mentioned previously can be stated as follows: "How do other students treat learning-disabled students?" "How do the learning-disabled respond?" Although the qualitative researcher intuitively arrives at hunches about the phenomenon, he or she does not formulate an initial hypothesis that the study tests.

Suppose one is interested in the general topic of bullying behavior in elementary schools. Elementary teachers have long observed that some students are bullies and others become their victims. In a qualitative study, a researcher might ask how and why this behavior develops and could use naturalistic observation to investigate this behavior in an elementary school. The investigator could use video cameras and remote microphones to record instances of children being exposed repeatedly to negative verbal or physical actions on the part of one or more classmates. The researcher would want to interview the bullies to find out what they are thinking and what their motives and goals are. The victims would also be interviewed to learn about their feelings. The researcher might also examine gender differences in bullying behavior and the reaction of peers to this behavior.

EVALUATING THE PROBLEM

After you have tentatively selected a question that interests you, you need to ask if it is a question that warrants an expenditure of time and effort to investigate. The following are criteria that one can use to evaluate a research problem:

1. *The problem should have significance*—that is, it should be one whose solution will make a contribution to educational theory or practice. The problem may fill in gaps in current knowledge or help resolve some of the inconsistencies in previous research. You should be able to answer the question "So what?" with respect to your proposed study. Would the solution make any difference to educational practice? Would other educators be interested in the findings? Would the findings be useful in an educational decision-making situation?
2. *The problem should be one that will lead to new problems and so to further research*. A good study, while arriving at an answer to one question, usually generates a number of other questions that need investigation. Avoid trivial problems that have little or no relationship to theory or previous research.

   We suggest that a beginning researcher consider selecting a problem that could possibly be expanded or followed up later in a master's thesis or even a doctoral dissertation. It may be helpful if students familiarize themselves with the research efforts of their professors, who not only can suggest related problems needing investigation but also may later serve as a mentor or a doctoral committee member.
3. *The problem must be researchable*. Although this criterion would seem self-evident, in practice, many proposed problems are not researchable. A researchable problem is one that can be attacked empirically; that is, it is possible to gather data that answer the question. Many interesting questions in education cannot be answered by scientific research. Philosophic questions, for example, that ask what should be done are not researchable and should

be avoided. Questions such as "Should we offer more vocational training in the high school?" or "Should schools give more attention to character education?" cannot be answered by scientifically gathering and analyzing data.

It is possible to restate philosophic questions to make them researchable. The previous question could be restated as follows: "What is the effect of a character education program on the incidence of cheating in high school?" It would be possible to gather data on this question, which could then be used by educators to help make decisions about a character education program.

4. *The problem should be suitable for the researcher*. The problem may be excellent from the standpoint of the previous criteria but inappropriate for the individual. First, the problem should be one in which you, the researcher, have a genuine interest and about which you can be enthusiastic. It should be a problem whose solution is personally important because of what it could contribute to your own knowledge or to improving your performance as an educational practitioner. Unless the problem is meaningful and interesting, it is doubtful whether you would be willing to expend the time and energy to do a thorough job.

   In addition to interest, one must have the necessary research skills to carry the study through to completion. One may have to develop and validate instruments or do complex statistical analyses. Another consideration is whether you will have access to participants and the data necessary to answer the research question. Lastly, one should choose a problem that can be investigated in the allotted time and with the resources available. Do not select a problem that is too large or too involved, and be sure to allow adequate time for constructing instruments, administering instruments, conducting interviews or observations, analyzing data, and writing the report.

5. *The problem should be ethically appropriate*. That is, the problem should be one that you can investigate without violating ethical principles. Unlike researchers in the physical sciences, educational researchers are dealing with human subjects with feelings, sensitivities, and rights who must be treated ethically. We discuss ethics in greater detail in Chapters 15 and 20. At this point, we mention briefly three issues the researcher should consider:

   a. *Consent*. Researchers need to obtain consent from the intended subjects. Subjects should be able to choose whether they wish to participate in the study or not. Obtain consent from subjects after taking steps to ensure that they have a complete understanding of the procedures to be used, any risks involved, and any demands that will be placed on them. Obtain parental consent if minor children are to be involved in the study.

   b. *Protection from harm*. Do not plan research that may cause physical harm or psychological harm such as stress, discomfort, or embarrassment that could have lasting adverse effects. Fortunately, most educational research does not involve great risk of harm to subjects. However, the potential for harm always exists, and a researcher should be prepared if a participant requests counseling or other help after participating in the study.

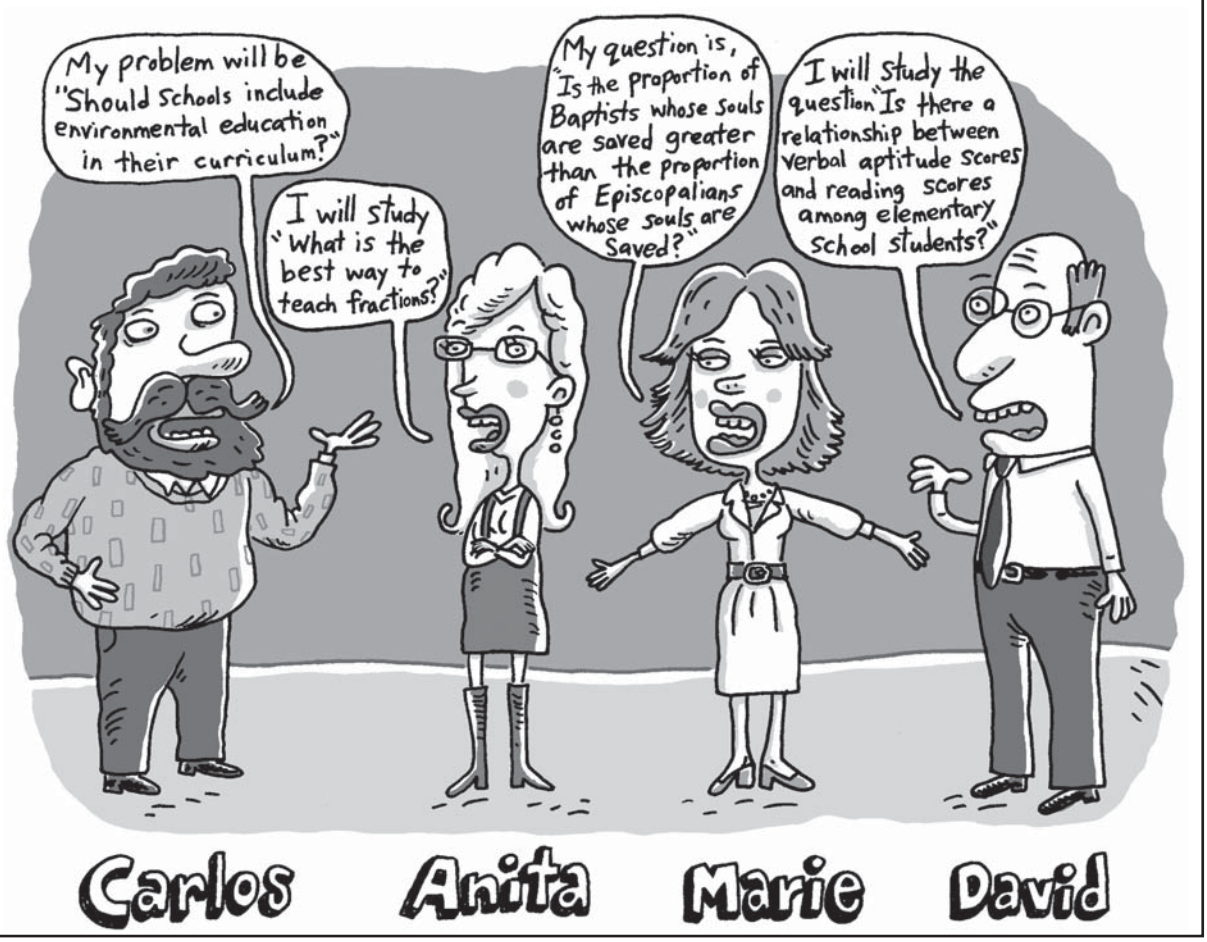
   c. *Privacy*. A researcher should invade the privacy of subjects as minimally as possible. For example, a researcher may plan to use an inventory that

asks adolescents questions about sexual experiences, religious beliefs, attitudes toward parents, or other sensitive topics. In this case, the researcher should not attach names to the inventories. Subjects have the right to expect that their anonymity will be preserved. Most educational researchers are interested in group data rather than individual responses; the scores or responses of individuals are generally pooled and reported as group averages, which tends to minimize the risk of invading privacy. Table 3.1 summarizes the criteria of a good research problem.

Table 3.1 Characteristics of a Good Research Problem

1. The problem is significant (it will contribute to the body of knowledge in education).
2. The problem is one that will lead to further research.
3. The problem is researchable (it can be investigated through the collection of data).
4. The problem is suitable (it is interesting and suits the researcher's skills, time, and available resources).
5. The problem is ethical (it will not cause harm to subjects).

PICTURE THIS



Joe Rocco

THINK ABOUT IT 3.1

How do the questions in the cartoon rate on the criteria for evaluating research problems?

Answers:

1. Carlos: Research cannot answer questions of "should." The question could be rewritten as "Do students who have had a unit on environmental awareness demonstrate greater knowledge of and more positive attitudes toward environmental issues than students who have had a control unit?" Then one could randomly assign some students to have a unit on environmental awareness while others have a unit not related to the environment. At the completion of the units, one could measure the students on their knowledge of the environment, their attitudes toward environmental legislation, and environmentally appropriate behaviors such as not littering.
2. Anita: As stated, the question is not researchable. There are so many possible ways to teach fractions that one could never investigate the outcomes of them all. One could operationally define two or three methods and compare the success of students taught by the different methods, using the same test of knowledge of fractions for all groups.
3. Marie: There is no way in this world to determine whose soul has been saved. A feasible question might be "Is the proportion of Baptists who say their souls have been saved different from the proportion of Episcopalians who say their souls have been saved?"
4. David: The question is trivial because it has been investigated sufficiently in past research.

STATING THE RESEARCH PROBLEM

After you have selected and evaluated the problem, the next task is to state the problem in a form amenable to investigation. We cannot overemphasize the importance of a clear statement of the problem. Beginning researchers often have a general idea of what they want to investigate but have trouble articulating it as a workable problem. They cannot make progress until they can state unambiguously what they are going to do. The statement of the problem varies according to the type of research. Thus, we consider quantitative and qualitative research statements separately.

THE PROBLEM STATEMENT IN QUANTITATIVE RESEARCH

The **problem statement** in quantitative research specifies the variables and the population of interest. The problem statement can be a declarative one such as "This study investigates the effect of computer simulations on the science achievement of middle school students." The statement can ask a question about a relationship between the two (or more) variables. The previous problem might be restated as "What is the relationship between use of computer simulations and achievement in middle school science?" Some scholars prefer the question form simply because it is straightforward and psychologically seems to orient the researcher to the task at hand—namely, to find the answer to the question. But either is an acceptable way to present the research problem.

The problem can be further clarified by operationally defining the variables involved. In the previous example, you might specify what computer simulations will be used, how science achievement will be measured, and how the sample of middle school students will be selected. The problem statement then becomes "What is the effect of a computer-assisted biology course on performance on the Test of Biological Concepts of students in an eighth-grade biology class?" One can then proceed to plan an experiment that compares the scores on the Test of Biological Concepts by students having the computer instruction with those of similar students having the traditional biology curriculum.

THE PROBLEM STATEMENT IN QUALITATIVE RESEARCH

Qualitative researchers also begin with a problem, but they state it much more broadly than in quantitative research. A qualitative problem statement or question indicates the *general* purpose of the study. Formulation of a qualitative problem begins with the identification of a general topic or an area you want to know more about. This general topic of interest is sometimes referred to by qualitative researchers as the **focus of inquiry**. This initial broad focus provides the framework but allows for changes as the study proceeds. As the researcher gathers data and discovers new meanings, the general problem narrows to more specific topics and new questions may arise. For example, Piert (2007) conducted a qualitative study to learn about a rite-of-passage program for transitioning black young people into adulthood. The program draws upon African traditional culture to impart values, improve self-concept, and develop cultural awareness. The specific problem was "What are the perceptions of former students who had experienced a rite-of-passage program while attending an African centered high school?" The findings suggest that the participants perceived the rite of passage as a community endeavor that facilitated their transition into adulthood. They viewed it as a method to inculcate social, cultural, and political values that will ensure the positive development of black young adults within the black community as well as American society.

Whereas the quantitative researcher always states the problem before collecting data, the qualitative researcher may formulate problems after beginning to collect data. In fact, the researcher often does not present the final statement of the problem—which typically specifies the setting, subjects, context, and aim of the study—until he or she has collected at least some data.

In qualitative research, the statement may be somewhat general in the beginning, but it will become more focused as the study proceeds. After exploring the sites, the people, and the situations, the researcher narrows the options and states the research problem more specifically.

IDENTIFYING POPULATION AND VARIABLES

A good strategy for shaping a felt problem—or a vague notion of what you want to investigate—into a researchable problem is to think in terms of population and variables. For example, let us consider Ms. Burke, an elementary school principal whose question is "Does individual tutoring by upper-grade students have a positive effect on the reading achievement of younger below-average readers?"

It is usually easiest to identify the **population**—those people about whom you wish to learn something. The population here is below-average readers. Reading ability is not a variable in this question because all the children being considered have already been diagnosed as below-average readers. Having identified below-average readers as the population in the original statement, Ms. Burke should now ask herself if that is really the population she wants. She will probably decide that below-average readers is too broad a category and she should confine herself to a particular age. Thus, she selects below-average second-grade readers.

Now she is ready to identify the variables in the remainder of her original statement. "Individual tutoring" can be made into a variable by varying the type of tutoring used, varying the amount of tutoring time, or having some children receive the tutoring and others not receive tutoring. Ms. Burke decides that the last alternative concerns what she really wants to know, so she rewrites the relevant part of the question to "Does receiving a specified amount of individual tutoring versus no tutoring … ?" Thus, tutoring is the independent variable because it is antecedent to reading achievement, and the principal is predicting that the tutoring will have an effect on reading achievement, the dependent variable. Recall that the dependent variable is the outcome of interest, and the independent variable is hypothesized to influence the dependent variable. Now it becomes obvious that the word *tutoring* is too general. Unless all subjects receive the same type and amount of tutoring, the results of the study will be meaningless. Ms. Burke decides to use word flash drill as the specific type of tutoring and to specify 15 minutes per day as the amount of time.

The phrase "have a positive effect on" is quite vague until she considers it in terms of her independent variable. Does word flash drill have an effect on … what? She knows it has an effect on word flash recall, but she wants to study its effects on other aspects of reading behavior that might be observed: expressive oral reading, silent reading, positive feelings toward reading, number of books read, comprehension, and so forth. However, she is afraid that teachers might rate good word callers as comprehending more and being more positive toward reading, whereas they view the poorer word callers as more inferior on these variables than they really are. She wants a dependent variable that is independent of teacher judgment and decides to use reading scores from the California Achievement Test (CAT) as the dependent variable.

Ms. Burke's revised statement of the problem now reads "Among below-average second-grade readers, is there a difference in CAT reading scores between those who have received 15 minutes per day of individual word flash drill by upper-grade students and those who have received no word drill?" This question tells whom she is studying, what will be done differently for some students, and what she expects differential treatment to influence. Note also that the value judgment "positive effect" has been dropped from the question.

It is often useful to follow this procedure in a formal manner similar to that used for diagramming a sentence. You can begin by drawing a vertical line and writing *Population* to the left and *Variables* to the right. Then list these elements in the study below the horizontal line. For the preceding example, the diagram would be as follows:

Population	Variables
Below-average second-grade readers	• Word flash drill for 15 minutes daily by upper-grade students versus no word flash drill (independent) • Reading scores on CAT (dependent)

Let us take another question: "What is the effect of having experienced versus not having experienced a preschool program on the reading achievement of first-graders?"

Population	Variables
First-graders	• Having experienced versus not having experienced a preschool program (independent) • Reading achievement (dependent)

This question is complete in that it has an identified population and both independent and dependent variables. Because "preschool program" precedes "reading achievement of first-graders," the former can be identified as the independent variable and the latter as the dependent variable.

Let us look at another example: "Does high school driver education do any good?" As it stands, the question has neither a population nor variables. An investigator starting with this question might first decide to compare 18-year-old drivers who have had high school driver education with those who have not. You now have a population statement and an independent variable. Now you can turn your attention to selecting a dependent variable. What effect might having versus not having driver education have on 18-year-old drivers? Let us say you decide that "accident rate" would be a suitable dependent variable. Putting these elements into a diagram, you now have the following:

Population	Variables
18-year-old drivers	• Have had versus have not had high school driver education (independent) • Accident rate (dependent)

You can now state a complete question: "Do 18-year-old drivers who have had high school driver education have a lower accident rate than 18-year-old drivers who have not had high school driver education?"

The question "What is the relationship of dogmatism to political attitudes among college freshmen?" illustrates another point. Consider this diagram:

Population	Variables
College freshmen	• Dogmatism • Political attitudes

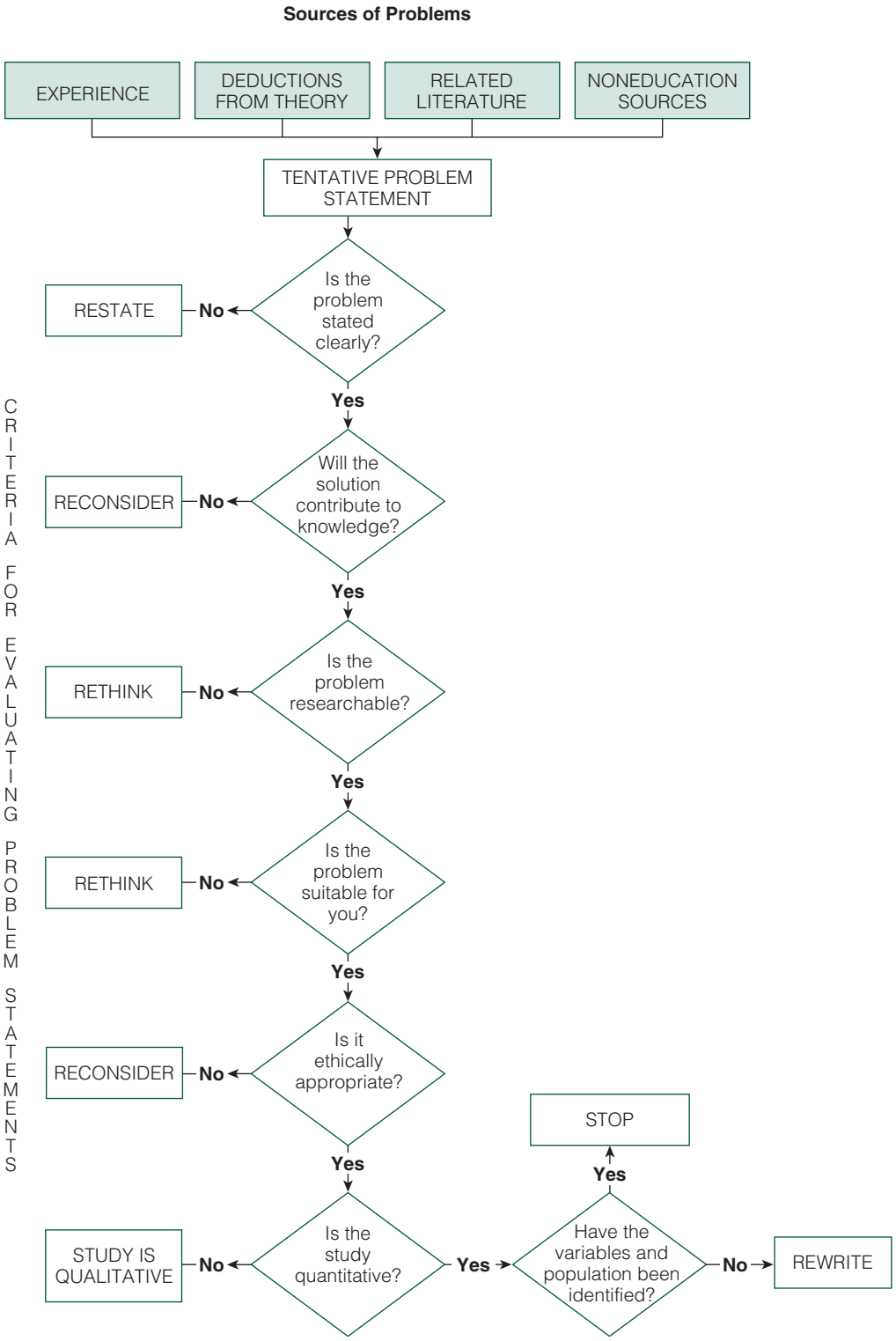


Figure 3.1 Developing a Research Problem

This question is complete with a population and two variables. However, you cannot label the variables as independent and dependent because it cannot be determined which is antecedent to the other.

If you conduct a study to investigate status quo rather than a relationship between variables, it may be complete with only one variable. For example, you might study the opinions of college seniors concerning legalization of marijuana. In this case, the population is college seniors and the single variable is their opinions on the subject. The process of evaluating a problem for research is summarized in Figure 3.1.

Think About It 3.2

For the revised problems of Carlos, Anita, and Marie, identify and/or add the independent variable(s), dependent variable, and population that they will need to identify in order to begin research on their questions.

Answers

1. Carlos

Population	*Independent Variable*	*Dependent Variables*
High school students	Unit on environmental awareness vs. control unit	Knowledge of environment Attitude toward environmental issues

2. Anita

Population	*Independent Variable*	*Dependent Variable*
Fourth-graders	Method of teaching fractions	Student success with fractions

3. Marie

Population	*Independent Variable*	*Dependent Variable*
Church members (Baptists and Episcopalians)	Religious affiliation	Whether they report their souls saved or not

SUMMARY

The first task facing researchers is selecting a researchable problem and stating it in a form suitable for research. To find a problem, investigators may look to their personal experiences, to theories from which questions may be deduced, to the current literature in their area of interest, or to noneducation sources. They must evaluate the significance of the proposed problem in terms of specific criteria, asking questions such as "Will the problem contribute to the present body of knowledge?" "Does it have potential for leading to further research?" "Is it testable—that is, can the variables be observed and measured?" "How appropriate is the problem with respect to my interests, experience, and knowledge in the area?" "Do I have access to the data required by the problem, and are instruments available, or could they be constructed, to measure the variables?" and "Can the data be analyzed and interpreted within

the time available?" The question should not directly involve philosophical issues, nor should it be so general that a research undertaking is impossible. A quantitative research question asks about the relationship between certain variables. The statement of the question should identify the population of interest and the variables to be investigated. A qualitative research question indicates the general purpose of the study. The criteria for evaluating qualitative problems are similar to those used for quantitative research problems.

KEY CONCEPTS

criteria for research problems
falsifiability
focus of inquiry
population
problem statement
research problem

EXERCISES

1. The following is an abstract taken from an article in *The Clearing House* (Springer, Pugalee, & Algozzine, 2007):

   In U.S. schools, students must pass statewide competency tests to graduate from high school. In this article, the authors summarize the development and testing of a program implemented to improve the skills of students failing to "make the grade" on these high-stakes tests. District personnel randomly assigned 28 students who previously failed the math test to participate in an experimental (Arizona Instrument to Measure Standards [AIMS]) or to a control math class. The AIMS group used a computerized tool to generate multiple-choice problems for students to practice the content of the state's competency test. Eight AIMS students (57 percent) and two control students (14 percent) passed the retest. The outcomes offer promise for schools looking for evidence-based solutions to problems related to increasing numbers of students experiencing difficulties with high-stakes assessments.

   a. What was the independent variable in this study?
   b. What was the dependent variable?
   c. What was the population?
2. Find a quantitative research report published in a journal, and answer the following questions based on your reading:
   a. What problem is investigated in the study?
   b. What are the independent and dependent variables?
   c. Where did you find the problem stated in the report?
   d. Was the problem stated with sufficient clarity so that you knew exactly what was being investigated in the study?
   e. Did the author suggest further research on this question?
3. Find a qualitative research report published in a journal and identify the
   a. Problem
   b. Methodology
   c. Findings
   d. Conclusions
4. Select a broad area in which you might be interested in doing research and then identify a research problem in that area. State this problem in an acceptable form for research. What was the source of this problem?
5. The following examples are inadequate statements of research problems. Restate each so that it becomes a specific question suitable for research.
   a. A later morning start for the high school
   b. Parental involvement and elementary school achievement
   c. Self-concept of children with learning disabilities
   d. Home-schooled adolescents
   e. Gender differences and logical thinking skills of talented preadolescents
   f. Teaching students with attention deficit/hyperactivity disorder (ADHD)
   g. Predicting achievement in a graduate education program

6. Evaluate the following research problems:
   a. Should learning-disabled students be mainstreamed in middle school English classes?
   b. Has No Child Left Behind legislation been good for U.S. education?
   c. Would it be wise to have a dress code for the city's high schools?
   d. What is the relationship between verbal aptitude scores and reading test scores?
7. State the most likely independent and dependent variables in the following studies:
   a. Peer interactions in children with autism
   b. The effect of participation in school sports on the social skills of mentally challenged adolescents
   c. The effect of an early intervention program on the academic achievement of children from low-income families
   d. The influence of an antismoking program on the attitudes of middle school students toward smoking
8. A principal wants to know if it is beneficial to keep class sizes small in kindergarten to grade 2. Write an appropriate research question designed to answer this question.
9. Classify the following studies as most likely being quantitative or qualitative:
   a. Life of an Adolescent with HIV Infection
   b. High School Principals' Perspectives on Student Expulsion
   c. The Effect of Ability Grouping on Academic Outcomes for Gifted Students
   d. Racial Stereotypes in Middle School Literature Textbooks
   e. Teaching in an Alternative High School
10. There has been an increase in the number of elementary school children diagnosed with attention deficit disorder. Based on your observation and experience, formulate a theory to explain this finding. Evaluate your theory according to the characteristics of a "good" theory. State a research problem based on your theory.

ANSWERS

1. a. Computerized program to practice math content versus control math class
   b. Performance on a repeat of a state math competency test
   c. Students who had failed the math competency test
2. Answers will vary.
3. Answers will vary.
4. Answers will vary.
5. a. What is the effect of a later morning start time on the achievement of students at Eastern High School?
   b. What is the effect of a program to increase parental involvement on the achievement of their elementary school children?
   c. How do children with learning disabilities perceive themselves socially and academically?
   d. How do students who have been home schooled perform academically during the freshman year at Central State U.?
   e. What is the relationship between gender and logical thinking skills in talented preadolescents?
   f. What is it like to teach students with ADHD?
   g. What are the best predictors of achievement in a graduate education program?
6. a. This question involves a value judgment that is impossible to investigate empirically.
   b. This question as stated involves a value judgment and cannot be investigated empirically.
   c. Research cannot answer questions of value; it can only provide information on which decisions can be based.
   d. This question has been thoroughly investigated in previous research; it would not contribute to the body of knowledge.
7. a. *Independent*: having autism; *dependent*: peer interactions
   b. *Independent*: participation in school sports; *dependent*: social skills of mentally challenged adolescents
   c. *Independent*: experiencing an early intervention program or not; *dependent*: academic performance

d. *Independent*: antismoking program; *dependent*: students' attitudes toward smoking

8. What is the effect of class size in grades K–2 on students' academic performance?

9. a. Qualitative
b. Quantitative
c. Quantitative
d. Qualitative
e. Qualitative

10. Answers will vary.

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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 ex post 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	Hypothesis
Achievement motivation (McClelland, 1953) People have a tendency to strive for success and to choose goal-oriented, success/failure activities.	There is a positive relationship between achievement motivation and success in school.
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.	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.
Theory of multiple intelligences (Gardner, 1993) People have a number of separate intelligences that may vary in strength.	Teaching science concepts using a variety of approaches will result in greater achievement than when using only linguistic and mathematical approaches.
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.	Requiring middle school students who smoke to write an essay on why young people should not smoke will change their attitudes about smoking.
Vygotsky's theory of learning (1978) Cognitive development is strongly linked to input from other people.	Tutoring by more able peers will have a positive effect on the learning of at-risk students.
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).	Children from economically disadvantaged homes who are given breakfast at school will show higher achievement than similar students not given breakfast.
Behaviorism (Skinner, 1953) Behavior that is positively reinforced will increase in strength.	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.

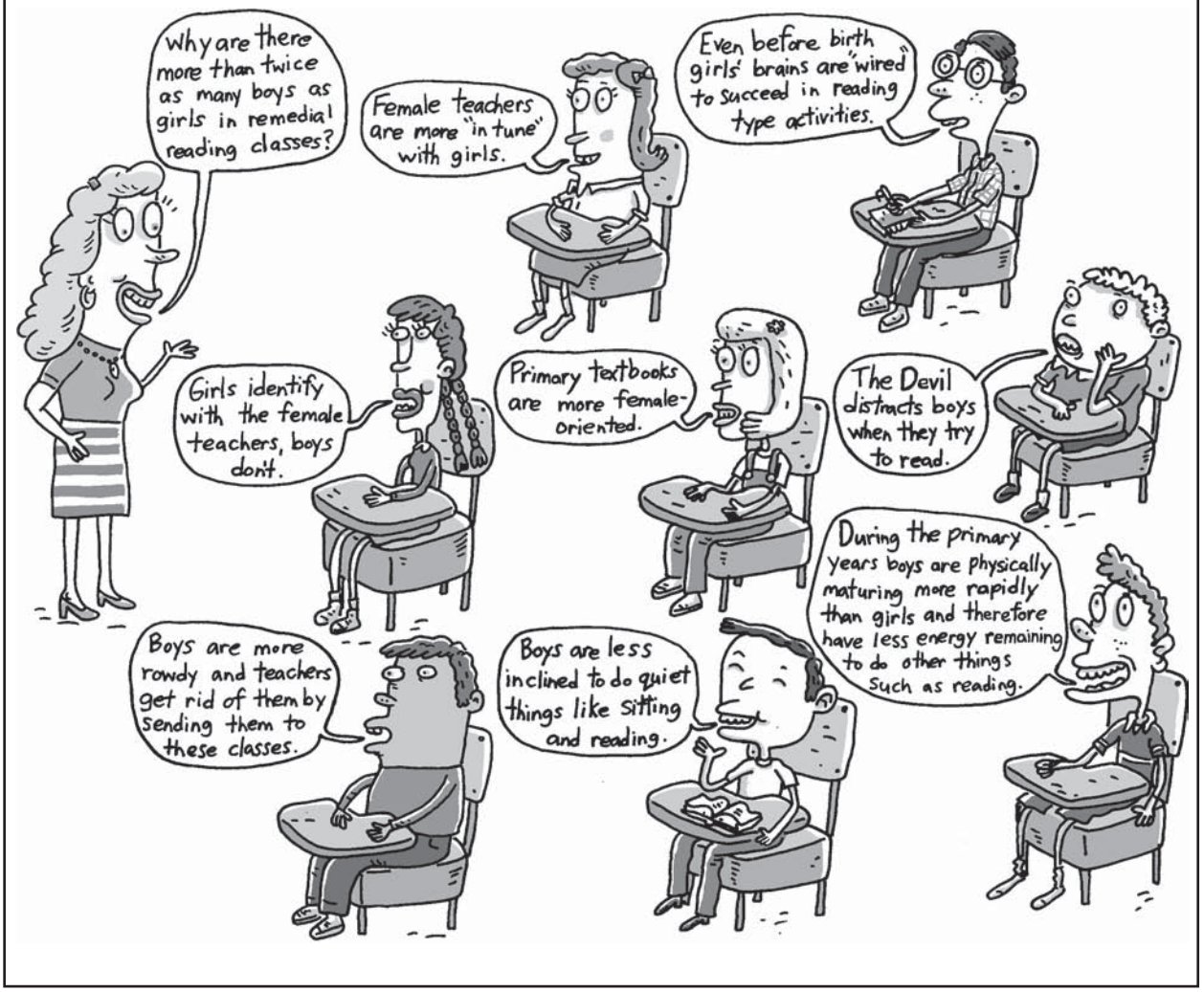
Many hypotheses—or propositions, as they may initially be stated—are essentially untestable. For instance, the hypothesis "Preschool experience promotes the all-around adjustment of the preschool child" would be difficult to test because of the difficulty of operationalizing and measuring "all-around 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.

PICTURE THIS



Joe Rocco

Think About It 5.1

Which of the explanations in the cartoon are not testable hypotheses about why there are more boys than girls in remedial reading classes?

Answer

The one about the "wiring" in the brain and the one about the devil's activities are not testable.

A HYPOTHESIS SHOULD BE CONSISTENT WITH THE EXISTING BODY OF KNOWLEDGE

Hypotheses should not contradict previously well-established knowledge. The hypothesis "My car will not start because the fluid in the battery has changed to gold" satisfies the first two criteria but is so contrary to what is known about the

nature of matter that you would not pursue it. The hypothesis "The car will not start because the fluid in the battery has evaporated to a low level" is consistent with previous knowledge and therefore is worth pursuing. It would probably be unprofitable to hypothesize an *absence* of relationship between the self-concept of adolescent boys and girls and their rate of physical growth because the preponderance of evidence supports the *presence* of such a relationship. Historians of science find that people such as Einstein, Newton, Darwin, and Copernicus developed truly revolutionary hypotheses that conflicted with what was accepted knowledge in their time. However, remember that the work of such pioneers was not really so much a denial of previous knowledge as a reorganization of existing knowledge into more satisfactory theory. In most cases, and especially for the beginning researcher, it is safe to suggest that the hypothesis should agree with knowledge already well established in the field. Again, this highlights the necessity for a thorough review of the literature so that hypotheses are formulated on the basis of previously reported research in the area.

A HYPOTHESIS SHOULD BE STATED AS SIMPLY AND CONCISELY AS POSSIBLE

A hypothesis should be presented in the form of a concise declarative statement. A complete and concisely stated hypothesis makes clear what the researcher needs to do to test it. It also provides the framework for presenting the findings of the study. If a researcher is exploring more than one relationship, he or she will need to state more than one hypothesis. The general rule is to state only one relationship in any one hypothesis. For example, if you were investigating the effect of a new teaching method on student achievement and student satisfaction, you would state two hypotheses—one for effect on achievement and one for effect on satisfaction. You need not worry about the verbal redundancy inevitable in stating multiple hypotheses. Remember that the goals of testability and clarity will be served better by more specific hypotheses.

Think About It 5.2

Which of the explanations used to explain the greater number of boys in remedial reading in the previous cartoon is not consistent with the existing body of knowledge?

Answer

The one that posits that in the primary grades boys mature more rapidly than girls. There is overwhelming evidence that at that stage girls mature more rapidly than boys. Boys finally catch up at approximately age 17 years.

The terms used in the hypothesis should be the simplest acceptable for conveying the intended meaning; avoid ambiguous or vague constructs. Use terms in the way that is generally accepted for referring to the phenomenon. When two hypotheses are of equal explanatory power, prefer the simpler one because it will provide the necessary explanation with fewer assumptions and variables to be defined. Remember that this principle of parsimony is important in evaluating hypotheses.

TYPES OF HYPOTHESES

There are three categories of hypotheses: research, null, and alternate.

THE RESEARCH HYPOTHESIS

The hypotheses we have discussed thus far are called **research hypotheses.** They are the hypotheses developed from observation, the related literature, and/or the theory described in the study. A research hypothesis states the relationship one expects to find as a result of the research. It may be a statement about the expected relationship or the expected *difference* between the variables in the study. A hypothesis about children's IQs and anxiety in the classroom could be stated "There is a positive relationship between IQ and anxiety in elementary schoolchildren" or "Children classified as having high IQs will exhibit more anxiety in the classroom than children classified as having low IQs." Research hypotheses may be stated in a **directional** or **nondirectional** form. A directional hypothesis states the direction of the predicted relationship or difference between the variables. The preceding two hypotheses about IQ and anxiety are directional. A directional hypothesis is stated when one has some basis for predicting a change in the stated direction. A nondirectional hypothesis, in contrast, states that a relationship or difference exists but without specifying the direction or nature of the expected finding—for example, "There is a relationship between IQ and anxiety in children." The literature review generally provides the basis for stating a research hypothesis as directional or nondirectional.

THE NULL HYPOTHESIS

It is impossible to test research hypotheses directly. You must first state a **null hypothesis** (symbolized H_0) and assess the probability that this null hypothesis is true. The null hypothesis is a statistical hypothesis. It is called the null hypothesis because it states that there is no relationship between the variables in the population. A null hypothesis states a negation (not the reverse) of what the experimenter expects or predicts. A researcher may hope to show that after an experimental treatment, two populations will have different means, but the null hypothesis would state that after the treatment the populations' means will *not* be different.

What is the point of the null hypothesis? A null hypothesis lets researchers assess whether apparent relationships are genuine or are likely to be a function of chance alone. It states, "The results of this study could easily have happened by chance." Statistical tests are used to determine the probability that the null hypothesis is true. If the tests indicate that observed relationships had only a slight probability of occurring by chance, the null hypothesis becomes an unlikely explanation and the researcher rejects it. Researchers aim to reject the null hypothesis as they try to show there *is* a relationship between the variables of the study. Testing a null hypothesis is analogous to the prosecutor's work in a criminal trial. To establish guilt, the prosecutor (in the U.S. legal system) must provide sufficient evidence to enable a jury to reject the presumption of innocence beyond reasonable doubt. It is not possible for a prosecutor to prove guilt conclusively, nor can a researcher obtain unequivocal support for a research hypothesis. The defendant is presumed innocent until sufficient evidence indicates that he or she is not, and the null hypothesis is presumed true until sufficient evidence indicates otherwise.

For example, you might start with the expectation that children will exhibit greater mastery of mathematical concepts through individual instruction than through group instruction. In other words, you are positing a relationship between the independent variable (method of instruction) and the dependent variable (mastery of mathematical concepts). The research hypothesis is "Students taught through individual instruction will exhibit greater mastery of mathematical concepts than students taught through group instruction." The null hypothesis, the statement of no relationship between variables, will read "The mean mastery scores (population mean μ_i) of all students taught by individual instruction will equal the mean mastery scores (population mean μ_g) of all those taught by group instruction." H_0: $\mu_i = \mu_g$.*

THE ALTERNATIVE HYPOTHESIS

Note that the hypothesis "Children taught by individual instruction will exhibit less mastery of mathematical concepts than those taught by group instruction" posits a relationship between variables and therefore is *not* a null hypothesis. It is an example of an **alternative hypothesis.**

In the example, if the sample mean of the measure of mastery of mathematical concepts is higher for the individual instruction students than for the group instruction students, and inferential statistics indicate that the null hypothesis is unlikely to be true, you reject the null hypothesis and tentatively conclude that individual instruction results in greater mastery of mathematical concepts than does group instruction. If, in contrast, the mean for the group instruction students is higher than the mean for the individual instruction students, and inferential statistics indicate that this difference is not likely to be a function of chance, then you tentatively conclude that group instruction is superior.

If inferential statistics indicate that observed differences between the means of the two instructional groups could easily be a function of chance, the null hypothesis is retained, and you decide that insufficient evidence exists for concluding there is a relationship between the dependent and independent variables. The retention of a null hypothesis is *not* positive evidence that the null hypothesis is true. It indicates that the evidence is insufficient and that the null hypothesis, the research hypothesis, and the alternative hypothesis are all possible.

TESTING THE HYPOTHESIS

A quantitative study begins with a research hypothesis, which should be a simple, clear statement of the expected relationship between the variables. Previously, we explained that hypotheses must be testable—that is, amenable to empirical verification. When researchers speak of testing a hypothesis, however, they are referring to the null hypothesis. Only the null hypothesis can be directly tested by statistical procedures. **Hypothesis testing** involves the following steps:

1. State, in operational terms, the relationships that should be observed if the research hypothesis is true.
2. State the null hypothesis.

*The Greek letter mu, μ, is used to symbolize population mean.

3. Select a research method that will enable the hypothesized relationship to be observed if it is there.
4. Gather the empirical data and select and calculate appropriate descriptive statistics for these data (see Chapter 6).
5. Calculate inferential statistics to determine the probability that your obtained results could have occurred by chance when the null hypothesis is true (see Chapter 7).
6. If the probability of the observed findings being due to chance is very small (e.g., only 1 in 100 chances), one would have sufficient evidence to reject the null hypothesis.

Many hypotheses that are formulated are rejected after empirical testing. Their predictions are not supported by the data. Many beginning researchers believe that if the data they collect do not support their hypothesis, then their study is a failure. This is not the case. In the history of scientific research, hypotheses that failed to be supported have greatly outnumbered those that have been supported. Experienced researchers realize that unconfirmed hypotheses are an expected and useful part of the scientific experience. They can lead to reconsideration or revision of theory and the generation of new hypotheses, which often brings science closer to a correct explanation of the state of affairs. Darwin (1887/2007) wrote,

> I have steadily endeavored to keep my mind free so as to give up any hypothesis, however much beloved (and I cannot resist forming one on every subject), as soon as facts are shown to be opposed to it. Indeed, I have had no choice but to act in this manner, for with the exception of the Coral Reefs, I cannot remember a single first-formed hypothesis which had not after a time to be given up or greatly modified. (p. 293)

Although you may find support for a hypothesis, the hypothesis is not *proved* to be true. A hypothesis is never proved or disproved; it is only supported or not supported. Hypotheses are essentially probabilistic in nature; empirical evidence can lead you to conclude that the explanation is probably true or that it is reasonable to accept the hypothesis, but it never proves the hypothesis.

CLASSROOM EXAMPLE OF TESTING A HYPOTHESIS

A teacher is interested in investigating reinforcement theory in the classroom. From her understanding of reinforcement theory, this teacher hypothesizes that teachers' positive comments on students' papers will lead to greater achievement.

Step 1. The deduced implication is stated as follows: "Teachers' positive comments on students' papers during a specified unit will result in higher scores on the end-of-unit test for those students, compared with students who received no comments." It is the relationship between the two variables—teachers' positive comments and pupil performance on the end-of-unit test—that will be investigated.

Step 2. For statistical testing, the research hypothesis must be transformed into a null hypothesis: "The population mean achievement score for students receiving positive comments (experimental group) will be the same as the population mean achievement score for students receiving no comments (control group)."

Step 3. After getting permission from parents or guardians for the children to participate, the teacher would select students to be randomly assigned to the experimental and control groups. For those students in the experimental group, she would write positive comments on their papers, whereas the students assigned to the control group would receive no comments. The comments to the experimental group should simply be words of encouragement, such as "Excellent," "Keep up the good work," or "You're doing better." These comments should have nothing to do with content or the correction of particular errors; otherwise, any improvement could be attributed to the instructional usefulness of such comments.

Step 4. After completing the specified unit, the teacher would administer a common end-of-unit test to both groups and derive average (mean) achievement scores on the test for each group.

Step 5. Inferential statistics can then be used to indicate whether any difference in mean achievement scores is real or is likely to be merely a function of chance. If the difference is not likely to be a function of chance, the researcher tentatively concludes that it results from the different treatments given to the two groups.

THE QUANTITATIVE RESEARCH PLAN

After identifying a worthwhile problem and stating the expected outcome in the form of a research hypothesis, you are ready to develop a tentative **research plan.** The research plan at this stage is only a preliminary proposal; many changes will probably be needed before the final, formal proposal is written. Developing this tentative research plan is essential because it forces you to set down ideas in a concrete form. Many initial ideas seem promising until you must spell them out in black and white; then the difficulties or the inadequacies become obvious.

Another advantage of a written plan is that you can give it to others for their comments and criticism. In a research methods class, for example, the professor would certainly need to see what research students are planning. The director of a thesis or dissertation would want to see a written plan rather early in the process. It is much easier for another person to detect flaws and problems in a proposal that is written out than in one communicated orally. Another point to keep in mind is that the more complete and detailed the initial proposal, the more useful it will be to the researcher and the more time may be saved later.

A research plan should include the following elements: the problem, the hypothesis, the research methodology, and proposed data analysis. The following list briefly describes each component:

1. *Problem*. The plan begins with a clear statement of the research problem. A quantitative problem asks about the relationship between specified variables. Include the rationale for the study and a brief description of the background of the problem in theory and/or related research.
2. *Hypothesis*. A quantitative question is followed by a concise statement of the research hypothesis. Provide operational definitions of the variables.

3. *Methodology*. This section explains how you will conduct the study. Include the proposed research design, the population of concern, the sampling procedure, the measuring instruments, and any other information relevant to the conduct of the study.
4. *Data analysis*. Indicate how you will analyze the data to test the hypothesis and/or answer the research question. Beginning quantitative researchers may find it difficult to write this section because they are not yet familiar with statistics. You might look at the related literature to determine what type of statistical analysis other researchers used, or you might consult with your professor or an expert in statistics.

Think About It 5.3

State a hypothesis to test the notion that teachers assign rowdy students to remedial reading classes to get rid of them. State the null hypothesis and list the steps for testing it.

Answer

1. Research hypothesis: Students assessed as rowdy on a behavioral assessment scale are more often assigned to remedial reading classes than are nonrowdy students with equivalent reading skills as measured on the California Achievement Test.
2. Null hypothesis: Rowdy and nonrowdy students with the same reading skills are equally likely to be assigned to remedial reading classes.
3. Administer the Reading subtest of the California Achievement Test to all students. Match students in remedial reading classes with students with the same reading skills who are in regular classes. Use a behavioral assessment scale to identify which students are rowdy and which are not.
4. Calculate the proportion of rowdy and nonrowdy students in remedial reading classes and the proportion of rowdy and nonrowdy students in regular classes.
5. Test the null hypothesis by using a statistical test to determine if the difference in the proportions could easily be a function of chance alone.

THE PILOT STUDY

After the tentative research plan is approved, it may be helpful to try out the proposed procedures on a few participants. This trial run, or **pilot study,** will help the researcher to decide whether the study is feasible and whether it is worthwhile to continue. At this point, one can ask a colleague to check one's procedures for any obvious flaws. The pilot study provides the opportunity to assess the appropriateness of the data-collection methods and other procedures and to make changes if necessary. It also permits a preliminary testing of the hypothesis, which may give some indication of its tenability and suggest whether further refinement is needed.

Unanticipated problems that appear can be solved at this stage, thereby saving time and effort later. A pilot study is well worth the time required and is especially recommended for the beginning researcher.

SUMMARY

To proceed with the confirmatory phase of a quantitative research study, it is important to have one or more clearly stated hypotheses. The hypothesis is a powerful tool in scientific inquiry. It enables researchers to relate theory to observation and observation to theory. Hypotheses enable researchers, in the search for knowledge, to employ both the ideas of the inductive philosophers, with their emphasis on observation, and the logic of the deductive philosophers, with their emphasis on reason.

The hypothesis is the researcher's prediction about the outcome of the study. Hypotheses are derived inductively from observation or deductively from a known theory. Experience and knowledge in an area and familiarity with previous research are important factors in formulating a satisfactory hypothesis.

The hypothesis serves multiple functions in research. It provides direction to the researcher's efforts because it determines the research method and the type of data relevant to the solution of the problem. It also provides a framework for interpreting the results and for stating the conclusions of the study.

A good hypothesis must satisfy certain criteria. It must be testable, which means that it is possible to gather evidence that will either support or fail to support the hypothesis. It must agree with the preponderance of existing data. It must be stated as clearly and concisely as possible. Also, it must state the expected relationship between variables that can be measured.

Once formulated and evaluated in terms of these criteria, the research hypothesis is ready to be subjected to an empirical test. The researcher also states a null hypothesis—the negation of what the researcher expects—which is important in the statistical analysis of the findings. It is important to remember that a research hypothesis cannot be proved or disproved, only supported or not supported. Even if it is not supported, a hypothesis may still serve a useful purpose because it can lead the researcher to reevaluate rationale and procedures and to consider other approaches to the problem.

KEY CONCEPTS

alternative hypothesis
deductive hypothesis
directional hypothesis
hypothesis
hypothesis testing
inductive hypothesis
nondirectional hypothesis
null hypothesis
operational definition
pilot study
purposes of hypotheses
research hypothesis
research plan
testable hypotheses
theory

EXERCISES

1. What are the purposes of the hypothesis in research?
2. What is the difference between an inductive and a deductive hypothesis?
3. State a hypothesis based on each of the following research questions:
   - **a.** What would be the effect of using the Cuisenaire method in teaching elementary arithmetic?
   - **b.** Is there a relationship between the gender of the tutor and the gains made in reading achievement by black male elementary students?
   - **c.** Does living in interracial housing affect attitudes toward members of another race?
   - **d.** Is there any relationship between the type of reinforcement (tangible or intangible) and the amount of learning achieved by socioeconomically disadvantaged children?
   - **e.** Does preschool experience reduce the educational gap separating advantaged and disadvantaged children before they enter first grade?
   - **f.** Do teacher expectations of children's intellectual performance have any effect on the children's actual performance?
4. Rewrite the following hypothesis in null form: "Children who read below grade level

will express less satisfaction with school than those who read at or above grade level."

5. Evaluate the adequacy of each of the following hypotheses. If a hypothesis is inadequate, state the reason for the inadequacy and write an adequate hypothesis.
   - **a.** "Teachers deserve higher pay than administrators."
   - **b.** "Students who take a middle school government course will be capable of more enlightened judgments concerning local political affairs than will those who do not take the course."
   - **c.** "Computer-based drill and practice is a better way to teach slow learners multiplication combinations than is flash cards."
   - **d.** "If students differ in their socioeconomic status, they will differ in their English proficiency scores."
   - **e.** "Children who show high achievement motivation will show high anxiety as measured by the Children's Manifest Anxiety Scale."
   - **f.** "Positive verbal reinforcement of student responses by the teacher will lessen the probability of future responses."
6. Write a directional and a nondirectional hypothesis based on the research question "What is the relationship between the rate of maturation of adolescent boys and their self-concepts?"
7. Why should a hypothesis be clearly stated before a quantitative research study is initiated?
8. Label the following hypotheses as research hypotheses or null hypotheses:
   - **a.** "Students will receive lower scores on achievement tests that measure the higher levels of Bloom's taxonomy than on tests measuring lower levels of Bloom's taxonomy.
   - **b.** "There is no difference in the performance of students taught mathematics by method A and those taught mathematics by method B."
   - **c.** "The mean retention scores of children receiving experimental drug X will not differ from the scores of children who do not receive drug X."
   - **d.** "Students taught by laissez-faire teachers will show higher problem-solving skills than students taught by highly structured teachers."
9. Locate a research study stating a hypothesis and try to identify the theory from which the hypothesis originated.
10. Evaluate the following statements as possible research hypotheses:
    - **a.** "Asian high school students are better in mathematics than American high school students."
    - **b.** "Do SAT prep courses improve students' scores on the SAT?"
    - **c.** "Students who participate in the high school volunteerism program become better adult citizens than students who do not."
11. A researcher has a theory about children's ordinal position in the family and their achievement motivation. Write a research hypothesis and a hypothesis in null form.
12. Formulate a tentative research plan for your class project.
    - **a.** What is the general research problem under consideration for investigation?
    - **b.** State the preceding general research problem as a research question.
    - **c.** Explain the rationale for such a study. What are its theoretical or practical applications?
    - **d.** State the hypothesis (or hypotheses) for this study.
    - **e.** Was this hypothesis derived deductively from theory or inductively from experience and observation? Explain.
    - **f.** Identify the variables in the study and operationally define each.
    - **g.** What kind of research methodology will be required for this study?
    - **h.** What subjects (sample) will you select for the study?
    - **i.** Have you located any published research related to your problem? If so, briefly summarize the findings.
13. Which of the following evidence contributes to the development of a theory?
    - **a.** Evidence that supports a hypothesis
    - **b.** Evidence that contradicts a hypothesis
    - **c.** Both of the above
14. Select a theory that you find interesting and derive a research hypothesis from this theory. You might choose a learning theory, motivational theory, theory of cognitive dissonance, or any other educational or psychological theory.

ANSWERS

1. The purposes of hypotheses are to provide a tentative proposition suggested as a solution to a problem or as an explanation of some phenomenon, stimulate research, provide a relational statement that is directly testable, and provide direction for research.
2. With an inductive hypothesis, the researcher makes observations of relationships and then hypothesizes an explanation for the observed behavior. With a deductive hypothesis, the researcher formulates a hypothesis based on known theory, accompanied by a rationale for the particular proposition.
3. **a.** "Elementary students taught by the Cuisenaire method will score higher on an arithmetic test than students taught by an alternative method."
   b. "Black male elementary students tutored by another male will achieve higher reading scores than will black male elementary students tutored by a female."
   c. "People living in interracial housing will express more favorable attitudes toward those of another race than will people living in segregated housing."
   d. "Socioeconomically disadvantaged children reinforced with tangible rewards will exhibit greater learning achievement than will children reinforced with intangible rewards."
   e. "Advantaged and disadvantaged children of preschool age receiving preschool training will be separated by a smaller educational gap than will advantaged and disadvantaged children of preschool age not receiving preschool training." (*Note*: The terms advantaged and disadvantaged children, preschool training, and educational gap would need to be defined.)
   f. "Children whose teachers have high expectations of their intellectual performance will perform at a higher level than will children whose teachers have low expectations of their intellectual performance."
4. There is no difference in the satisfaction with school expressed by children who read below grade level and children who read at or above grade level.
5. **a.** The hypothesis is inadequate because it is a value statement and cannot be investigated in a research study. A legitimate hypothesis would be "Teachers who receive higher pay than their administrators will express greater job satisfaction than will teachers who do not receive higher pay than their administrators."
   b. The hypothesis is inadequate because enlightened judgments is a value term. An acceptable hypothesis would be "Students who take a middle school government course will evidence more knowledge concerning local political affairs, and will more often arrive at inferences based on this knowledge, than will students who do not take a middle school government course."
   c. The hypothesis is inadequate because *better* is a value term and because it lacks clear and concise operational definitions. A testable hypothesis would be "Those students performing below grade level in math who practice multiplication combinations through computer drill and practice will, on average, score a higher proportion of correct answers on a criterion test than will students performing below grade level who spend the same amount of time practicing multiplication combinations with flash cards."
   d. The hypothesis is inadequate because there is no statement of an expected relationship between variables. An acceptable hypothesis would be "Students classified as having high socioeconomic status will have higher scores on an English proficiency test than will students classified as having low socioeconomic status."
   e. The hypothesis is inadequate because there are no independent or dependent variables. An acceptable hypothesis would be "Children who show high achievement motivation will have higher scores on the Children's Manifest Anxiety Scale than children with low achievement motivation."
   f. The hypothesis is inadequate because it is inconsistent with the existing knowledge of positive reinforcement and its effect on student responses.

6. *Directional hypothesis*: "Early maturing boys will exhibit more positive self-concepts than late-maturing boys." *Nondirectional hypothesis*: "There is a difference in the self-concepts of early and late-maturing adolescent boys."
7. The hypothesis gives direction to the collection and interpretation of data. Clearly stating the hypothesis reveals flaws that were not apparent while developing the vague idea of the study in mind.
8. **a.** Research
   b. Null
   c. Null
   d. Research
9. Answers will vary.
10. **a.** "Better in math" needs to be operationally defined.
    b. A hypothesis should not be stated in question form.
    c. It is not testable as stated. How would you define and measure "better adult citizens"?
11. *Research hypothesis*: "Achievement motivation and ordinal birth position in the family are positively related; or first-born children have greater achievement motivation than their siblings." *Null hypothesis*: "There is no relationship between children's birth position in the family and their achievement motivation."
12. Answers will vary.
13. c
14. Answers will vary.

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