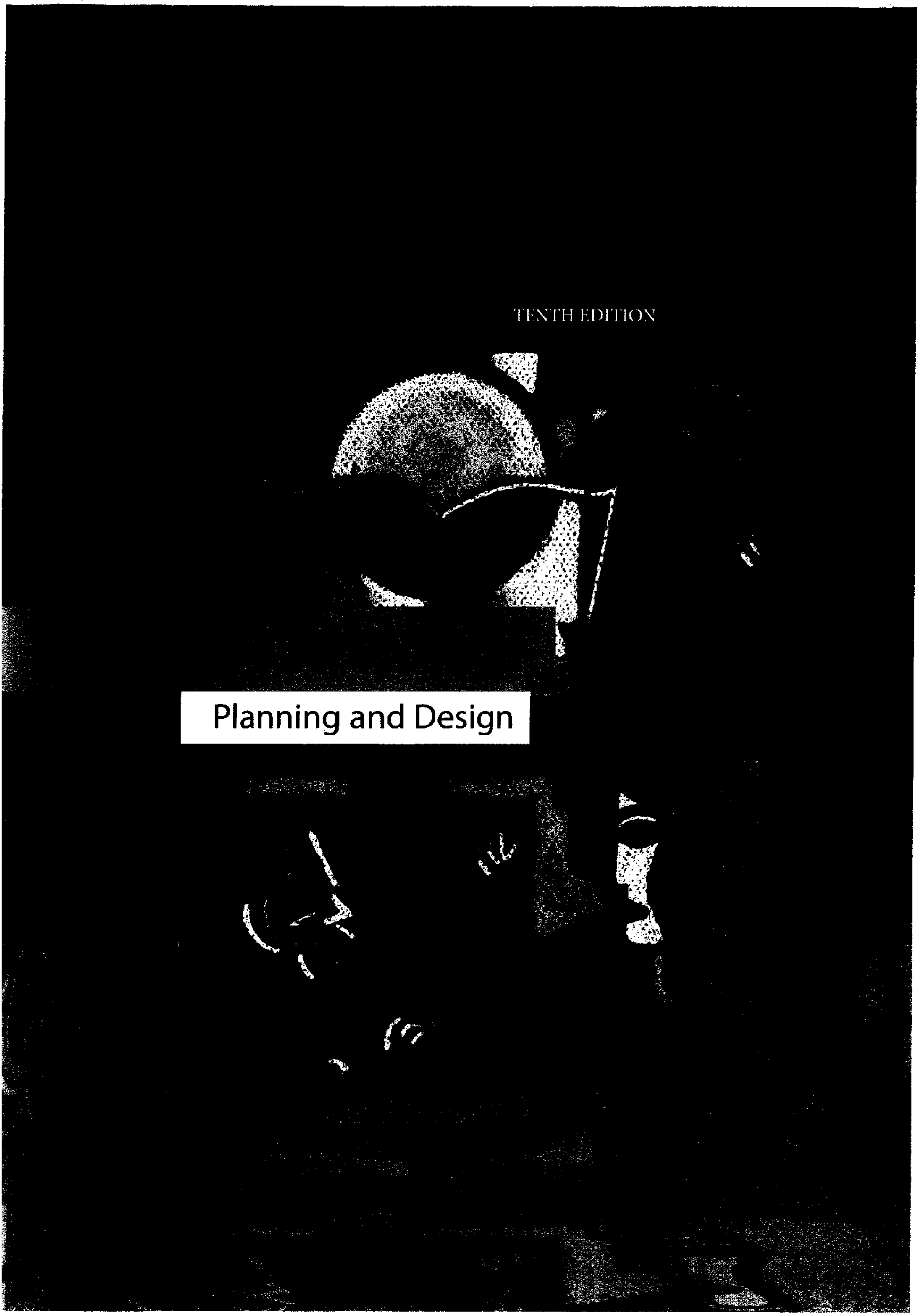

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ALWAYS LEARNING

1 The Nature and Tools of Research

In virtually every subject area, our knowledge is incomplete and problems are waiting to be solved. We can address our incomplete knowledge and unsolved problems by asking relevant questions and then seeking answers through systematic research. We have many tools at our disposal to help us do these things—not only physical tools but also mental and social tools.

In everyday speech, the word *research* has numerous meanings, making it a decidedly confusing term for university students, who must learn to use the word in a narrower, more precise sense. From elementary school to college, students hear the word *research* used to describe a variety of activities. In some situations the word connotes 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 activities have often been called research but are more accurately called other names: information gathering, library skills, self-enlightenment, documentation, or summarization.

Yet when used more appropriately, for many people the word *research* suggests a mystical activity that is somehow exclusive and removed from everyday life. Researchers are sometimes regarded as aloof individuals who seclude themselves in laboratories, scholarly libraries, or the ivory towers of large universities. The general public is often unaware of what researchers do on a day-to-day basis and how their work contributes to people's overall quality of life and well-being.

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 the general tools that make it possible.

What Research Is Not

We have suggested that the word *research* has been so widely used in everyday speech that few people have any idea of its true meaning. 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 much money 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 rummaging through files to discover what the realtor

previously did not know. Rummaging—whether through one's personal records or at the public or college library—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—collecting information, organizing it in a certain way for presentation to others, supporting statements with documentation, referencing statements properly, and so on—these activities do not add up to a true research paper. 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.

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. 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 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, in general, research has eight distinct characteristics:

1. Research originates with a question or problem.
2. Research requires clear articulation of a goal.
3. Research usually divides the principal problem into more manageable subproblems.
4. Research is guided by the specific research problem, question, or hypothesis.
5. Research requires a specific plan for proceeding.
6. Research rests on certain critical assumptions.
7. Research requires the collection and interpretation of data in an attempt to resolve the problem that initiated the research.
8. Research is, by its nature, cyclical or, more exactly, helical.

Let's look at each of these characteristics more closely.

1. *Research originates with a question or problem.* The world is filled with unanswered questions and unresolved problems. Everywhere we look, we see things that cause us to wonder, to speculate, to ask questions. And by asking questions, we strike a spark that ignites a chain reaction leading to the research process. An inquisitive mind is the beginning impetus for research; as one popular tabloid puts it, "Inquiring minds want to know!"

Look around you. Consider the unresolved situations that evoke these questions: What is such-and-such a situation like? Why does such-and-such a phenomenon occur? What does it all mean? These are everyday questions. With questions like these, research begins.

2. *Research requires clear articulation of a goal.* A clear, unambiguous statement of the problem is critical. This statement is an exercise in intellectual honesty: The ultimate goal of the

research must be set forth in a grammatically complete sentence that specifically and precisely answers the question, "What problem do you intend to solve?" 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. *Research usually 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 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 50 miles 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?

What seems like 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. *Research is guided by the specific research problem, question, or hypothesis.* Having stated the problem and its attendant subproblems, the researcher usually forms one or more hypotheses about what he or she may discover. A **hypothesis** is a logical supposition, a reasonable guess, an educated conjecture. 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 to resolve the principal research problem.

Hypotheses are certainly not unique to research. They are constant, recurring features of everyday life and represent the natural working of the human mind. Something happens. Immediately you attempt to account for the cause of the event by making a series of reasonable guesses. In so doing, you are hypothesizing. As an example, let's take a commonplace event: You come home after dark, open the 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 begin to construct a series of reasonable guesses—hypotheses—to explain the lamp's failure:

1. The bulb has burned out.
2. The lamp is not plugged into the wall outlet.
3. A recent weather event interrupted your electrical service.
4. The wire from the lamp to the wall outlet is defective.
5. You forgot to pay your electric bill.

Each of these hypotheses hints at a direction you might proceed in order to acquire information that may resolve the problem of the malfunctioning lamp. Now you go in search of information to determine which hypothesis is correct. In other words, you look for data that will support one of your hypotheses and enable you to reject others.

1. You get a flashlight from your car, find a new bulb, and put the new bulb in the lamp. The lamp fails to light. (Hypothesis 1 is rejected.)
2. You glance down at the wall outlet and see that the lamp is plugged into it. (Hypothesis 2 is rejected.)
3. You look at your neighbors' homes. Everyone has electrical power. (Hypothesis 3 is rejected.)
4. You lift the cord that connects the lamp to the wall outlet. The lamp lights briefly and then goes out. You lift the cord again. Again the lamp lights briefly. The connecting cord is defective. (Hypothesis 4 is supported. Furthermore, because you clearly do have an active electric current, you can reject Hypothesis 5—your electric bill payments are up to date.)
5. Fortunately, Hypothesis 4 solved the problem. By repairing or replacing the cord, you can count on adequate light from the lamp in the near future.

Hypotheses in a research project are as tentative as those just formed for the malfunctioning 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.

Let's return to a point we made a few paragraphs back, this time emphasizing a particular word: The researcher *usually* forms one or more hypotheses about what he or she may discover. Hypotheses—predictions—are an essential ingredient in certain kinds of research, especially experimental research (see Chapter 9). To a lesser degree, they guide most 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* research in Chapter 6). Yet regardless of whether researchers form specific hypotheses in advance, they must, at a minimum, use their research problem or question to focus their efforts.

5. *Research requires a specific plan for proceeding.* Research is not a blind excursion into the unknown, with the hope that the data necessary to answer the question at hand will somehow fortuitously 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 addition to identifying the specific goal of your research, then, you must also identify how you propose to reach your goal. You cannot wait until you're chin deep in the project to plan and design your strategy. In the formative stages of a research project, much can be decided: Where are the data? Do any existing data address themselves to the research problem? If the data exist, are you likely to have access to them? And if you have access to the data, what will you do with them after you have 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.[1]

Ultimately the research methodology directs the whole research endeavor: It controls the study, dictates how the data are acquired, arranges them in logical relationships, sets up an approach for refining and synthesizing them, suggests a manner in which the meanings that lie

[1]As should be apparent in the questions we pose in this paragraph, 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*.

below the surface of the data become manifest, and finally yields one or more conclusions that lead to an expansion of knowledge. Thus, research methodology has two primary functions:

1. To dictate and control the acquisition of data
2. To analyze the acquired data in order to extract meaning from them

The second of these functions is what we mean by the phrase *interpretation of the data.*

6. *Research rests on certain critical assumptions.* Whereas a hypothesis involves a prediction that may or may not be supported by the data, an **assumption** is a condition that is taken for granted, without which the research project would be pointless. In research, assumptions are equivalent to axioms in geometry—self-evident truths that any reasonable person might accept. Careful researchers—certainly those conducting research in an academic environment—set forth a statement of their assumptions as the bedrock upon which their study rests.

An example may clarify the point. 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, the researcher 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.

Assumptions are often so self-evident that a researcher may consider it unnecessary to mention them. For instance, two assumptions underlie almost all research:

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

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 the beginning researcher, it is better to be overly explicit than to take too much for granted.

7. *Research requires the collection and interpretation of data in an attempt to resolve the problem that initiated the research.* After a researcher has isolated the problem, divided it into appropriate subproblems, posited reasonable hypotheses, identified a suitable design and methodology, and identified the assumptions that underlie the entire effort, the next step is to collect whatever data seem appropriate and to organize them in meaningful ways so that they can be interpreted.[2]

Events, observations, and measurements are, in and of themselves, *only* events, observations, and measurements—nothing more. The significance of the data depends on how the researcher extracts *meaning* from them. In research, data uninterpreted by the human mind 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

[2] Some people in academia use the term *research* more broadly to include deriving new equations or abstract principles from existing equations and/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.

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.

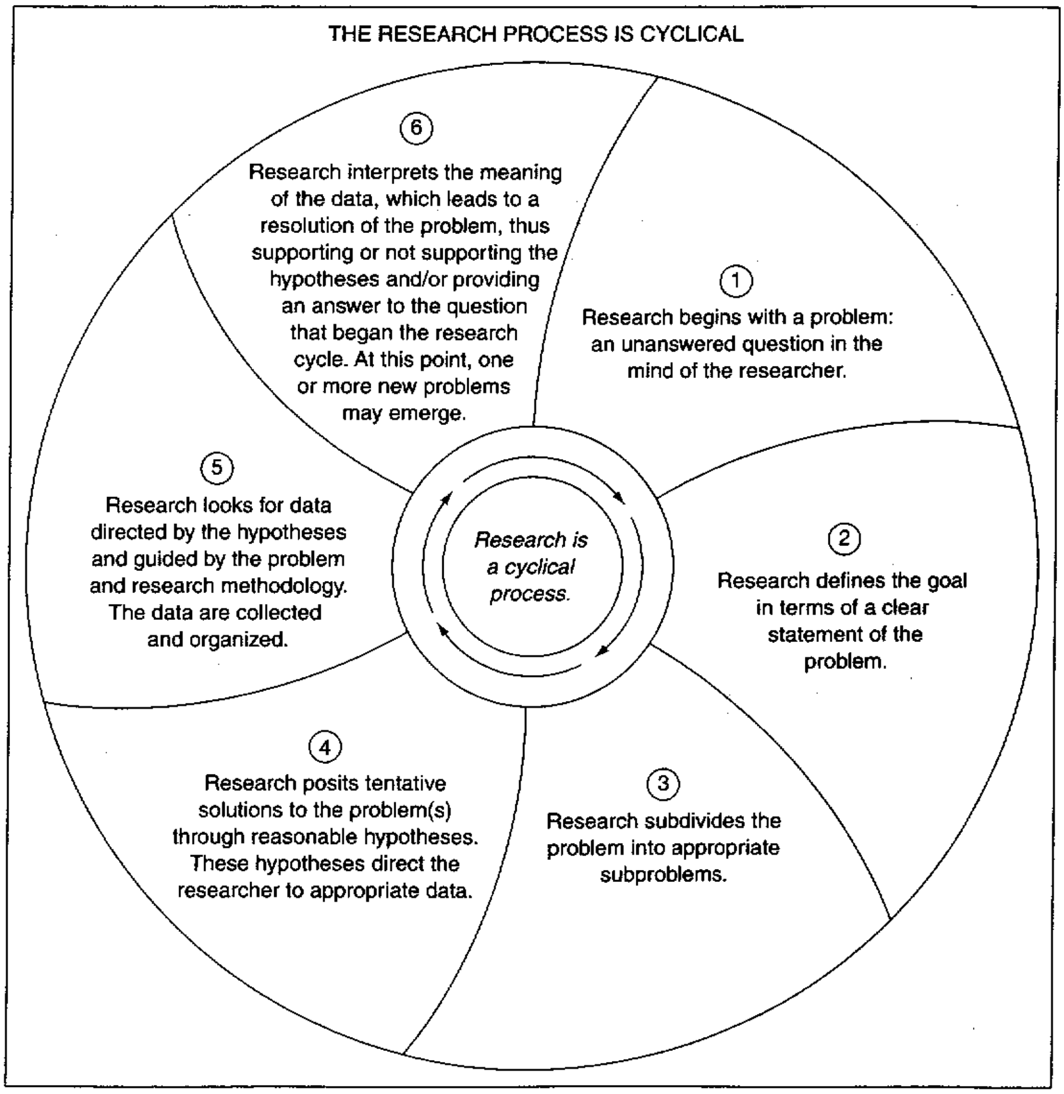
Once we believed that clocks measured time and that yardsticks measured space. In one sense, they still do. We further assumed that time and space were two different entities. Then along came Einstein's theory of relativity, and time and space became locked into one concept: the time–space continuum. What is the difference between the old perspective and the new perspective? 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 hypotheses, assumptions, and logical reasoning processes. In subsequent chapters we present a number of potentially useful methods for organizing and interpreting data.

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 interpretation of the data.

8. *Research is, by its nature, cyclical or, more exactly, helical.* Any research project begins simply and then follows a predictable, systematic sequences of steps, as shown in Figure 1.1:

FIGURE 1.1
The research cycle



1. A questioning mind observes a particular situation and asks, Why? What caused that? How come? (This is the internal, mental origin of research.)
2. One or more of these questions become formally stated as a problem. (This is the overt, observable beginning of research.)
3. The problem is divided into several simpler, more specific subproblems.
4. Preliminary information is gathered that appears to bear on the problem. This information may include informal observations of events in one's environment; typically it also includes previous research findings related to the topic at hand. The preliminary information may point to a tentative solution to the problem. A guess is made; a hypothesis or guiding question is formed.
5. A method of collecting data more systematically is identified and carried out in order to address the problem.
6. The body of data is processed and interpreted. A discovery is made, a conclusion reached. The tentative hypothesis is either supported or not supported by the data; the question is either answered (partially or completely) or not answered.

Such is the general format of all research. Different academic disciplines merely use different routes to arrive at the same destination.

Yet only rarely is a research project a one-shot effort that completely resolves a problem. For instance, even with the best of data, hypotheses in a research project are rarely proved or disproved—and thus research questions are rarely answered—beyond a shadow of a doubt. Instead, hypotheses 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 turns to other hypotheses as being more likely explanations of the phenomenon in question. In either case, 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 act that is static, self-contained, an end in itself. Here we see another difference between true research and the nonexamples of research presented early 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.

Tools of Research

Every professional needs specialized tools in order to work effectively. Without hammer and saw, the carpenter is out of business; without scalpel or forceps, the surgeon cannot practice. Researchers, likewise, have their own set of tools to carry out their plans.

The tools researchers use to achieve their research goals may vary considerably depending on the discipline. The microbiologist needs a microscope and culture media; the attorney requires a library of legal decisions and statute law. By and large, we do not discuss such discipline-specific tools in this book. Rather, our concern here is with general tools of research that the great majority of researchers of all disciplines need in order to collect data and derive meaningful conclusions.

We should be careful not to equate the *tools* of research with the *methodology* of research. A **research tool** is a specific mechanism or strategy the researcher uses to collect, manipulate, or interpret data. The **research methodology** is the general approach the researcher takes in carrying out the research project; to some extent, this approach dictates the particular tools the researcher selects.

Confusion between the tool and the research method is immediately recognizable. Such phrases as "library research" and "statistical research" are telltale signs and largely meaningless terms. They suggest a failure to understand the nature of formal research, as well as a failure to differentiate between tool and method. The library is merely a place for locating or discovering certain data that will be analyzed and interpreted at some point in the research process. Likewise, statistics merely provide ways to summarize and analyze data, thereby allowing us to see patterns within the data more clearly.

Six general tools of research are these:

1. The library and its resources
2. Computer technology
3. Measurement
4. Statistics
5. Language
6. The human mind

In the following sections, we look more closely at each of these general tools.

The Library and Its Resources

Historically, many literate human societies used libraries to assemble and store their collective knowledge. For example, in the seventh century B.C., the ancient Assyrians' Library of Nineveh contained 20,000 to 30,000 tablets, and in the second century A.D., the Romans' Library of Celsus in Ephesus housed more than 12,000 parchment and papyrus scrolls.

Until the past few decades libraries were primarily repositories of concrete, physical representations of knowledge—clay tablets, scrolls, manuscripts, books, journals, and so on. For the most part, any society's collective knowledge expanded rather slowly and could seemingly be contained within masonry walls. But by the latter half of the 20th century, people's knowledge about their physical and social worlds began to increase many times over, and at the present time it continues to increase at an astounding rate. In response, libraries have evolved in important ways. First, they have made use of many emerging technologies (e.g., microforms, compact disks, online databases) to store information in more compact forms. Second, they have provided increasingly fast and efficient means of locating and accessing information on virtually any topic. And third, many of them have made catalogs of their holdings available on the Internet (e.g., see www.library.unh.edu or library.brown.edu). The libraries of today—especially university libraries—extend far beyond their local, physical boundaries.

We explore efficient use of a library and its resources in depth in Chapter 3. For now, we simply want to stress that the library is—and must be—one of the most valuable tools in any researcher's toolbox.

Computer Technology

USING TECHNOLOGY

As a research tool, the personal computer is now commonplace. Personal computers have become increasingly compact and portable—first in the form of laptops and more recently in the form of iPads and other tablet computers. And computer software packages have become increasingly user friendly, such that novice researchers can learn to use them quickly and easily. But like any tool—no matter how powerful—computers have their limitations. Yes, computers can certainly calculate, compare, search, retrieve, sort, and organize data more efficiently and more accurately than you can. But in their present stage of development, they depend largely on people to give them directions about what to do.

A computer is not a miracle worker. It cannot do your thinking for you. It can, however, be a fast and faithful assistant. When told exactly what to do, it is one of the researcher's best friends.

Throughout this book, you will find many "Using Technology" sections that describe specific ways in which, as a researcher, you can use computers to make your job easier. Table 1.1 provides suggestions for how you might use a computer to assist you in the research process.

TABLE 1.1 The computer as a research assistant

Part of the Study	*Team of Research Assistants*
Planning the study	• Brainstorming assistance—software used to help generate and organize ideas for the research focus, to illustrate how different concepts could be related, and to consider how the process will be conducted. • Outlining assistance—software used to help structure the different aspects of the study and coordinate work efforts. • Project management assistance—software used to highlight and coordinate all the different efforts that need to occur in a timely fashion. • Budget assistance—spreadsheet software to help in outlining, estimating, and monitoring the potential costs involved in the research effort.
Literature review	• Background literature identification assistance—CDs and online databases that identify and describe related published research that should be considered during the formative stages of the research endeavor. • Telecommunication assistance—computer technology used to communicate with other researchers and groups of researchers through e-mail, electronic bulletin boards, list servers, and so on. • Writing assistance—software used to facilitate the writing, editing, formatting, and printing of the literature review.
Study implementation and data gathering	• Materials production assistance—software used for the development and use of instructional materials, graphics, simulations, and so on to be used in experimental interventions. • Experimental control assistance—software used to control the effects of specific variables and restrict the occurrence of other potentially confounding variables. • Survey distribution assistance—database use coupled with word processing to identify and send specific communications to a targeted population. • Data collection assistance—software used to take field notes or to monitor specific types of responses made by the participants in a research study.
Analysis and interpretation	• Organizational assistance—software used to assemble, categorize, code, integrate, and search potentially huge data sets (e.g., open-ended responses to survey questions, qualitative interview data). • Conceptual assistance—software used to write and store ongoing reflections about data or to construct theories that integrate research findings. • Statistical assistance—statistical and spreadsheet software packages used to categorize and analyze various types of data sets. • Graphic production assistance—software used to depict data in graphic form to facilitate interpretation.
Reporting	• Communication assistance—telecommunication software used to distribute and discuss research findings and initial interpretations with colleagues and to receive their comments and feedback. • Writing and editing assistance—word processing software used to write and edit successive drafts of the final report. • Publishing assistance—desktop publishing software used to produce professional-looking documents that can be distributed at conferences and elsewhere to get additional comments and feedback. • Distribution assistance—the Internet and other, more specific networks used to electronically distribute a report of one's findings and to generate discussion for follow-up studies by others in the field.

Measurement

Most researchers strive for objectivity: They believe that their observations should be influenced as little as possible—ideally not at all—by their own perceptions, impressions, and biases. (As we will note in Chapter 6, some qualitative researchers are an exception to this rule.) And one important way of remaining objective is to identify a systematic way of *measuring* a phenomenon being studied.

To measure something, of course, a researcher needs some sort of measurement instrument. Some common, everyday measurement instruments—rulers, scales, speedometers—can occasionally be helpful in a research project. Such instruments are, of course, designed to measure easily observable physical characteristics, such as length, weight, or speed. More typically, however, a researcher needs more specialized instruments. For example, an astronomer might need a high-powered telescope to detect patterns of light in the night sky, and a neurophysiologist might need a magnetic resonance imaging (MRI) machine to detect and measure neural activity in the brain.

Yet social and psychological phenomena—phenomena that have no concrete physical basis—require measurement as well. For example, an economist might use the Dow-Jones or NASDAQ index to track economic growth over time, a sociologist might use a questionnaire to assess people's attitudes about marriage and divorce, and an educational researcher might use an achievement test to measure the extent to which children are learning at school.

Valid, reliable measurement instruments are critical for any research endeavor. Thus, we explore measurement strategies in some depth when we discuss the research planning process in Chapter 4.

Statistics

As data come to us from the real world, they are unorganized, separate bits of information. They have no focus; they need to be managed in some way. Statistics provide a means to get order out of chaos.

Statistics have two principal functions: to help the researcher (1) describe the data and (2) draw inferences from the data. **Descriptive statistics** summarize the general nature of the data obtained—for instance, how certain measured characteristics appear to be "on average," how much variability exists among different pieces of data, how closely two or more characteristics are associated with one another, and so on. In contrast, **inferential statistics** help the researcher make decisions about the data; for instance, they might help a researcher decide whether the differences observed between two groups in an experiment are large enough to be attributed to the experimental intervention rather than to a once-in-a-blue-moon fluke. Both of these functions of statistics ultimately involve summarizing the data in some way.

Statistics are typically more useful in some academic disciplines than in others. For instance, researchers use them quite often in such fields as psychology, medicine, and business; they use statistics less frequently in such fields as history, musicology, and literature. But whenever we use statistics, we must remember that statistical values are not—and must not be—the final, ultimate goal of a research endeavor. The ultimate question in research is, *What do the data indicate?*, not What is their numerical configuration?—where do they cluster, how broadly do they spread, or how closely are they interrelated? Statistics give us *information* about the data, but a conscientious researcher is not satisfied until the *meaning* of this information is revealed.

Many beginning researchers erroneously think that calculating statistics is the final step in a research project, when in fact all they have done is to arrive at a few numbers that can help them interpret the data. Behind every statistic lies a sizable body of data; the statistic may summarize these data in a particular way, but it cannot capture all the nuances of the data. The entire body of data collected, not any single calculated statistic, is what ultimately must be used to resolve the research problem. There is no substitute for the task the researcher ultimately faces: to discover the meaning of the data and its relevance to the research problem. Any statistical process you may employ is merely ancillary to this central quest.

Furthermore, even the most sophisticated statistical procedures can never make amends for a poorly conceived research study. An editorial in the journal *Research in Nursing and Health* once made this point quite poignantly:

> The use of elegant statistics can never compensate for inelegant conceptual bases. The new evaluative procedures are exciting because they enable examination of data in ways previously not possible. The bottom line remains the same, however. One cannot draw large savings out of an account into which little has been deposited. Neither can one draw useful meanings from studies into which less-than-important notions have been entered. ("Use of Elegant Statistics," 1987, p. iii)

In the process of summarizing data, statistical analyses often create entities that have no counterpart in reality. Let's take a simple example: Four students have part-time jobs on campus.

One student works 24 hours a week in the library, a second works 22 hours a week in the campus bookstore, a third works 12 hours a week in the parking lot, and the fourth works 16 hours a week in the cafeteria. One way of summarizing the students' work hours is to calculate the arithmetic mean. By doing so, we find that the students work, "on average," 18.5 hours a week. Although we have learned something about these four students and their working hours, to some extent we have learned a myth: None of the four students has worked exactly 18.5 hours a week. That figure represents absolutely no fact in the real world.

Apparently, we have solved one problem only to create another. We have created a dilemma. If statistics offer us only an unreality, then why use them? Why create myth out of hard, demonstrable data? The answer lies in the nature of the human mind. Human beings can cognitively think about only so much information at any single point in time.[3] Statistics help condense an overwhelming body of data into an amount of information that the mind can more readily comprehend and deal with. In the process, they can help the researcher detect patterns and relationships in the data that might otherwise go unnoticed. More generally, statistics *help the human mind comprehend disparate data as an organized whole.*

Although a book such as this one cannot provide all of the nitty-gritty details of statistical analysis, we give you an overview of potentially useful statistical techniques in Chapter 11.

Language

One of humankind's greatest achievements is language. Not only does it allow us to communicate with one another, but it also enables us to think more effectively. People can often think more clearly and efficiently about a topic when they can represent their thoughts in their heads with specific words and phrases.

For example, imagine that you are driving along a country road. In a field to your left, you see something with the following characteristics:

- Black and white in color, in a splotchy pattern
- Covered with a short, bristly substance
- Appended at one end by an object similar in appearance to a paintbrush
- Appended at the other end by a lumpy thing with four pointy objects sticking upward (two soft and floppy, two hard and curved around)
- Held up from the ground by four spindly sticks, two at each end

Unless you have spent most of your life living under a rock, you would almost certainly identify this object as a *cow.*

Words—even those as simple as *cow*—and the concepts that the words represent enhance our thinking in several ways (J. E. Ormrod, 2012; also see Jaccard & Jacoby, 2010):

1. *Words reduce the world's complexity.* Classifying similar objects and events into categories and labeling those categories in terms of specific words make our experiences easier to understand. For instance, it is much easier to think to yourself, "I see a herd of cows," than to think, "There is a brown object, covered with bristly stuff, appended by a paintbrush and a lumpy thing, and held up by four sticks. Ah, yes, and I also see a black-and-white spotted object, covered with bristly stuff, appended by a paintbrush and a lumpy thing, and held up by four sticks. And over there is a brown-and-white object. . . ."
2. *Words allow abstraction of the environment.* An object that has bristly stuff, a paintbrush at one end, a lumpy thing at the other, and several spindly sticks at the bottom is a concrete entity. The concept *cow,* however, is more abstract: It connotes such characteristics as *female, supplier of milk,* and, to the farmer or rancher, *economic asset.* Concepts and the labels associated with them allow us to think about our experiences without necessarily having to consider all of their concrete characteristics.

[3] If you have studied cognitive psychology, you may recognize that we are talking about the limited capacity of *working memory*.

3. *Words enhance the power of thought.* When you are thinking about an object covered with bristly stuff, appended by a paintbrush and a lumpy thing, held up by four sticks, and so on, you can think of little else (as mentioned earlier, human beings can think about only a very limited amount of information at any one time). In contrast, when you simply think *cow,* you can easily think about other ideas at the same time and perhaps form connections and interrelationships among them in ways you hadn't previously considered.
4. *Words facilitate generalization and inference drawing in new situations.* When we learn a new concept, we associate certain characteristics with it. Then, when we encounter a new instance of the concept, we can draw on our knowledge of associated characteristics to make assumptions and inferences about the new instance. For instance, if you see a herd of cattle as you drive through the countryside, you can infer that you are passing through either dairy or beef country, depending on whether you see large udders hanging down between some of the spindly sticks.

Just as *cow* helps us categorize certain experiences into a single idea, so, too, does the terminology of your discipline help you interpret and understand your observations. The words *tempo, timbre,* and *perfect pitch* are useful to the musicologist. Such terms as *central business district, folded mountain,* and *distance to k* have special meaning for the geographer. The terms *lesson plan, portfolio,* and *charter school* communicate a great deal to the educator. Learning the specialized terminology of your field is indispensable to conducting a research study, grounding it in prior theory and research, and communicating your results to others.

Two outward manifestations of language usage are also helpful to the researcher: (1) knowing two or more languages and (2) writing one's thoughts either on paper or in electronic form.

The value of knowing two or more languages It should go without saying that not all significant research is reported in a researcher's native tongue. Accordingly, many doctoral programs require that students demonstrate reading competency in one or two foreign languages in addition to their own language. The choice of these languages is usually linked to the area of proposed research.

The language requirement is a reasonable one. Research is and always has been a worldwide endeavor. For example, researchers in Japan have made gigantic strides in electronics and robotics. And two of the most influential theorists in child development today—Jean Piaget and Lev Vygotsky—wrote in French and Russian, respectively. Many new discoveries are first reported in a researcher's native language.

The importance of writing To be generally accessible to the larger scientific community and ultimately to society as a whole, all research must eventually be presented as a written document—a *research report*—either on paper or in electronic form. A basic requirement for writing such a report is the ability to use language in a clear, coherent manner.

Although the conventional wisdom is that clear thinking *precedes* clear writing, in fact writing can be a productive form of thinking in and of itself. When you write your ideas down on paper, you do several things:

- You must identify the specific ideas you do and do not know about your topic.
- You must clarify and organize your thoughts sufficiently to communicate them to your readers.
- You may detect gaps and logical flaws in your thinking.

Perhaps it is not surprising, then, that writing about a topic actually enhances the writer's understanding of the topic (Kellogg, 1994; Shanahan, 2004).

If you wait until all of your thoughts are clear before you start writing, you may never begin. Therefore we recommend that you start writing your research proposal or report as soon as possible. Begin with a title and a purpose statement for your study. Commit your title to paper; keep it in plain sight as you focus your ideas. Although you may very well change the title later as your research proceeds, creating a working title in the early stages can provide both focus and direction. And when you can draft a clear and concise statement that begins, "The purpose of this study is . . . ," you are well on your way to planning a focused research study.

PRACTICAL APPLICATION Communicating Effectively through Writing

Judging from our own experience, most students have a great deal to learn about what good writing entails. Yet we authors also know that with effort, practice, expert guidance, and regular feedback, students *can* learn to write more effectively. Chapters 3, 5, and 12 present specific strategies for writing literature reviews, research proposals, and research reports. Here we offer general strategies for writing in ways that clearly communicate your ideas and reasoning to others. We also offer suggestions for using word processing software.

GUIDELINES

The following guidelines are based on techniques often seen in effective writing. Furthermore, such techniques have consistently been shown to facilitate readers' comprehension of what others have written (e.g., J. E. Ormrod, 2012).

1. *Say exactly what you mean.* Precision is of utmost importance in all aspects of a research endeavor, including writing. Choose your words and phrases carefully so that you communicate your *exact* meaning, not some vague approximation. Many books and other resources offer suggestions for writing clear, concise, and effective sentences and in combining those sentences into unified and coherent paragraphs (e.g., see the sources in the "For Further Reading" list at the end of the chapter).

2. *Continually keep in mind your primary objective in writing your paper, and focus your discussion accordingly.* All too often, novice researchers try to include everything they have learned—both from their literature review and from their data analysis—in their writing. But ultimately, everything you say should relate either directly or indirectly to your research problem. If you cannot think of how something relates, leave it out! You will undoubtedly have enough things to write about as it is.

3. *Provide an overview of what you will be talking about in upcoming pages.* Your readers can more effectively read your work when they know what to expect as they read. Providing an overview of what topics you will discuss and in what order—and possibly also showing how the various topics interrelate—is known as an **advance organizer**. As an example, a doctoral student in educational psychology, Dinah Jackson, was interested in the possible effects of *self-questioning*—that is, asking oneself questions about course material one is studying—on college students' note taking. Jackson began her dissertation's "Review of the Literature" with the following advance organizer:

> The first part of this review will examine the theories, frameworks, and experimental research behind the research on adjunct questioning. Part two will investigate the transition of adjunct questioning to self-generated questioning. Specific models of self-generated questioning will be explored, starting with the historical research on question position [and progressing] to the more contemporary research on individual differences in self-questioning. Part three will explore some basic research on note taking, and tie note taking theory with the research on self-generated questioning. (Jackson, 1996, p. 17)

4. *Organize your ideas into general and more specific categories, and use headings and subheadings to guide your readers through your discussion of these categories.* Take a moment to flip through the pages of this book. Notice how often we use headings to let you know what we will be talking about in upcoming paragraphs. In our own experience, students often organize their thoughts (their literature reviews, for example) without communicating their organizational scheme to their readers. Using headings is one simple way to make that scheme crystal clear.

5. *Use concrete examples to make abstract ideas more understandable.* There is a fine line between being abstract and being vague. Even as scholars who have worked in our respective academic disciplines for many years, we authors still find that we can more easily understand something

when the writer gives us a concrete example to illustrate an abstract idea. As an example, we return to Jackson's dissertation on self-questioning and class note taking. Jackson makes the point that how a researcher evaluates, or *codes,* the content of students' class notes will affect what the researcher discovers about those notes. More specifically, she argues that a superficial coding scheme (e.g., counting the number of main ideas included in notes) fails to capture the true quality of the notes. She clarifies her point with a concrete example:

> For example, while listening to the same lecture, Student A may record only an outline of the lecture, whereas Student B may record an outline, examples, definitions, and mnemonics. If a researcher only considered the number of main ideas that students included in their notes, then both sets of notes might be considered equivalent, despite the fact that the two sets differ considerably in the *type* of material recorded. (Jackson, 1996, p. 9)

6. *Use figures and tables to help you more effectively present or organize your ideas and findings.* Although the bulk of your research proposal or report will almost certainly be prose, in some cases it might be helpful to present some information in figure or table form. For example, as you read this book, look at the variety of mechanisms we use to accompany our prose, including art, diagrams, graphs, and summarizing tables. We hope you will agree that these mechanisms are critical in helping you understand and organize some of the ideas we present.

7. *At the conclusion of a chapter or major section, summarize what you have said.* Chances are, you will be presenting a great deal of information in any research proposal or report that you write. Summarizing what you have said in preceding paragraphs or pages helps your readers identify the things that are, in your mind, the most important things for them to remember. For example, in a dissertation that examined children's beliefs about the mental processes involved in reading, Debby Zambo summarized a lengthy discussion about the children's understanding of what it means to pay attention:

> In sum, the students understand attention to be a mental process. They know their attention is inconsistent and affected by emotions and interest. They also realize that the right level of material, amount of information, and length of time helps their attention. The stillness of reading is difficult for some of the students but calming for others, and they appear to know this, and to know when reading will be difficult and when it will be calming. This idea is contrary to what has been written in the literature about struggling readers. (Zambo, 2003, p. 68)

8. *Anticipate that you will almost certainly have to write multiple drafts.* All too often, we authors have had students submit research proposals, theses, or dissertations with the assumption that they have completed what they set out to do. Such students have invariably been disappointed—sometimes even outraged—when we have asked them to revise their work, usually several times. The necessity to write multiple drafts applies not only to novice researchers but to experienced scholars as well. For instance, we would hate to count the number of times this book has undergone revision—certainly far more often than the label "tenth edition" indicates! Multiple revisions enable you to reflect on and critically evaluate your own writing, revise and clarify awkward passages, get feedback from peers and advisors who can point out where a manuscript lacks clarity, and spend more time ensuring that the final draft is as clear and precise as possible.

9. *Fastidiously check to be sure that your final draft uses appropriate grammar and punctuation, and check your spelling.* Appropriate grammar, punctuation, and spelling are not just bothersome formalities. On the contrary, they help you better communicate your meanings. For example, a colon announces that what follows it explains the immediately preceding statement; a semicolon communicates that a sentence includes two independent clauses (as the semicolon in this sentence does!).

Correct grammar, punctuation, and spelling are important for another reason as well: They communicate to others that you are a careful and well educated scholar whose thoughts and work are worth reading about. If, instead, you mispel menny of yur words—as we our doing in this sentance—your reeders may quikly discredit you as a sloppy resercher who shuldn't be taken seriusly!

Many style manuals, such as those in the "For Further Reading" list at the end of this chapter, have sections dealing with correct punctuation and grammar. And dictionaries and word processing spell-check functions can obviously assist you in your spelling.

GUIDELINES Using a Word Processor

USING TECHNOLOGY

Fortunately, word processing software makes the revision process infinitely easier than it was in the days of manual typewriters. Most word processing programs include the following features:

- *Editing features.* Common editing features allow you to enter information quickly, change wording, and delete unwanted letters, words, and paragraphs. As you examine what you have written, it is easy to move sections of text from one location to another. In general, editing features give the researcher more freedom to write, critically examine what has been written, and make modifications as necessary.
- *Formatting features.* Common formatting features provide control over how the words appear on the page. If special emphasis is needed, a word can be highlighted by changing the type size or by underlining, *italicizing,* or using **boldface**. Text can be arranged in columns with various types of margins and alignments. Tables can be set up easily with borders and shading to highlight information. Most word processing programs also let the writer insert graphics quickly and easily into a body of text.
- *Special editing features.* Several special features have proved invaluable to writers using word processors. These include an *outliner* to facilitate the initial planning and organization of the major sections of a writing project; a *spell checker* to call attention to and make suggestions for suspiciously spelled words; a *thesaurus* to help the writer identify potentially more appropriate words and phrases; a *grammar checker* to detect potential problems in how words have been put together; and a *track changes* feature that enables collaborating researchers to identify changes that others make to a coauthored paper.
- *Search-and-replace-features.* These features enable you to scan an entire document very quickly for certain contents—perhaps a particular word, phrase, date, or punctuation mark—and, if desired, replace it with something else. For example, imagine that you want to replace the term *autism* with the broader term *autism spectrum disorder.* A *search-and-replace* command enables you to make the switch for the entire document automatically or, if you prefer, to look at your uses of *autism* on a case-by-case basis. Or imagine, instead, that you discover that you have misunderstood when semicolons are appropriately used. You can search a document for all of its semicolons and, as necessary, change them to more appropriate punctuation.

Word processing software is an invaluable tool throughout the research process; in fact, we authors don't know how we lived without it for as long as we did. For example, as the *study is being planned,* word processing software can be used for brainstorming and organizing ideas. As *literature is being reviewed,* the software provides one means of recording and organizing what others have written related to the topic of investigation. As the *study is being implemented,* the software can be used to generate various types of data collection instruments and to transcribe people's responses to such instruments as interviews and questionnaires. As the *data are being analyzed,* tables and graphics can be developed to help categorize and summarize patterns in the data. Finally, as the *final report is being completed,* it can be written in the proper form for review and potential publication.

We offer three general recommendations for using a word processor effectively:

1. *Save your document frequently.* This seems like such an obvious point that we almost left it on the editing room floor, but then we remembered all the personal horror stories we have heard (and in some cases experienced ourselves) about losing data, research materials, and other valuable information. Every computer user eventually encounters some type of glitch that causes

problems in information retrieval. Whether the electricity goes out before you can save a file, a misguided keystroke leads to a system error, or your personal computer inexplicably crashes, data sometimes get lost. It is imperative that you get in the habit of saving your work. Save multiple copies so that if something goes awry in one place, you will always have a backup in a safe location. Here are a few things to think about:

- Save at least two copies of important files, and save them in different places—perhaps one file at home and another at the office, at a friend's house, or in a safe deposit box. One good option is to save everything on a **flash drive**, an inexpensive device about the size of a package of gum that can hold a mind-boggling amount of information. One of us authors uses a single flash drive to save all of her past work (including the manuscripts of more than 20 books) and any in-progress work; she keeps this flash drive in her purse and takes it everywhere she goes. If her house burns down (she certainly hopes that it won't!), she will at least be able to carry on with her professional life.
- Save your work-in-progress frequently, perhaps every 10 minutes or so; many software programs will do this for you automatically if you give them instructions about whether and how often to do it.
- Save various versions of your work with titles that help you identify each version—for instance, by including the date on which you completed each file.
- 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.

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., such surnames 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 that was 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, 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 comes into play as well. The human mind is undoubtedly the most important tool in the researcher's toolbox. Its functioning dwarfs all other gadgetry. Nothing equals its powers of comprehension, integrative reasoning, and insight.

Over the past few millennia, human beings have developed several 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, the scientific method, theory building, and collaboration with *other* minds.

Critical Thinking

Before beginning a research project, effective researchers typically look at research studies and theoretical perspectives 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 methodology, inappropriate statistical analyses, and unwarranted conclusions. And, of course, effective 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 (Beyer, 1985; Halpern, 2008; Moon, 2008).

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; 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 society 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 these 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, however—we conclude that tulips are likely 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, and 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 is finite and small (premise), then 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 a faulty premise: that the earth is flat.

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 final 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 the questions people ask themselves (mentally) and try to answer as they learn (e.g., as they sit in class or read a textbook) affect 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?") Jackson's reasoning was as follows:

> If learning information in an associative, integrative fashion is more effective than learning information piecemeal, (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 class notes that are more integrative in nature. (Conclusion)

Such reasoning led Jackson to form and test the following hypothesis:

> 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 her hypothesis.

Inductive Reasoning

Inductive reasoning begins not with a preestablished truth or assumption but instead with an observation. For instance, 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 took another cracker from the tray on your high chair, held it in front of you, 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 so on—and invariably observed the same result. You probably eventually 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 population from which the sample has been taken. For instance, an anthropologist might draw conclusions about a certain culture after studying a particular 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 autism to recommend that teachers use the instructional approach with other students who have autism. A sociologist might conduct three surveys (one in 1995, a second in 2005, a third in 2015) asking 1,000 people to describe their beliefs about AIDS and then drawing conclusions about how society's attitudes toward AIDS have changed over that time.

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 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: *It is unlikely that a recovery might take place for those who exhibit flat EEGs for a period of 24 hours or more.* We cannot, of course, rule out the unexplored cases, but *from the data observed,* the conclusion reached was that recovery seems impossible. The EEG line from *every* case led to that *one* conclusion.

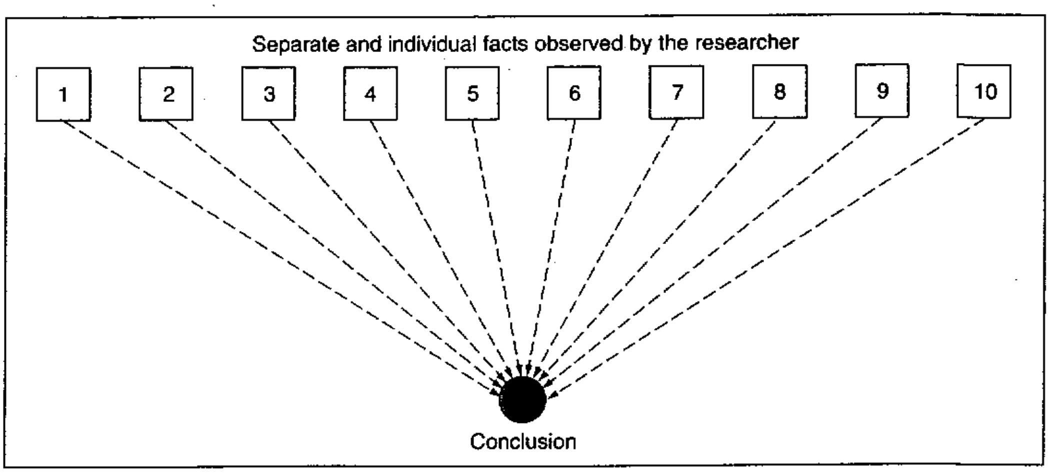
The Scientific Method

During the Renaissance, people found that when data are assembled and studied objectively and systematically, the data may yield previously undiscovered insights. Thus was the scientific method born; the words literally mean "the method that searches after 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 **scientific method** is a means whereby insight into the unknown is sought by (1) identifying a problem that defines the goal of one's quest; (2) positing a hypothesis that, if confirmed, resolves the problem; (3) gathering data relevant to the hypothesis; and (4) analyzing and interpreting the data to see whether they support the hypothesis and resolve the question that initiated the research.

Figure 1.1, which depicts research as a cyclical process, is a good illustration of the scientific method in action. We should keep in mind, however, that not all research methodologies follow the steps we have just listed in exactly that sequence. For instance, as you will discover when you read Chapter 6, such approaches as ethnographic research and grounded theory research involve collecting data and *then* developing one or more hypotheses about them. Rather than being a rigid, lock-step procedure, then, the scientific method is a somewhat flexible—although certainly also rigorous—process.

FIGURE 1.2
The inductive process



As you may already have realized, application of the scientific method typically involves both deductive logic and inductive reasoning. Researchers may develop a hypothesis either from a theory (deductive logic) or from observations of specific events (inductive reasoning). Then, using deductive logic, they make predictions about the patterns they are likely to see in the data *if* the hypothesis is true. And often, using inductive reasoning, they generalize from data taken from a sample to describe the characteristics of a larger population.

Theory Building

Psychologists are increasingly realizing that the human mind is a very *constructive* mind. People don't just take in and remember the innumerable pieces of information they acquire in a piecemeal fashion. Instead, they pull together what they learn about the world 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, 2012).

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—why the sun "goes down" at night, where babies come from, why certain individuals behave in particular ways, and so on. People's everyday, informal theories about the world are not always accurate. For example, imagine that as an airplane travels forward through the air, it drops a large metal ball. 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 (McCloskey, 1983).

What distinguishes the theory building of a good researcher is 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 under study.* 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 Schwarzchild 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-Schwarzchild hypothesis—and therefore also supported Einstein's theory of relativity.

As new data emerge that either do or do not support particular hypotheses, 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, relating the theory to other theories regarding overlapping phenomena, and so on (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, and so on. 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. Typically, three or more heads are even better. Any single researcher is apt to have certain perspectives, assumptions, and theoretical biases—not to mention gaps in his or her knowledge about the subject matter—that will limit how he or she approaches a research project. By bringing one or more professional colleagues onto the scene—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 (e.g., see Nichols, 1998).

Sometimes these colleagues enter the picture as equal partners. On other occasions 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—perhaps more importantly—will make a genuine contribution to the student's topic of study.

USING TECHNOLOGY

Collaborative interactions don't need to be face to face, of course. Technology offers many ways to facilitate collaboration across far distances. For example, we authors have found e-mail to be an excellent way to collaborate with colleagues in designing research studies and writing journal articles. One researcher will write a first draft of a proposed design or manuscript, send it to a *co-researcher* as an **attachment** to an e-mail message,[4] who will revise and add to the document and either send it to a third collaborator or back to the first person for inspection and further editing, and so on.

As a general rule, productive researchers keep in regular communication with others who conduct similar research in their field, exchanging ideas, critiquing one another's work, and so on. Such ongoing communication is also a form of collaboration—albeit a less systematic one—in that everyone can benefit from and build on what others are thinking and finding. Here, too, technology plays important roles. For example, some researchers maintain professional **web pages** 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. Also of value are **list servers**, which provide a mechanism for electronic discussion groups. A list server (sometimes abbreviated as "listserv") is essentially a mailing list, and any e-mail message sent to it is distributed to everyone who has subscribed to the list. Thousands of list servers on a wide variety of topics are available for subscription, often without charge. Through them, people can easily communicate with one another about topics of common interest. For example, if you like music, you can subscribe to list servers that focus on any number of special musical interests. As e-mail messages are received by a particular list server, you will automatically receive a copy.

At various points in the book we present exercises to help you apply concepts and ideas we have presented. In the first of these exercises, which follows, we ask you to identify ways in which you might use technology to draw on the wisdom of or more directly collaborate with others.

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[4]Depending on the e-mail software one uses, an attachment may instead be called an *enclosure*.

CONCEPTUAL ANALYSIS EXERCISE Using the Internet to Facilitate Communication and Collaboration with Others

USING TECHNOLOGY

Following are three scenarios. In each case, think about how the researcher might use the Internet to solve his or her problem. The answers appear after the "For Further Reading" list at the end of the chapter.

1. Arwin is a professor at a small college. Although his research is prominent in his field, few people on campus share his enthusiasm for his specialty—forensic pathology. Although Arwin avidly reads relevant academic journals, he looks forward to the annual meetings of his national organization, where he can exchange ideas with others who have similar interests. He wishes that such exchanges could occur more frequently.
2. Deirdre has a once-in-a-lifetime opportunity to spend 6 months in Australia collecting data about various marine plants of the Great Barrier Reef. Although she is excited about the opportunity, she realizes that the work of her campus research group will suffer. She wants to continue providing feedback on the group's ongoing projects and papers.
3. Recently Alexis read about a new corrective eye procedure being investigated at a major medical research institution. The work is possibly relevant to her own research, but she has questions about the procedures and long-term results.

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 that we do not look objectively at the data we collect. And sometimes we are so emotionally attached to particular perspectives or theories about a phenomenon that we cannot abandon them when mountains of evidence indicate that we should. Figure 1.3 describes 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.

Reflections on Significant 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.

Fleming, however, 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 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 particularly 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

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 that we have trouble separating 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 $a = F/m$ and therefore that if there is no acceleration ($a = 0$), then there is no force ($F = 0$), and vice versa. 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 Detroit—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.
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 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 hope that they don't find such evidence, of course, but they look for it nevertheless.
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 is not 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 are apt to think quite rationally and objectively when dealing with topics we do not 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 does not necessarily cause the other. The ability for a researcher to distinguish between causation and correlation is a critical one, as you will discover in Chapters 8 and 11.

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.

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.

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

If you wish to know 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 document will give you an insight into the way great research comes into being.

The procedures of great research are identical to those every student follows in doing a dissertation, a thesis, or a research report. All research begins with a problem, an observation, a question. Curiosity is the germinal seed. Hypotheses are formulated. Data are gathered.

Conclusions are reached. What *you* are doing in research methodology is the same as what has been done by 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 task to be meaningless busywork that has little or no relevance to the world beyond the university campus. This "busywork" conception of an academic program's research requirement is simply not accurate. Conducting the research required to write an acceptable thesis or dissertation is one of the most valuable educational experiences a person can have. Furthermore, a good research project adds to our knowledge about our physical and social worlds and so can ultimately promote the welfare and well-being of ourselves and the planet as a whole.

Even if you plan to become a practitioner rather than a researcher—say, a nurse, social worker, or school principal—knowledge of strong research methodologies and appropriate ways to collect and analyze data is essential for keeping up with advances in your field. The alternative—that is, *not* being well versed in sound research practices—can lead you to base important professional decisions on faulty data, inappropriate interpretations and conclusions, or unsubstantiated personal intuitions. Truly competent and effective practitioners base their day-to-day decisions and long-term priorities on solid research findings in their field.

As a way of getting your feet wet in the world of research, take some time to read articles in research journals in your own academic discipline. You can do so by spending an hour or two in the *periodicals* section of your local college or university library. Some libraries organize these journals alphabetically by title. Others organize them using the Library of Congress classification system, which allows journals related to the same topic to be placed close together (more about the Library of Congress system in Chapter 3).

Your professors should have suggestions about journals that are especially relevant to your academic discipline. Reference librarians can be helpful as well. In addition, especially if you are shy about asking other people for advice, you can get insights about important journals by scanning the reference lists in textbooks in your discipline.

Browse the journals related to your field just to get acquainted with them. Go first to those that pique your interest and skim a few studies that relate to particularly intriguing topics. Then, get acquainted with as many of the journals in your discipline as you can. Competent researchers have general knowledge of the resources available in their field.

Keep in mind that the quality of research you find in your explorations may vary considerably. One rough indicator of the quality of a research study is whether the research report has been juried or nonjuried. A **juried** (or *refereed*) research report has been judged by respected colleagues in one's field and deemed to be of sufficient quality and importance to warrant publication. For instance, the editors of many academic journals send submitted manuscripts to one or more reviewers who pass judgment on the manuscripts, and only manuscripts that meet certain criteria are published in the journal. A **nonjuried** (or *nonrefereed*) report is one that appears in a journal or on the Internet without first being screened by one or more experts. Some nonjuried reports are excellent, but others may not be.

PRACTICAL APPLICATION Identifying Important Tools in Your Discipline

In this chapter we have introduced several key tools used by researchers as they go about their work. These tools can, of course, be effective and helpful only to the extent that they are used—and used correctly.

Some of the tools you learn about in this book may be somewhat new to you. How will you learn when, how, and why you should use them? One effective means of learning about research tools is to work closely with an expert researcher in your field. Watch and observe this person in action as he or she uses a variety of research tools.

Take the time to find a person who has completed a few research projects—perhaps someone who teaches a research methods class, someone who has published in several journals, someone who has successfully obtained research grants, or even someone who has recently finished a dissertation. Ideally this individual should be someone in your own field of study. Ask the questions listed in the following checklist and, if possible, observe the person as he or she goes about research work. If you cannot locate anyone locally, it may be possible to contact one or more persons through e-mail.

✔ **CHECKLIST**

Interviewing an Expert Researcher

_____ 1. How do you start a research project?

____

____

_____ 2. What specific tools do you use (e.g., library resources, computer software, forms of measurement, statistics)?

____

____

_____ 3. How did you gain your expertise with the various tools you use?

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____

_____ 4. What are some important experiences you suggest for a novice researcher?

____

____

_____ 5. If I wanted to learn how to become a competent researcher, what specific tools would you suggest I work with?

____

____

For Further Reading

General Research Design

Bouma, G. D., & Ling, R. (2004). *The research process* (5th ed.). New York: Oxford University Press.

Goodwin, C. J. (2007). *Research in psychology: Methods and design* (5th ed.). New York: Wiley.

Luczun-Friedman, M. E. (1986). Introduction to research: A basic guide to scientific inquiry. *Journal of Post Anesthetic Nursing, 1*, 64–75.

McMillan, J. H., & Wergin, J. F. (2010). *Understanding and evaluating educational research* (4th ed.). Upper Saddle River, NJ: Pearson.

Nieswiadomy, R. M. (2012). *Foundations in nursing research* (6th ed.). Upper Saddle River, NJ: Prentice Hall.

Repko, A. F. (2008). *Interdisciplinary research.* Thousand Oaks, CA: Sage.

Rosnow, R. L., & Rosenthal, R. (2008). *Beginning behavioral research: A conceptual primer* (6th ed.). Upper Saddle River, NJ: Pearson.

Using Technology in Research

Angell, D. (1994). *The elements of e-mail style: Communicate effectively via electronic mail.* Reading, MA: Addison-Wesley.

Edyburn, D. L. (1999). *The electronic scholar: Enhancing research productivity with technology.* Upper Saddle River, NJ: Merrill/Prentice Hall.

Mills, S. C., & Roblyer, M. D. (2006). *Technology tools for teachers: A Microsoft Office tutorial* (2nd ed.). Upper Saddle River, NJ: Allyn & Bacon/Pearson.

Effective Writing and Word Processing

American Psychological Association. (2010). *Concise rules of APA style* (6th ed.). Washington, DC: Author.

American Psychological Association (APA). (2010). *Publication manual of the American Psychological Association* (6th ed.). Washington, DC: Author.

Beebe, L. (Ed.). (1992). *Professional writing for the human services.* Washington, DC: National Association of Social Workers Press.

Chicago manual of style (16th ed.). (2010). Chicago: University of Chicago Press.

Council of Science Editors. (2006). *Scientific style and format: The CSE manual for authors, editors, and publishers* (7th ed.). Reston, VA: Author.