

## SCENARIO

With your major in food science, you were delighted to find work with Sheffield Farms, a medium-sized supermarket chain in the Middle West. Your first assignment was to a small group that studies consumer food preferences and habits. The group leader is Shirley Gomez. One of your tasks was to research the readability of the new food labels required by the Food and Drug Administration.

You had sought volunteers among people shopping in Sheffield Farm stores. You had provided them labels to read and then questioned them on their understanding of the information on the label. To a high degree they understood the information provided about fat, cholesterol, fiber, protein, and so forth. But as you were conducting your research, you wondered how many Sheffield Farms customers actually made decisions based on the labels.

You brought the idea up to Shirley. “Good thought,” she said. “How would you go about it?”

“I can think of three ways,” you said. “Observation for one. Simply watch to see how many people read a food label when they take food off a shelf. Another would be to ask people at checkout how often they read food labels. Third, we could take some common purchase like cereal out of customers’ baskets, and without showing them the food label, try to find out how much of the information on the label they’re actually aware of.”

“Has anyone done this?” Shirley asked.

“My preliminary search in the journals and on the Web hasn’t turned up anything like what I’m proposing,” you said. “There has been a lot of focus group research about readability and decision making based on the labels, but I found nothing that checked their actual use by ordinary consumers. In any case, we haven’t done anything like this with Sheffield customers. If we find that most our customers really don’t use the labels, we might want to start an awareness program of some sort.”

“Well, check the lit some more,” Shirley said. “If you find the research you propose hasn’t been done, you might have a journal article. In any case, the research report could be useful for us in-house,” As an afterthought, she added, “Check your methodology with me before you begin, though. You can’t be too intrusive, or you’ll annoy our customers. Maybe you can offer people some small reward for answering your questions.”

And so empirical research reports are born. Someone sees a need for the research and checks the literature carefully to see if it really needs to be done. If the need is perceived, the methodology for carrying out the research is planned

and executed. When the results are in and analyzed, it's time to write the report, what this chapter is all about.

## ***chapter 17***

### **Empirical Research Reports**

- ▶ Audience Adaptation
- ▶ Introduction and Literature Review
  - Statement of Objectives
  - Choice of Materials or Methodology
  - Rationale for Investigation
  - Verb Tense in Literature Reviews
- ▶ Materials and Methods
  - Design of the Investigation
  - Materials
  - Procedures
  - Methods for Observation, Analysis, and Interpretation
  - Voice in Materials and Methods Section
- ▶ Results
- ▶ Discussion
- ▶ A Final Word

How do spiders produce their silk? Why do some foods cook better in microwave ovens than others? Why do certain hunter-gatherer tribes in Africa exchange gifts? Does the neutrino (a subatomic particle) have mass?

To get answers to questions of this kind, you can do two things:

- You can find, through research in libraries and on the Internet, the answers that researchers have obtained.
- You can obtain firsthand answers for yourself, by the direct empirical methods of experimentation and observation.

An illustration may help to clarify our point. Suppose that we have a chunk of glass, crude and irregular, dumped out of the ladle and unmolded. We desire to find the impact strength of the chunk of glass. That is, how many pounds of force will be required to shatter it? We may approach our solution in two ways:

- We may read up on the chemical makeup of the chunk of glass. We may measure its geometric properties. We may pass white light through it to obtain

a reading of its internal structure. By turning to suitable handbooks, we may then estimate the minimum impact force required to shatter the chunk.

- We can whack the chunk with a hammer, hitting harder and harder until it shatters. A pressure gauge or similar accessory will tell us how hard we had to hit to get the result we wanted. This is the pragmatic test, pure and simple.

The empirical research study places the emphasis on the second approach, but contains elements of the first approach. That is, before researchers embark on their observations or experiments, they wisely research the existing literature to see what is already known from past work in the area of the research.

The reports that result from such activities comprise four major sections that reflect how the research was carried out, what resulted, and an interpretation of the results:

- **Introduction and literature review:** research objectives and a review of past research in relevant areas
- **Materials and methods:** how the research was performed
- **Results:** the data revealed by the research
- **Discussion:** interpretation and evaluation of the results

When put into final form, the empirical research report may also contain the usual elements found in reports, such as tables of content, abstracts, and references. Where the research is reported—usually either in a journal article or a student thesis—will determine the exact format. Because we cover the additional parts in Appendix B, Formal Elements of Document Design, we deal here only with the sections just listed. Figure 17-1 shows a complete report. Skim through it before you continue on.

## AUDIENCE ADAPTATION

To illustrate the characteristics of empirical research reports, we draw upon Figure 17-1 and excerpts from several other research reports. We have been careful to select passages that you should be able to read regardless of your specialization. On several occasions, however, we do define terms that a nonspecialist might not know. We place these definitions in brackets to distinguish them from the authors' work. Our need to define terms demonstrates a major point about audience adaptation in empirical research reports. Experts write these reports for their fellow experts, and thus they are free to use a professional vocabulary. When you write a research report, you may use the standard vocabulary and standard knowledge of your field and expect your audience to understand you. In fact, your audience would be annoyed if you took time to define familiar terms or explain well-understood concepts.

At times, however, even in reports written for your fellow experts, you may be moving to the fringe of what is standard knowledge. If you use a new term or

a highly specialized one, you will have to define it, using the definition techniques we describe on pages 185–188. Nor is there any reason in writing for experts to set aside the concepts of good style discussed in Chapter 5, Achieving a Readable Style. A heavy, pretentious style, full of long convoluted sentences is a bad style, no matter the audience.

## **INTRODUCTION AND LITERATURE REVIEW**

When research reports are presented in journal articles, most often the introduction and literature review are integrated as they are in Figure 17-1. The major function of this integrated section is to describe the subject, scope, significance, and objectives of the research.

The literature review, as the name implies, reviews the scientific literature pertinent to the research being reported. In it the author defines the problem being investigated as a way of leading to a statement of objectives. The author may also use the literature review to explain a choice of materials or methodology, or show the rationale for the investigation.

Because space in journals is expensive, the integrated introduction and literature review is held to information absolutely necessary to the investigation. However, when a research report is presented as a student thesis rather than as an article, the literature review is often quite extensive and is given separately from the introduction. The purpose of such a detailed review is not only to introduce the research but to demonstrate the writers mastery of certain subject matter. In writing a thesis, always check with your adviser to determine the type of literature review required and the subject matter coverage desired.

Read now the introduction and literature review of the article in Figure 17-1.

As is typical of a scientific research article, this article is documented by parenthetical references (see Documentation in Appendix B). The authors use the literature cited to define the nature and scope of the problem. We know from the introduction that the researcher's objectives are to determine the impact of the pales weevil on forestry, nursery, and Christmas tree management, the management tactics used to combat the weevil, and the research needs of state forest health officers. We will expect before the article is finished to know how well those objectives were met.

### **Statement of Objectives**

Objectives may be stated in various ways. Frequently, they are expressed as questions, as in this passage from a report on discourse communities:

1. What were the salient features of the discourse community under investigation that influenced or complemented writing activity?
2. What was the interrelationship of genres and the discourse community in which they were used?
3. What issues arose when writers had to learn new genres as they moved from academic contexts for writing to this professional context for writing?<sup>1</sup>

Sometimes, objectives are presented as a hypothesis, as in this study of the abilities of infants:

The general hypothesis of these studies were as follows:(a) Infants know that an object exists even when it is not visible or sounding, (b) they can learn and remember the outcomes of two auditory–visual events, and (c) they can subsequently engage in actions appropriate to the outcomes with no supporting perceptual signal.<sup>2</sup>

No matter how you present your objectives, be sure to present them with absolute clarity. No doubt should exist in the reader’s mind concerning what you were up to in your research.

### **Choice of Materials or Methodology**

Literature reviews are sometimes used to explain the choice of the materials used in the investigation, as in this passage:

Brentids [weevils] make good candidates for studies of sexual selection and individual variation because most species of the family exhibit pronounced sexual dimorphism [differences between the sexes in characteristics such as size and color] (Muizon, 1960; Haedo Rossi, 1961; Damoiseau, 1967, 1971). The males generally possess greater body length, a stouter rostrum [beak or snout], and more powerful mandibles [jaws], one of which may be grossly enlarged (Darwin, 1871). Within each sex there is impressive phenotypic variation in body size, especially in males, which fight one another with snout and mandible for access to females (Wallace, 1869; Meads, 1976). The most size-variable brentid may be *B. anchorago*: after examining a large series of this species, Sharp (1895) commented that “the variation in length is enormous, and perhaps not equaled in the case of any other species of Coleoptera, small males being only 10–11 mm long, while large examples of the same size attain 52 mm.” Such variation in size is common within a single aggregation, and is important in male mating success, in female choice, and in patterns of mating in the aggregation as a whole.<sup>3</sup>

Similarly, the investigator could use the literature review to explain or justify a choice of methodology.

### **Rationale for the Investigation**

Often the rationale for the investigation lies in past research. That is, past research may not have solved a problem adequately, or perhaps it was faulty in some way. There may be many reasons, and the investigator can use the literature review as a medium to express the reason or reasons for the research that he or she has conducted. The close of the introduction in Figure 17-1 presents such a rationale:

State forest health officers were targeted because they keep abreast of forest pest activity and are often called upon to make recommendations or develop programs for residents of their state.

### **Verb Tense in Literature Reviews**

Choosing proper verb tense is frequently a problem in writing a literature review. It will help to keep these principles in mind. When referring to the actual work that researchers have already done, use the past tense. When referring to the knowledge their research produced, if the content is still considered to be true, use the present tense. Thus the literature review usually mixes together past and present tense as shown in this passage in which we have italicized the verb forms:

While significant improvements in ceramic technology *have been made* and *are currently being evaluated*, the issue of ceramic component reliability *has been raised* at this high temperature. An alternative to ceramic filter technology is sintered metal filter technology. Metal filter systems *offer* reduced potential for brittle failure. . . .<sup>4</sup>

### **MATERIALS AND METHODS**

The major criterion by which you can measure the success of a materials and methods (M & M) section is simply stated: An experienced researcher in the discipline should be able to use the information in this section to duplicate the research. For a second criterion, an experienced researcher should be able to use the information in this section to evaluate the research. If these criteria are not met, the M & M section fails.

M & M sections follow a fairly definite pattern incorporating some or all of the following parts:

- Design of the investigation
- Materials

- Procedures
- Methods for observation, analysis, and interpretation

The M & M section in Figure 17-1 consists of methods only. But every M & M section should contain all the information needed to meet the criteria of duplication and evaluation.

### **Design of the Investigation**

When you have a complex design, give your readers an overview before you plunge them into the details. The overview need not, usually should not, be elaborate. Some turtle researchers gave it in one sentence and, indeed, included in the same sentence information about the materials used:

The effect of temperature on sex determination was studied in turtles of the subfamily Emydinae, genera *Graptemys* (map turtles), *Pseudemys* (sliders), and *Chrysemys* (painted turtles), from populations in the northern U.S. (Wisconsin) and southern U.S. (Alabama, Mississippi, and Tennessee).<sup>5</sup>

### **Materials**

Materials can be human, animal, vegetable, or mineral. They are whatever you used by way of subjects, material, or equipment to do your research. In a report for the social sciences, instruments such as questionnaires would be described in this section. Remember that your descriptions of your materials have to be accurate enough to permit your readers to obtain or make similar materials. In the case of animals and plants, this usually means using the scientific as well as the common names. If you have a good deal of necessary information about your subjects or materials, use a table to display some of it. Equipment used throughout the experiment should be described, as in this passage:

A bank of five parallel G.E. G8T5 germicidal lamps were used to generate ultraviolet light predominantly at 254 nm. The uncovered dishes to be irradiated were placed on a rotating platform 82 cm from the light source. A 10 cm diameter aperture midway between the light source and the rotating platform was used to collimate the incident light and to reduce shielding by the sides of the culture dishes.<sup>6</sup>

### **Procedures**

In the procedures part, you describe for your readers step by step how you did your investigation. The description should be as complete as necessary, but remember that you are writing for an expert audience. When you are working with a procedure or equipment common in the discipline, you do not need to describe it in detail. However, if you anticipate that your readers might have

some question about why you conducted some step as you did, take time to explain.

You can save a great many words by referring to procedures described elsewhere rather than repeating the information found in the original source as in this passage:

The methods for digoxigenin labeling of RNA probes, tissue preparation, and in situ hybridization were as described by Bradley, et al. (1993).<sup>7</sup>

This is an excellent practice as long as you don't refer to sources inaccessible to your readers either by reason of geographic location or obscurity.

### **Methods for Observation, Analysis, and Interpretation**

When such information is applicable, tell your readers how you observed your materials during the investigation and how you analyzed and interpreted your results. Because methods of observation, analysis, and interpretation are often quite standardized, this part can frequently be quite short.

### **Voice in Material and Methods Sections**

In the passages we have quoted from M & M sections, the authors have used far more passive voice than active voice sentences. In most cases it is either obvious that the researchers performed the steps described, or it is unimportant who performed them. Under such circumstances, passive voice is as good a choice as active voice, perhaps even a better choice. But don't fear using active voice and first person when they seem appropriate to you. Most modern style books encourage such practices, and an occasional *I* or *we* reminds your readers that real people are at work. The author of the report in Figure 17-1 follows such advice and uses *I* freely.

Also, remember that passive voice used carelessly creates a great many dangling modifiers: "After drawing the blood, the calf was returned to the pen." Here the case of the blood-drawing calf can be cleared up with judicious use of active voice: "After drawing the blood, I returned the calf to the pen." (See pages 92–93, 198.)

## **RESULTS**

Because your results section answers the questions you have posed, it is the most important section of your report. Nonetheless, it is often the shortest section of an empirical report. It often takes a great deal of work to gain only a few bits of knowledge.



Begin your results section with an overview of what you have learned. The first sentence or two should be like the lead in a newspaper story, where the main points are quickly given, to be followed in later paragraphs by the details. Because the report in Figure 17-1 is organized into sections that reflect its multiple objectives, each section, rather than the whole begins with such an overview, with details presented in tables and graphs. If you make good use of tables and graphs, you do not need to restate such details. But you may want to refer to key data, both to emphasize their significance and to help your readers comprehend your tables and graphs.

## **DISCUSSION**

Many research reports combine the results and discussion sections as is done in Figure 17-1. Whether separate or combined, the discussion interprets and evaluates the results. It answers questions such as these:

- Was the hypothesis proved or disproved, or did the experimental results prove to be inconclusive?
- Are there any doubts about the results? Why? Was the methodology flawed? How could it be improved?
- How do the results compare with results from previous research? Are there areas of disagreement? Can disagreements be explained?
- What are the implications for future work?

Though the discussion section may cover a lot of ground, keep it tightly organized around the answers to the questions that need to be asked.

If major conclusions are not presented during the discussion or if there are certain conclusions the author wishes to emphasize, the report may contain a conclusions section, as is the case in Figure 17-1.

## **A FINAL WORD**

In this chapter we have given you general advice about reporting empirical research. If you are to become a professional in any field that requires such reporting, doing it well will be of vital importance to you. Therefore, we strongly urge you to examine representative journals and student theses in your discipline. Observe closely their format and style. Most journals have a section labeled something like "Information for Contributors." This section gives guidelines for manuscript preparation and style. Often it will refer you to the style manual, such as *The ACS Style Guide*, that governs the journal. Likely your library will have a copy of the manual you need. Read it carefully. It will supplement what you have learned here.

## **PLANNING AND REVISION CHECKLISTS**

*You will find the planning and revision checklists that follow Chapter 2, Composing, and Chapter 4, Writing for Your Readers, valuable in planning and revising any presentation of technical information. The following questions specifically apply to empirical research reports. They summarize the key points in this chapter and provide a checklist for planning and revising.*

## **Planning**

- What is the subject of your research? The scope? The significance?
- What were your objectives? How can you best state your objectives? As hypotheses? As questions? As a statement of purpose?
- What do you want to accomplish with your literature review? Definition of the research problem? Explanation of choice of materials and methods? Rationale for investigation?
- Is your report going to be a journal article or a thesis? If a thesis, have you consulted with your thesis adviser about it?
- Do you have the following well in mind for your materials and methods section?

Design of the investigation?

Materials?

Procedures?

Methods for observation and interpretation?

- Are all your results in? Can some of them be tabulated or displayed in charts or graphics?
- Which of these questions need to be answered in your discussion section?

Do the results really answer the questions raised?

Are there any doubts about the results? Why? Did you find at some point that the methodology was flawed? How could it be improved?

Were the research objectives met?

Was the hypothesis proved or disproved?

How do the results compare with results from earlier research? Are there areas of disagreement? Can disagreements be explained?

What are the implications for future work?

## Revision

- Will your reader know the subject, scope, significance, and objectives of your investigation? Are your objectives stated absolutely clearly?
- Have you used past and present tenses appropriately in your literature review?
- Would an experienced researcher in your field be able to use your materials and methods section either to duplicate your investigation or to evaluate it?
- Have you used active voice and passive voice appropriately in your materials and methods section? If you have used passive voice, have you avoided dangling modifiers?
- Do the first few sentences of your results section present an overview of the results? Have you used tables and graphs when appropriate?
- Have you kept your discussion tightly organized around the questions that needed answering?

## EXERCISES

1. Empirical research is primarily concerned with fact-finding and interpretation. Do you see any similarity between empirical research and recommendation reports (Chapter 16)? In what major respects are they different?
2. Referring to Chapter 8, Gathering, Evaluating, and Documenting Information, determine how the methods used to gather information are affected by the nature and purpose of the investigation. How do the techniques discussed in Chapter 8 relate to empirical research?
3. Choose a research problem in your discipline, perhaps with the help of an instructor in that discipline. Research the literature in the problem until you can formulate an empirical study to deal with some aspect of the problem. Then write an introduction and literature review and a materials and methods section for the study. (What you will have when you finish is what a great many scientific and technical departments require as a proposal to conduct thesis research.) Submit your work to both your writing teacher and the teacher in the discipline.
4. Divide the class into groups by discipline and let each group choose a recorder to summarize its discussion. Each group is to choose an empirical research report published in a journal in its discipline. With the help of this chapter and the style manual that governs the journal, if one is available, the group then discusses the report's format, style, organization, and content. How closely does the report follow the principles of this chapter and the style manual? Does it differ in any significant ways?

Following the group discussions, the summaries become the basis for a full class discussion.

5. Using an empirical research report from your field, do the following exercise.

Imagine that you are at work on your first job after graduation. You have read an empirical research report that contains information that might be useful for the company for which you work. Report the research to decision-making executives in your company. Write the report in language they will understand. Executives will have little interest in methodology. Rather, they will want answers to questions such as these:

What was investigated? Why? What were the results? What were the conclusions of the researcher? What are the implications of the research for the company? What are your conclusions and recommendations as to possible actions the company might take to use the research?

Chapters 2, Composing, and 4, Writing for Your Readers, will be helpful for this exercise. Write your report as a memo (see Letter and Memorandum Format in Appendix B).

**FIGURE 17-1 • Empirical Research Report**

Source: Scott M. Solam, "Status and Management of Pales Weevil in the Eastern United States," *Tree Planters' Notes* 48 (1997): 4–10.