Chapter 1 The Nature and Tools of Research

In virtually every subject area, our collective knowledge about the world is incomplete: Certain questions remain unanswered, and certain problems remain unsolved. Systematic research provides many powerful tools—not only physical tools but also mental and social tools—that can help us discover possible answers and identify possible solutions.

Learning Outcomes

1.1 Distinguish between (a) common uses of the term *research* that reflect misconceptions about what research involves and (b) the true nature of research in academic settings.

1.2 Describe the iterative, cyclical nature of research, including the steps that a genuine research project involves.

1.3 Distinguish among positivism, postpositivism, constructivism, and pragmatism/realism as philosophical underpinnings of a research project.

1.4 Identify examples of how six general research tools can play significant roles in a research project: (a) the library and its resources, (b) computer technology, (c) measurement, (d) statistics, (e) language, and (f) the human mind.

1.5 Describe steps you might take to explore research in your field.

In everyday speech, the word *research* is often used loosely to refer to a variety of activities. In some situations the word connotes simply finding a piece of information or taking notes and then writing a so-called "research paper." In other situations it refers to the act of informing oneself about what one does not know, perhaps by rummaging through available sources to locate a few tidbits of information. Such uses of the term can create considerable confusion for university students, who must learn to use it in a narrower, more precise sense.

Yet when used in its true sense—as a systematic process that leads to new knowledge and understandings—the word *research* can suggest a mystical activity that is somehow removed from everyday life. Many people imagine researchers to be aloof individuals who seclude themselves in laboratories, scholarly libraries, or the ivory towers of large universities. In fact, research is often a practical enterprise that—given appropriate tools—*any* rational, conscientious individual can conduct. In this chapter we lay out the nature of true research and describe general tools that make it possible.

WHAT RESEARCH IS NOT

Following are three statements that describe what research is not. Accompanying each statement is an example that illustrates a common misconception about research.

1. ***Research is not merely gathering information.*** A sixth-grader comes home from school and tells her parents, "The teacher sent us to the library today to do research,

and I learned a lot about black holes." For this student, research means going to the library to find a few facts. This might be *information discovery,* or it might be learning *reference skills.* But it certainly is not, as the teacher labeled it, research.

2. ***Research is not merely rummaging around for hard-to-locate information.*** The house across the street is for sale. You consider buying it and call your realtor to find out how much someone else might pay you for your current home. "I'll have to do some research to determine the fair market value of your property," the realtor tells you. What the realtor calls doing "some research" means, of course, reviewing information about recent sales of properties comparable to yours; this information will help the realtor zero in on a reasonable asking price for your own home. Such an activity involves little more than searching through various files or websites to discover what the realtor previously did not know. Rummaging—whether through records in one's own office, at a library, or on the Internet—is not research. It is more accurately called an *exercise in self-enlightenment.*

3. ***Research is not merely transporting facts from one location to another.*** A college student reads several articles about the mysterious Dark Lady in William Shakespeare's sonnets and then writes a "research paper" describing various scholars' suggestions of who the lady might have been. Although the student does, indeed, go through certain activities associated with formal research—such as collecting information, organizing it in a certain way for presentation to others, supporting statements with documentation, and referencing statements properly—these activities do not add up to true research. The student has missed the essence of research: the *interpretation* of data. Nowhere in the paper does the student say, in effect, "These facts I have gathered seem to indicate such-and-such about the Dark Lady." Nowhere does the student interpret and draw conclusions from the facts. This student is approaching genuine research; however, the mere compilation of facts, presented with reference citations and arranged in a logical sequence—no matter how polished and appealing the format—misses genuine research by a hair. Such activity might more realistically be called *fact transcription, fact documentation, fact organization,* or *fact summarization.*

Going a little further, this student would have traveled from one world to another: from the world of mere transportation of facts to the world of interpretation of facts. The difference between the two worlds is the distinction between transference of information and genuine research—a distinction that is critical for novice researchers to understand.

MyLab Education **Self-Check 1.1**

WHAT RESEARCH IS

Research is a systematic process of collecting, analyzing, and interpreting information—*data*—in order to increase our understanding of a phenomenon about which we are interested or concerned.[1] People often use a systematic approach when they collect and interpret information to solve the small problems of daily living. Here, however, we focus on *formal*

[1]Some people in academia use the term *research* more broadly to include deriving new equations or abstract principles from existing equations or principles through a sequence of mathematically logical and valid steps. Such an activity can be quite intellectually challenging, of course, and is often at the heart of doctoral dissertations and scholarly journal articles in mathematics, physics, and related disciplines. In this book, however, we use the term *research* more narrowly to refer to *empirical* research—research that involves the collection and analysis of new data.

FIGURE 1.1 ■ The Research Cycle

research, research in which we intentionally set out to enhance our understanding of a phenomenon and expect to communicate what we discover to the larger scientific community.

Although research projects vary in complexity and duration, research generally involves seven distinct steps, shown in Figure 1.1. We now look at each of these steps more closely.

1. ***The researcher begins with a problem—an unanswered question—related to a topic of interest and concern.*** The impetus for all good research is a desire to acquire new information that advances our collective understandings of physical, biological, social, or psychological phenomena. At a minimum, good researchers are *curious* researchers: They genuinely want to learn more about a particular topic. Many of them are also motivated to identify possible solutions to local, regional, or global problems—solutions that might either directly or indirectly enhance the well-being of humankind or of the physical, biological, and social environments in which we live.

As you think about your topic of interest, consider these questions: What is such-and-such a situation like? Why does such-and-such a phenomenon occur? Might such-and-such an intervention alter the current state of affairs? What does it all mean? With questions like these, research begins.

2. ***The researcher clearly and specifically articulates the goal of the research endeavor.*** A critical next step is to pin down the issue or question—which we will refer to as the research problem—that the researcher will address. The ultimate goal of the research must be set forth in a grammatically complete sentence that specifically and precisely identifies the question the researcher will try to answer. When you describe your objective in clear, concrete terms, you have a good idea of what you need to accomplish and can direct your efforts accordingly.

3. ***The researcher often divides the principal problem into more manageable subproblems.*** From a design standpoint, it is often helpful to break a main research problem into several subproblems that, when solved, can possibly resolve the main problem.

Breaking down principal problems into small, easily solvable subproblems is a strategy we use in everyday living. For example, suppose you want to drive from your hometown to a town many miles or kilometers away. Your principal goal is to get from one location to the other as expeditiously as possible. You soon realize, however, that the problem involves several subproblems:

Main problem:	How do I get from Town A to Town B?
Subproblems:	1. What route appears to be the most direct one?
	2. Is the most direct one also the quickest one? If not, what route might take the least amount of time?
	3. Which is more important to me: minimizing my travel time or minimizing my energy consumption?
	4. At what critical junctions in my chosen route must I turn right or left?

Thus, what initially appears to be a single question can be divided into several smaller questions that must be addressed before the principal question can be resolved.

So it is with most research problems. By closely inspecting the principal problem, the researcher often uncovers important subproblems. By addressing each of the subproblems, the researcher can more easily address the main problem. If a researcher doesn't take the time or trouble to isolate the lesser problems within the major problem, the overall research project can become cumbersome and difficult to manage.

Identifying and clearly articulating the problem and its subproblems are the essential starting points for formal research. Accordingly, we discuss these processes in depth in Chapter 2.

4. ***The researcher identifies general assumptions—and possibly also specific hypotheses—that underlie the research effort.*** An assumption is a condition that is taken for granted, without which the research project would be pointless. For example, imagine that your problem is to investigate whether students learn the unique grammatical structures of a language more quickly by studying only one foreign language at a time or by studying two foreign languages concurrently. What assumptions would underlie such a problem? At a minimum, you must assume that

- The teachers used in the study are competent to teach the language or languages in question and have mastered the grammatical structures of the language(s) they are teaching.
- The students taking part in the research are capable of mastering the unique grammatical structures of any language(s) they are studying.
- The languages selected for the study have sufficiently different grammatical structures that students might reasonably learn to distinguish between them.

Aside from such basic ideas as these, however, careful researchers state their assumptions, so that other people inspecting the research project can evaluate it in accordance with *their own* assumptions. For instance, a researcher might assume that

- Participants' responses in a paper-and-pencil questionnaire, face-to-face interview, or online survey are reasonably accurate indicators of their actual behaviors or opinions.
- Behaviors observed in an artificial laboratory environment can effectively reveal how people or other animal species are likely to behave in more natural, real-world settings.
- Certain assessment instruments (e.g., widely used intelligence tests, personality tests, and interest inventories) reflect relatively stable personal characteristics that are unlikely to change very much in the near future. (We examine this issue in detail in the discussion of *validity* of assessment instruments in Chapter 4.)

As you will discover in upcoming chapters, researchers can sometimes support such assumptions by citing past research findings or collecting certain kinds of data within their own research projects.

In addition to stating basic assumptions, many researchers form one or more hypotheses about what they might discover. A *hypothesis* is a logical supposition, a reasonable guess, an educated conjecture. In formal research, it might be more specifically called a research hypothesis, in that it provides a tentative explanation for a phenomenon under investigation. It may direct your thinking to possible sources of information that will aid in resolving one or more subproblems and, as a result, may also help you resolve the principal research problem. When one or more research hypotheses are proposed prior to any data collection, they are known as *a priori* hypotheses—a term whose Latin roots mean "from something before."

Hypotheses are certainly not unique to research. In your everyday life, if something happens, you immediately try to account for its cause by making some reasonable conjectures. For example, imagine that you come home after dark, open your front door, and reach inside for the switch that turns on a nearby table lamp. Your fingers find the switch. You flip it. No light. At this point, you identify several hypotheses regarding the lamp's failure:

Hypothesis 1: A recent storm has disrupted your access to electrical power.
Hypothesis 2: The bulb has burned out.
Hypothesis 3: The lamp isn't securely plugged into the wall outlet.
Hypothesis 4: The wire from the lamp to the wall outlet is defective.
Hypothesis 5: You forgot to pay your electric bill.

Each of these hypotheses hints at a strategy for acquiring information that may resolve the nonfunctioning-lamp problem. For instance, to test Hypothesis 1, you might look outside to see whether your neighbors have lights, and to test Hypothesis 2, you might replace the current light bulb with a new one.

Hypotheses in a research project are as tentative as those for a nonfunctioning table lamp. For example, a biologist might speculate that certain human-made chemical compounds increase the frequency of birth defects in frogs. A psychologist might speculate that certain personality traits lead people to show predominantly liberal or conservative voting patterns. A marketing researcher might speculate that humor in a television commercial will capture viewers' attention and thereby will increase the odds that viewers buy the advertised product. Notice the word *speculate* in all of these examples. Good researchers always begin a project with open minds about what they may—or may *not*—discover in their data.

Hypotheses—predictions—are an essential ingredient in certain kinds of research, especially experimental research (see Chapter 7). To a lesser degree, they might guide other forms of research as well, but they are intentionally *not* identified in the early stages of some kinds of qualitative research (e.g., see the discussion of grounded theory studies in Chapter 8).

5. ***The researcher develops a specific plan for addressing the problem and its subproblems.*** Research is not a blind excursion into the unknown, with the hope that

the data necessary to address the research problem will magically emerge. It is, instead, a carefully planned itinerary of the route you intend to take in order to reach your final destination—your research goal. Consider the title of this text: *Practical Research: Planning and Design.* The last three words—*Planning and Design*—are especially important ones. Researchers plan their overall research design and specific research methods in a purposeful way so that they can acquire data relevant to their research problem and subproblems. Depending on the research question, different designs and methods are more or less appropriate.

In the formative stages of a research project, much can be decided: Are any existing data directly relevant to the research problem? If so, where are they, and are you likely to have access to them? If the needed data *don't* currently exist, how might you generate them? And later, after you have acquired the data you need, what will you do with them? Such questions merely hint at the fact that planning and design cannot be postponed. Each of the questions just listed—and many more—must have an answer early in the research process. In Chapter 4, we discuss several general issues related to research planning. Then, beginning in Chapter 6, we describe strategies related to various research methodologies.

You should note here that we are using the word *data* as a plural noun; for instance, we ask "Where *are* the data?" rather than "Where *is* the data?" Contrary to popular usage of the term as a singular noun, *data* (which has its origins in Latin) refers to two or more pieces of information. A single piece of information is known as a *datum,* or sometimes as a *data point.*

6. ***The researcher collects, organizes, and analyzes data related to the problem and its subproblems.*** After a researcher has isolated the problem, divided it into appropriate subproblems, identified assumptions (and possibly also *a priori* hypotheses), and chosen a suitable design and methodology, the next step is to collect whatever data might be relevant to the problem and organize and analyze those data in meaningful ways.

The data collected in research studies take one or both of two general forms. Quantitative research involves looking at amounts, or *quantities,* of one or more variables of interest. A quantitative researcher tries to measure variables in some numerical way, perhaps by using commonly accepted measures of the physical world (e.g., rulers, thermometers, oscilloscopes) or carefully designed measures of psychological characteristics or behaviors (e.g., tests, questionnaires, rating scales).

In contrast, qualitative research involves looking at characteristics, or *qualities,* that cannot be entirely reduced to numerical values. A qualitative researcher typically aims to examine the many nuances and complexities of a particular phenomenon. You are most likely to see qualitative research in studies of complex human situations (e.g., people's in-depth perspectives about a particular issue, the behaviors and values of a particular cultural group) or complex human creations (e.g., television commercials, works of art). Qualitative research isn't limited to research problems involving human beings, however. For instance, some biologists study, in a distinctly qualitative manner, the complex social behaviors of other animal species; Dian Fossey's work with gorillas and Jane Goodall's studies of chimpanzees are two well-known examples (e.g., see Fossey, 1983; Goodall, 1986).

The two kinds of data—quantitative and qualitative—often require distinctly different research methods and data analysis strategies. Accordingly, three of the book's subsequent chapters focus predominantly on quantitative techniques (see Chapters 6, 7, and 11), and two others focus almost exclusively on qualitative techniques (see Chapters 8 and 12). Nevertheless, we urge you *not* to think of the quantitative–qualitative distinction as a mutually exclusive, *it-has-to-be-one-thing-or-the-other* dichotomy. Many researchers collect both quantitative and qualitative data in a single research project—an approach sometimes known as mixed-methods research (see Chapter 9). And in action research, one or more researchers—who are often practitioners in a particular helping profession (e.g., education, counseling, social work, medicine)—might use both quantitative and qualitative methods in an effort to improve current practices and desired outcomes (see Chapter 10). Good researchers tend to be *eclectic* researchers who draw from diverse methodologies and data sources in order to best address their research problems and questions (e.g., see Gorard, 2010; Lather, 2006; Onwuegbuzie & Leech, 2005).

7. ***The researcher interprets the meaning of the data as they relate to the problem and its subproblems.*** Quantitative and qualitative data are, in and of themselves, *only* data—nothing more. The significance of the data depends on how the researcher extracts *meaning* from them. In research, uninterpreted data are worthless: They can never help us answer the questions we have posed.

Yet researchers must recognize and come to terms with the subjective and dynamic nature of interpretation. Consider, for example, the many books written on the assassination of U.S. President John F. Kennedy. Different historians have studied the same events: One may interpret them one way, and another may arrive at a very different conclusion. Which one is right? Perhaps they both are; perhaps neither is. Both may have merely posed new problems for other historians to try to resolve. Different minds often find different meanings in the same set of facts.

Once we believed that clocks measured time and that yardsticks measured space. In one sense, they still do. We further assumed that time and space were two different entities. Then along came Einstein's theory of relativity, and time and space became locked into one concept: the time–space continuum. What's the difference between the old perspective and the new one? It's the way we think about, or interpret, the same information. The realities of time and space have not changed; the way we interpret them has.

Data demand interpretation. But no rule, formula, or algorithm can lead the researcher unerringly to a correct interpretation. Interpretation is inevitably a somewhat subjective process that depends on the researcher's assumptions, hypotheses, and logical reasoning processes.

Now think about how we began this chapter. We suggested that certain activities cannot accurately be called research. At this point you can understand why. None of those activities demands that the researcher draw any conclusions or make any interpretations of the data.

We must emphasize two important points related to the seven-step process just described. First, *the process is* ***iterative:*** A researcher sometimes needs to move back and forth between two or more steps along the way. For example, while developing a specific plan for a project (Step 5), a researcher might realize that a genuine resolution of the research problem requires addressing a subproblem not previously identified (Step 3). And while interpreting the collected data (Step 7), a researcher may decide that additional data are needed to fully resolve the problem (Step 6).

Second, *the process is* ***cyclical.*** The final step in the process depicted in Figure 1.1—interpretation of the data—is not *really* the final step at all. Only rarely is a research project a one-shot effort that completely resolves a problem; more often, it is likely to unearth new questions related to the issue at hand. And if specific hypotheses have been put forth, either *a priori* or after data have been collected and analyzed, those hypotheses are rarely proved or disproved beyond a shadow of a doubt. Instead, they are either *supported* or *not supported* by the data. If the data are consistent with a particular hypothesis, the researcher can make a case that the hypothesis probably has some merit and should be taken seriously. In contrast, if the data run contrary to a hypothesis, the researcher *rejects* the hypothesis and might turn to other hypotheses as being more likely explanations of the phenomenon in question. In any of these situations, one or more additional, follow-up studies are called for.

Ultimately, then, most research studies don't bring total closure to a research problem. There is no obvious end point—no point at which a researcher can say "*Voila!* I've completely answered the question about which I'm concerned." Instead, research typically involves a cycle—or more accurately, a *helix* (spiral)—in which one study spawns additional, follow-up studies. In exploring a topic, one comes across additional problems that need resolving, and so the process must begin anew. Research begets more research.

To view research in this way is to invest it with a dynamic quality that is its true nature—a far cry from the conventional view, which sees research as a one-time undertaking that is static, self-contained, an end in itself. Here we see another difference between true research and the nonexamples of research presented earlier in the chapter. Every researcher soon learns that genuine research is likely to yield as many problems as it resolves. Such is the nature of the acquisition of knowledge.

MyLab Education **Self-Check 1.2**
MyLab Education **Application Exercise 1.1:** Identifying Hypotheses and Assumptions

PHILOSOPHICAL ASSUMPTIONS UNDERLYING RESEARCH METHODOLOGIES

Let's return to Step 4 in the research process: *The researcher identifies assumptions—and possibly also hypotheses—that underlie the research effort.* The assumptions underlying a research project are sometimes so seemingly self-evident that a researcher may think it unnecessary to mention them. In fact, the researcher may not even be consciously aware of them. For example, two general assumptions underlie many research studies:

- The phenomenon under investigation is somewhat lawful and predictable; it is *not* comprised of completely random events.
- Cause-and-effect relationships can account for certain patterns observed in the phenomenon.

But are such assumptions justified? Is the world a lawful place, with some things definitely causing or influencing others? Or are definitive laws and cause-and-effect relationships nothing more than figments of our fertile human imaginations?

As we consider such questions, it is helpful to distinguish among different philosophical orientations that point researchers in somewhat different directions in their quests to make sense of our physical, biological, social, and psychological worlds.[2] Historically, a good deal of research in the natural sciences has been driven by a perspective known as positivism. Positivists believe that, with appropriate measurement tools, scientists can objectively uncover absolute, undeniable *truths* about cause-and-effect relationships within the physical world and human experience.

In the social sciences, many researchers are—and most others *should* be—less self-assured and more tentative about their assumptions. Some social scientists take a perspective known as postpositivism, believing that true objectivity in seeking absolute truths can be an elusive goal. Although researchers might strive for objectivity in their collection and interpretation of data, they inevitably bring certain *biases* to their investigations—perhaps biases regarding the best ways to measure certain variables or the most logical inferences to draw from patterns within the data. From a postpositivist perspective, progress toward genuine understandings of physical, social, and psychological phenomena tends to be gradual and probabilistic. For example, recall the earlier discussion of hypotheses being either *supported* or *not supported* by data. Postpositivists don't say, "I've just proven such-and-such." Rather, they're more likely to say, "This increases the probability that such-and-such is true."

[2]Some writers use terms such as *worldviews, epistemologies,* or *paradigms* instead of the term *philosophical orientations.*

- If your computer completely dies—seemingly beyond resuscitation—some software programs (e.g., Norton Utilities) may be able to fix the damage and retrieve some or all of the lost material. And service departments at computer retailers can often retrieve documents from the hard drives of otherwise "dead" machines.

2. ***Use such features as the spell checker and grammar checker to look for errors, but do NOT rely on them exclusively.*** Although computers are marvelous machines, their "thinking" capabilities have not yet begun to approach those of the human mind. For instance, although a computer can detect spelling errors, it does so by comparing each word against its internal "dictionary" of correctly spelled words. Not every word in the English language will be included in the dictionary; for instance, proper nouns (e.g., surnames such as Leedy and Ormrod) will *not* be. Furthermore, it may assume that *abut* is spelled correctly when the word you really had in mind was *about,* and it may very well not know that *there* should actually be *their* or *they're.*

3. ***Print out a paper copy for final proofreading and editing.*** One of us authors once had a student who turned in a dissertation draft chock-full of spelling and grammatical errors—and this from a student who was, ironically, teaching a college-level English composition course at the time. A critical and chastising e-mail message to the student made her irate; she had checked her document quite thoroughly before submitting it, she replied, and was convinced that it was virtually error-free. When her paper draft was returned to her almost bloodshot with spelling and grammatical corrections in red ink, she was quite contrite. "I don't know how I missed them all!" she said. When asked if she had ever edited a printed copy of the draft, she replied that she had not, figuring that she could read her work just as easily on her computer monitor and thereby save a tree or two. But in our own experience, it is *always* a good idea to read a printed version of what you have written. For some reason, reading a paper copy often alerts us to errors we have previously overlooked on the computer screen.

The Human Mind

The research tools discussed so far—the library, computer technology, measurement, statistics, and language—are effective only to the extent that another critical tool also comes into play. The human mind is undoubtedly the most important tool in the researcher's toolbox. Nothing equals its powers of comprehension, integrative reasoning, and insight.

Over the past few millennia, human beings have developed a number of general strategies through which they can more effectively reason about and better understand worldly phenomena. Key among these strategies are critical thinking, deductive logic, inductive reasoning, scientific methods, theory building, and collaboration with other minds.

Critical Thinking

Before beginning a research project, good researchers typically look at research reports and theoretical discussions related to their topic of interest. But they don't just accept research findings and theories at face value; instead, they scrutinize those findings and theories for faulty assumptions, questionable logic, weaknesses in methodologies, and unwarranted conclusions. And, of course, good researchers scrutinize their *own* work for the same kinds of flaws. In other words, good researchers engage in critical thinking.

In general, critical thinking involves evaluating the accuracy, credibility, and worth of information and lines of reasoning. Critical thinking is reflective, logical, and evidence-based. It also has a purposeful quality to it—that is, the researcher thinks critically in order to achieve a particular goal.

Critical thinking can take a variety of forms, depending on the context. For instance, it may involve any one or more of the following (Halpern, 1998, 2008; Mercier, Boudry, Paglieri, & Trouche, 2017; Nussbaum, 2008):

- ***Verbal reasoning.*** Understanding and evaluating persuasive techniques found in oral and written language.
- ***Argument analysis.*** Discriminating between reasons that do and do not support a particular conclusion.
- ***Probabilistic reasoning.*** Determining the likelihood and uncertainties associated with various events.
- ***Decision making.*** Identifying and evaluating several alternatives and selecting the alternative most likely to lead to a successful outcome.
- ***Hypothesis testing.*** Judging the value of data and research results in terms of the methods used to obtain them and their potential relevance to certain conclusions. When hypothesis testing includes critical thinking, it involves considering questions such as these:
  - Was an appropriate method used to measure a particular outcome?
  - Are the data and results derived from a relatively large number of people, objects, or events?
  - Have other possible explanations or conclusions been eliminated?
  - Can the results obtained in one situation be reasonably generalized to other situations?

To some degree, different fields of study require different kinds of critical thinking. In history, critical thinking might involve scrutinizing various historical documents and looking for clues as to whether things *definitely* happened a particular way or only *maybe* happened that way. In psychology, it might involve critically evaluating the way in which a particular psychological characteristic (e.g., intelligence, personality) is being measured. In anthropology, it might involve observing people's behaviors over an extended period of time and speculating about what those behaviors indicate about the cultural group being studied.

Deductive Logic

Deductive logic begins with one or more *premises*. These premises are statements or assumptions that the researcher initially takes to be true. Reasoning then proceeds logically from the premises toward conclusions that—if the premises are indeed true—must *also* be true. For example,

> If all tulips are plants, (Premise 1)
>
> And if all plants produce energy through photosynthesis, (Premise 2)
>
> Then all tulips must produce energy through photosynthesis. (Conclusion)

To the extent that the premises are false, the conclusions may also be false. For example,

> If all tulips are platypuses, (Premise 1)
>
> And if all platypuses produce energy through spontaneous combustion, (Premise 2)
>
> Then all tulips must produce energy through spontaneous combustion. (Conclusion)

The if-this-then-that logic is the same in both examples. We reach an erroneous conclusion in the second example—we conclude that tulips are apt to burst into flames at unpredictable times—only because both of our premises are erroneous.

Let's look back more than 500 years to Christopher Columbus's first voyage to the New World. At the time, people held many beliefs about the world that, to them, were irrefutable facts: People are mortal; the Earth is flat; the universe is finite and relatively small. The terror that gripped Columbus's sailors as they crossed the Atlantic was a fear supported by deductive logic. If the Earth is flat (premise), and the universe finite and small (premise), the

Earth's flat surface must stop at some point. Therefore, a ship that continues to travel into uncharted territory must eventually come to the Earth's edge and fall off, and its passengers (who are mortal—another premise) will meet their deaths. The logic was sound; the conclusions were valid. Where the reasoning fell short was in two faulty premises: that the Earth is flat and also relatively small.

Deductive logic provides the basis for mathematical proofs in mathematics, physics, and related disciplines. It is also extremely valuable for generating research hypotheses and testing theories. As an example, let's look one more time at doctoral student Dinah Jackson's dissertation project about the possible effects of self-questioning during studying. Jackson knew from well-established theories about human learning that forming mental associations among two or more pieces of information results in more effective learning than does trying to learn each piece of information separately from the others. She also found a body of research literature indicating that the kinds of questions students ask themselves (mentally) and try to answer as they listen to a lecture or read a textbook influence both what they learn and how effectively they remember it. (For instance, a student who is trying to answer the question, "What do I need to remember for the test?" might learn very differently from the student who is considering the question, "How might I apply this information to my own life?") From such findings, Jackson generated several key premises and drew a logical conclusion from them:

> If learning information in an associative, integrative manner is more effective than learning information in a fact-by-fact, piecemeal manner, (Premise 1)
>
> If the kinds of questions students ask themselves during a learning activity influence how they learn, (Premise 2)
>
> If training in self-questioning techniques influences the kinds of questions that students ask themselves, (Premise 3)
>
> And if learning is reflected in the kinds of notes that students take during class, (Premise 4)
>
> Then teaching students to ask themselves integrative questions as they study class material should lead to better-integrated class notes and higher-quality learning. (Conclusion)

Such reasoning led Jackson to form and test several hypotheses, including this one:

> Students who have formal training in integrative self-questioning will take more integrative notes than students who have not had any formal training. (Jackson, 1996, p. 12)

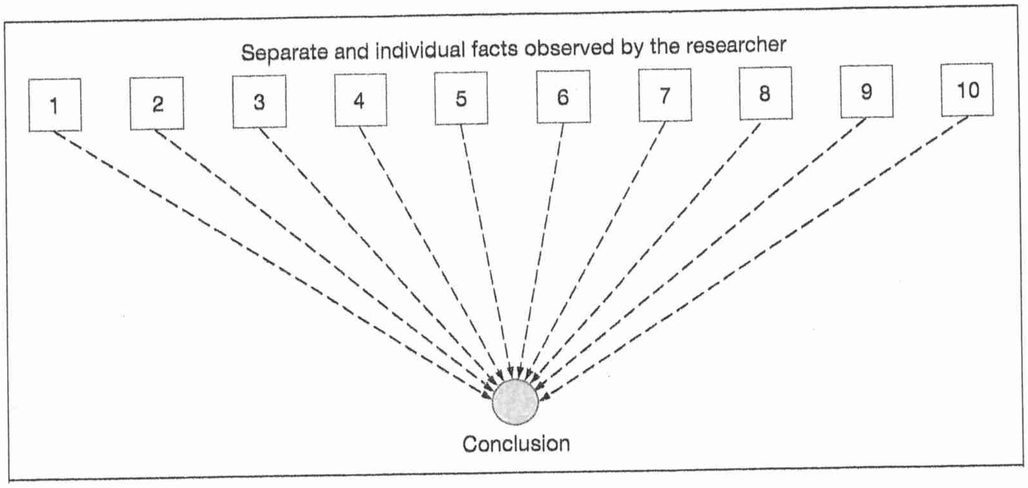
Happily for Jackson, the data she collected in her dissertation research supported this hypothesis.

Inductive Reasoning

Inductive reasoning begins not with a preestablished truth or assumption but instead with an observation. For example, as a baby in a high chair many years ago, you may have observed that if you held a cracker in front of you and then let go of it, it fell to the floor. "Hmmm," you may have thought, "what happens if I do that again?" So you grabbed another cracker, held it out, and released it. It, too, fell to the floor. You followed the same procedure with several more crackers, and the result was always the same: The cracker traveled in a downward direction. Eventually, you may have performed the same actions on other things—blocks, rattles, peas, milk—and invariably observed the same result. Eventually, you drew the conclusion that all things fall when dropped—your first inkling about a force called *gravity*. (You may also have concluded that dropping things from your high chair greatly annoyed your parents, but that is another matter.)

In **inductive reasoning**, people use specific instances or occurrences to draw conclusions about entire classes of objects or events. In other words, they observe a *sample* and then draw conclusions about the larger *population* from which the sample has been

FIGURE 1.2 ■ The Inductive Process



taken. For instance, an anthropologist might draw conclusions about a certain culture after studying a certain community within that culture. A professor of special education might use a few case studies in which a particular instructional approach is effective with students who have dyslexia to recommend that teachers use the instructional approach with other students with dyslexia. A sociologist might (a) conduct three surveys (one each in 1995, 2005, and 2015) asking 1,000 people to describe their beliefs about AIDS and then (b) draw conclusions about how society's attitudes toward AIDS have changed over the 20-year period.

Figure 1.2 graphically depicts the nature of inductive reasoning. Let's look at an example of how this representation applies to an actual research project. Neurologists Silverman, Masland, Saunders, and Schwab (1970) sought the answer to a problem in medicine: How long can a person have a flat electroencephalogram (EEG) (i.e., an absence of measurable electrical activity in the brain, typically indicative of cerebral death) and still recover? Silverman and his colleagues observed 2,650 actual cases. They noted that, in all cases in which the flat EEG persisted for 24 hours or more, not a single recovery occurred. All of the data pointed to the same conclusion: *People who exhibit flat EEGs for 24 hours or longer will not recover.* We cannot, of course, rule out the unexplored cases, but *from the data observed,* the conclusion reached was that recovery is impossible. The EEG line from *every* case led to that *one* conclusion.

Scientific Method

During the Renaissance, people found that when they systematically collected and analyzed data, new insights and understandings might emerge. Thus was the scientific method born; the words literally mean "the method that searches for knowledge" (*scientia* is Latin for "knowledge" and derives from *scire,* "to know"). The scientific method gained momentum during the 16th century with such men as Paracelsus, Copernicus, Vesalius, and Galileo.

Traditionally, the term scientific method has referred to an approach in which a researcher (a) identifies a problem that defines the goal of one's quest; (b) posits a hypothesis that, if confirmed, resolves the problem; (c) gathers data relevant to the hypothesis; and (d) analyzes and interprets the data to see whether they support the hypothesis and resolve the question that instigated the research. In recent years, however, the term has been a controversial one because not all researchers follow the steps just listed in a rigid, lockstep manner; in fact, as noted earlier, some researchers shy away from forming any hypotheses about what they might find. Some of the controversy revolves around which article to use in front of the term—more specifically, whether to say "*the* scientific method" or "*a* scientific method." If we are speaking generally about the importance of collecting and analyzing data systematically rather than haphazardly, then saying "*the* scientific method" makes sense. If, instead, we are speaking about a specific methodology—say, experimental research or ethnographic research (described in Chapter 7 and Chapter 8, respectively), it is probably better to say "*a* scientific method." In any event, we are talking about a somewhat flexible—although certainly also rigorous—process.

As you may already have realized, application of a scientific method usually involves both deductive logic and inductive reasoning. Researchers might develop a hypothesis either from a theory (deductive logic) or from observations of specific events (inductive reasoning). Using deductive logic, they might make predictions about the patterns they are likely to see in their data *if* a hypothesis is true, and even researchers who have not formulated hypotheses in advance must eventually draw logical conclusions from the data they obtain. Finally, researchers often use inductive reasoning to generalize about a large population from which they have drawn a small sample.

Theory Building

Psychologists are increasingly realizing that the human mind is a very *constructive* mind. People don't just passively absorb and remember a large body of unorganized facts about the world. Instead, they pull together the things they see and hear to form well-organized and integrated understandings about a wide variety of physical and social events. Human beings, then, seem to have a natural tendency to develop *theories* about the world around them (e.g., see Bransford, Brown, & Cocking, 2000; J. E. Ormrod, 2016).

In general, a **theory** is an organized body of concepts and principles intended to explain a particular phenomenon. Even as young children, human beings are inclined to form their own personal theories about various physical and social phenomena—for instance, why the sun "goes down" at night, where babies come from, and why certain individuals behave in particular ways. People's everyday, informal theories about the world aren't always accurate. For example, imagine that an airplane drops a large metal ball as it travels forward through the air. What kind of path will the ball take as it falls downward? The answer, of course, is that it will fall downward at an increasingly fast rate (thanks to gravity) but will also continue to travel forward (thanks to inertia). Thus, its path will have the shape of a parabolic arc. Yet many college students erroneously believe that the ball (a) will fall straight down, (b) will take a straight diagonal path downward, or (c) will actually move *backward* from the airplane as it falls down (Cook & Breedin, 1994; McCloskey, 1983).

What characterizes the theory building of a good researcher is the fact that it is supported by well-documented findings—rather than by naive beliefs and subjective impressions of the world—and by logically defensible reasoning. Thus, the theory-building process involves thinking *actively* and *intentionally* about a phenomenon under investigation. Beginning with the facts known about the phenomenon, the researcher brainstorms ideas about plausible and, ideally, *best* explanations—a process that is sometimes called **abduction** (e.g., Jaccard & Jacoby, 2010; Walton, 2003). Such explanations are apt to involve an interrelated set of concepts and propositions that, taken together, can reasonably account for the phenomenon being studied.

After one or more researchers have developed a theory to explain a phenomenon of interest, the theory is apt to drive further research, in part by posing new questions that require answers and in part by suggesting hypotheses about the likely outcomes of particular investigations. For example, one common way of testing a theory is to use deductive reasoning to make a prediction (hypothesis) about what should occur *if the theory is a viable explanation of the phenomenon being examined.* As an example, let's consider Albert Einstein's theory of relativity, first proposed in 1915. Within the context of his theory, Einstein hypothesized that light passes through space as photons—tiny masses of spectral energy. If light has mass, Einstein reasoned, it should be subject to the pull of a gravitational field. A year later, Karl Schwarzschild predicted that, based on Einstein's reasoning, the gravitational field of the sun should bend light rays considerably more than Isaac Newton had predicted many years earlier. In 1919 a group of English astronomers traveled to Brazil and North Africa to observe how the sun's gravity distorted the light of a distant star now visible due to a solar eclipse. After the data were analyzed and interpreted, the results clearly supported the Einstein–Schwarzschild hypothesis—and therefore also supported Einstein's theory of relativity.

As new data emerge, a researcher may continue to revise a theory, reworking parts to better account for research findings, filling in gaps with additional concepts or propositions, extending the theory to apply to additional situations, and relating the theory to other theories regarding overlapping phenomena (Steiner, 1988; K. R. Thompson, 2006). Occasionally, when an existing theory cannot adequately account for a growing body of evidence, a good researcher casts it aside and begins to formulate an alternative theory that better explains the data.

Theory building tends to be a relatively slow process, with any particular theory continuing to evolve over a period of years, decades, or centuries. Often, many researchers contribute to the theory-building effort, testing hypotheses that the theory suggests, suggesting additional concepts and propositions to include in the theory, and conducting additional investigations to test one or more aspects of the theory in its current state. This last point brings us to yet another strategy for effectively using the human mind: collaborating with *other* minds.

Collaboration with Other Minds

As an old saying goes, two heads are better than one. Three or more heads can be even better. Any single researcher is apt to have certain perspectives, assumptions, and theoretical biases—not to mention gaps in knowledge about the subject matter—that will limit how the researcher approaches a research project. By bringing one or more professional colleagues into a project—ideally, colleagues who have perspectives, backgrounds, and areas of expertise somewhat different from the researcher's own—the researcher brings many more cognitive resources to bear on how to tackle the research problem and how to find meaning in the data obtained.

Sometimes these colleagues enter the picture as equal partners. At other times they may simply offer suggestions and advice. For example, when a graduate student conducts research for a master's thesis or doctoral dissertation, the student is, of course, the key player in the endeavor. Yet the student typically has considerable guidance from an advisor and, especially in the case of a doctoral dissertation, from a faculty committee. The prudent student selects an advisor and committee members who have the expertise to help shape the research project into a form that will truly address the research question and—more importantly—will make a genuine contribution to the student's topic of study.

Many productive researchers keep in regular communication with others who conduct research on the same or similar topics, perhaps exchanging ideas, critiquing one another's work, and directing one another to potentially helpful resources. Such ongoing communication is also a form of collaboration—albeit a less systematic one—in that everyone can benefit from and build on what other people are thinking and finding. Increasingly, computer technology is playing a central role in this cross-communication and cross-fertilization. For example, many researchers subscribe to topic-specific electronic discussion groups—you may also see such terms as *list servers, online discussion forums, bulletin boards,* and *message boards*—in which any message sent to or posted on them is available and possibly sent to all subscribers. In addition, some researchers maintain professional websites that describe their research programs and include links to relevant research reports; often you can find these web pages by going to the websites of the researchers' universities or other home institutions.

As the preceding sections should make clear, we human beings are—or at least have the potential to be—*logical, reasoning* beings. But despite our incredible intellectual capabilities—which almost certainly surpass those of all other species on the planet—we don't always reason as logically or objectively as we might. For example, sometimes we "discover" what we *expect* to discover, to the point where we don't look objectively at the data we collect. And sometimes we are so emotionally attached to particular perspectives or theories about a phenomenon that we can't abandon them when mountains of evidence indicate that we should. Figure 1.3 describes

We human beings often fall short of the reasoning capacities with which Mother Nature has endowed us. Following are seven common pitfalls to watch for in your own thinking as a researcher.

1. ***Confusing what must logically be true with what seems to be true in the world as we know it—a potential pitfall in deductive reasoning.*** Our usual downfall in deductive reasoning is failing to separate logic from everyday experience. For example, consider Isaac Newton's second law of motion: Force equals mass times acceleration ($F = ma$). According to this basic principle of Newtonian physics, any force applied to an object results in acceleration of the object. Using simple algebra—deductive reasoning at its finest—we can conclude that $a = F \div m$ and therefore that if there is no acceleration ($a = 0$), then there is no force ($F = 0$). This deduction makes no sense to anyone who has ever tried to push a heavy object across the floor: The object may not move at all, let alone accelerate. What explains the object's stubbornness, of course, is that other forces, especially friction with and resistance from the floor, are counteracting any force that the pusher may be applying.
2. ***Making generalizations about members of a category after having encountered only a restricted subset of that category—a potential pitfall in inductive reasoning.*** The main weakness of inductive reasoning is that even if all of our specific observations about a particular set of objects or events are correct, our generalizations about the category as a whole may *not* be correct. For example, if the only tulips we ever see are red ones, we may erroneously conclude that tulips can *only* be red. And if we conduct research about the political or religious beliefs of people who live in a particular location—say, people who live in Chicago—we may draw conclusions that don't necessarily apply to the human race as a whole. Inductive reasoning, then, is most likely to fall short when we gather data from only a small, limited sample and want to make *generalizations* about a larger group.
3. ***Looking only for evidence that supports our hypotheses, without also looking for evidence that would disconfirm our hypotheses.*** We humans seem to be predisposed to look for confirming evidence rather than disconfirming evidence—a phenomenon known as **confirmation bias**. For many everyday practical matters, this approach serves us well. For example, if we flip a light switch and fail to get any light, we might immediately think, "The light bulb has probably burned out." We unscrew the existing light bulb and replace it with a new one—and *voila!* We now have light. Hypothesis confirmed, problem solved, case closed. However, truly objective researchers don't just look for evidence that confirms what they believe to be true. They also look for evidence that might *disprove* their hypotheses. They secretly hope that they don't find such evidence, of course, but they open-mindedly look for it nonetheless.
4. ***Confirming expectations even in the face of contradictory evidence.*** Another aspect of our confirmation bias is that we tend to ignore or discredit any contradictory evidence that comes our way. For example, consider the topic of global climate change. Convincing evidence continues to mount to support the ideas that (a) the Earth's average temperature is gradually rising and (b) this temperature rise is at least partly the result of carbon emissions and other human activities. Yet some folks have great difficulty looking at the evidence objectively—perhaps the researchers incorrectly analyzed the data, they say, or perhaps the scientific community has a hidden agenda and so isn't giving us the straight scoop.
5. ***Mistaking dogma for fact.*** Although we might be inclined to view some sources of information with a skeptical, critical eye, we might accept others without question. For example, many of us willingly accept whatever an esteemed researcher, scholarly book, or other authority source says to be true. In general, we may uncritically accept anything said or written by individuals or groups we hold in high esteem. Not all authority figures and works of literature are reliable sources of information and guidance, however, and blind, unquestioning acceptance of them can be worrisome.
6. ***Letting emotion override logic and objectivity.*** We humans are emotional beings, and our emotions often infiltrate our efforts to reason and think critically. We're apt to think quite rationally and objectively when dealing with topics we don't feel strongly about and yet think in decidedly irrational ways about emotionally charged issues—issues we find upsetting, infuriating, or personally threatening.
7. ***Mistaking correlation for causation.*** In our efforts to make sense of our world, we human beings are often eager to figure out what causes what. But in our eagerness to identify cause-and-effect relationships, we sometimes "see" them when all we really have is two events that just happen to occur at the same time and place. Even when the two events are *consistently* observed together—in other words, when they are *correlated*—one of them doesn't necessarily cause the other. An ability to distinguish between causation and correlation is critical in any research effort, as you will discover in Chapter 6.

FIGURE 1.3 ■ Common Pitfalls in Human Reasoning

List of pitfalls based on Chapter 8, "Common Sense Isn't Always Sensible: Reasoning and Critical Thinking" in *Our Minds, Our Memories* by J. E. Ormrod, 2011, pp. 151–183. Copyright by Pearson Education, Inc. Used by permission.

some common pitfalls in human reasoning—pitfalls we urge you to be on the lookout for and try to overcome. Good researchers are *reflective* researchers who regularly and critically examine not only their research designs and data but also their own thinking processes.

MyLab Education **Self-Check 1.4**

MyLab Education **Application Exercise 1.3:** Communicating Effectively about Research

REFLECTIONS ON NOTEWORTHY RESEARCH

The time: February 13, 1929. The place: St. Mary's Hospital, London. The occasion: the reading of a paper before the Medical Research Club. The speaker: a member of the hospital staff in the Department of Microbiology. Such was the setting for the presentation of one of the most significant research reports of the early 20th century. The report was about a discovery that has transformed the practice of medicine. Dr. Alexander Fleming presented to his colleagues his research on penicillin. The group was apathetic. No one showed any enthusiasm for Fleming's paper. Great research has frequently been presented to those who are imaginatively both blind and deaf.

Despite the lukewarm reception, Fleming knew the value of what he had done. The first public announcement of the discovery of penicillin appeared in the *British Journal of Experimental Pathology* in 1929. It is a readable report—one that André Maurois (1959) called "a triumph of clarity, sobriety, and precision." Get it; read it. You will be reliving one of the great moments in 20th-century medical research.

Soon after Fleming's presentation of his paper, two other names became associated with the development of penicillin: Ernst B. Chain and Howard W. Florey (Chain et al., 1940; also see Abraham et al., 1941). Together they developed a pure strain of penicillin. Florey was especially instrumental in initiating its mass production and its use as an antibiotic for wounded soldiers in World War II (Coghill, 1944; also see Coghill & Koch, 1945). Reading these reports takes you back to the days when the medical urgency of dying people called for a massive research effort to make a newly discovered antibiotic available for immediate use.

On October 25, 1945, the Nobel Prize in medicine was awarded to Fleming, Chain, and Florey.

If you want to learn more about the discovery of penicillin, read André Maurois's *The Life of Sir Alexander Fleming* (1959), the definitive biography done at the behest of Fleming's widow. The book will give you an insight into the way great research comes into being.

The procedures used in groundbreaking research are identical to those every student follows in completing a dissertation, thesis, or other research project. Triggered by curiosity, all research begins with an observation, a question, a problem. Assumptions are made. Hypotheses might be formulated. Data are gathered. Conclusions are reached. What *you* do in a research project is the same as what many others have done before you, including those who have pushed back the barriers of ignorance and made discoveries that have greatly benefited humankind.

EXPLORING RESEARCH IN YOUR FIELD

Early in the chapter we mentioned that academic research is popularly seen as an activity far removed from everyday living. Even graduate students working on theses or dissertations may consider their tasks to be meaningless busywork that have little or no