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Proposal Writing

Introduction

After you have begun background research on your topic and have a preliminary hypothesis, you Will Write your proposal. A proposal is a document that describes the proposed experimental design of your research project. Essentially, it is a paper written by you to show your teacher that (a) you understand the background of your topic, (b) you have a testable hypothesis, and (c) you have an appropriate procedure to test that hypothesis. In the proposal you also address safety and ethical issues. The proposal will include the following six components: title, introduction, experimental design table, hypothesis, materials, and methods. If necessary, your proposal will also contain one or more appendixes.

Learning Objectives

The main objective of this chapter is to have you put together a proposal for your research project.

By the end of the chapter, you should also be able to

1. explain the purpose of writing a research proposal,
2. defend the need for a detailed methods section in a proposal,
3. describe how pre-trials might apply to your own research project, and
4. analyze the disagreements that scientists and journal editors have about various aspects of scientific writing.

Key Terms

Pretrial: A pretesting of experimental methods with the purpose of tweaking the procedure before actual data collection begins.

Proposal: A written document that describes the proposed experimental design of a research project.

Depending on your situation, either your classroom teacher or a mentor will be the one to guide you through the proposal process. If you are working with an industry or university mentor, your experience is likely to differ from that of your classmates. For example, if you are working in your mentor's lab, the procedure of your experiment is probably already determined. However, it will be your job to fully understand and be able to explain the procedure adequately that means spending time in the lab-acquainting yourself with the entity being studied, the equipment being used, and the background knowledge required to perform the experiment. Your mentor may be the one to review and provide feedback on your proposal or he or she may ask- your teacher to do that. From this point on in this book, the term teacher will be used to represent either teacher or mentor.

Writing the proposal is a process. Do not View it as a one-time effort. Your teacher will provide feedback, most likely in the form of questions, that will help you to clarify-in your mind as well as on paper-what you intend to do. Then you will probably rewrite the proposal to address the issues that your teacher has highlighted. This exchange between you and your teacher may happen several times before your teacher gives his or her approval to the proposal and says that you can begin your research study.

The Proposal Components

Write the proposal paper with the following six headings: Title, Introduction, Experimental Design Table, Hypothesis, Materials, and Methods. (Your proposal might also contain one or more appendixes.) Follow these formatting rules for the headings in your proposal:

- Center each heading on the page.
- Use Times New Roman or Arial font and 12 pt. type.
- Do not hold or underline the headings and or put any of them in all capital letters -so, no **Hypothesis** or Hypothesis or HYPOTHESIS. Simply use: Hypothesis.

Title

List the working title for your research project. Titles should be concise, descriptive, and informative. They should be written in scientific style and therefore not in the form of a question. At a minimum, the independent variable and dependent variable must be included, but the more descriptive titles are, the better. Provide genus and species names of organisms and specific chemical names rather than vague references. So, for example, a better title than "Do Radish Seeds Prefer Acid or Bases?" would be "Effect of pH on *Raphrmus sativus* Seed Germination."

Introduction

The purpose of the introduction section is to state the problem or topic and why you are studying it. You will explain how you are addressing the problem and how you plan to find a solution (Day and Gastel 2006). The introduction is more than just a "literature review" (i.e., a summary of all the

journal articles you have read) or a collection of all the background information you have gathered. More information about how to write an introduction as well as how to properly document this section will be found in Chapter 10. (It is possible that your teacher may not want you to write an introduction as part of the proposal. If you do not write it now, you will write it later as part of the final paper.)

Experimental Design Table

Update your Research Design Table to match this proposal. That will allow your teacher to compare your intended research design with the methods you are now proposing. Your teacher will make sure that your procedure will actually test what your hypothesis is predicting.

Hypothesis

State the hypothesis that was approved by your teacher at the end of Chapter 4.

Materials

Provide a list of the materials required to conduct your experiment. Include supplies needed to set up the experiment, consumables (items that will be used up during the experiment), tools and instruments used for measurement, and any additional items you will use.

Include exact technical specifications for each material listed, such as purity of chemicals, their concentrations, and their suppliers; the type, brand, and model of each apparatus; and genus and species along with characteristics such as age or sex of organisms. Be sure to give amounts (in metric units) when applicable. For example, instead of listing “water,” list "600 ml of distilled water.” The genus and species of any organism should be italicized. Furthermore, if an item is listed in the materials section, it must be listed in the methods section, and vice versa. It is easiest to write the methods first, then go back and list the materials.

Methods

The purpose of the methods section is to describe how the experimental design procedure will be carried out. This section should be written in enough detail so that another person would be able to replicate the experiment. The methods section also allows your readers to “judge the appropriateness of the experimental methods” and therefore the extent that the results can be generalized (Day and Gastel 2006, p. 60). The methods section describes the “how” and "how much” of the experiment and makes up the bulk of your proposal.

Before Writing the Methods Section

Before you begin writing the methods section of your proposal, you may need to do two things.

1. *Refer to your background research*. Read up again on various procedures that will help you obtain the measurements you are seeking. You may need to do more background research to find additional or supplemental procedures.

2. *Run some pretrials*. A pretrial is a pretest of experimental methods that you conduct to tweak the procedure before actual data collection begins. Pretrials will help you during the proposal-writing phase to describe in specific detail what you propose to do for your

experiment. Pretrials also increase your chance of success with your experimental design because you can work out any kinks before collecting data.

Running pretrials can mean different things depending on your research topic. In the case of a seed germination project, for example, the pretrial may involve trying several seed types before choosing a specific species. For a range-of-motion project, pretrials may require that you receive training on how to use a goniometer and practice taking measurements accurately so you can write a precise description of how the measurements will be taken. For a stream ecology project, you may practice various methods of recording water velocity to determine the best method for your experiment. And for a behavioral study, you might develop and pretest categories or surveys to fine-tune them.

Using the Narrative Approach in the Methods Section

Traditionally there are two ways to write the methods section. Some teachers prefer that you write it as a step-by-step, numbered procedure-a set of instructions. Other teachers may prefer it in a narrative form (or an essay, as you would call it in English or history class). The narrative form is the one used in scientific journals. Both step-by-step and narrative method sections must include enough detail so that another individual would have no questions if he or she wanted to replicate your experiment exactly. If you are asked to write a narrative proposal, here are some suggestions for paragraph organization.

- Start the methods section with a paragraph discussing how the experiment will be set up. What preparation will need to be done before the experiment can be started? Describe any pretrials that were used to help determine the methods. Be sure to mention the number of entities being studied, how they will be labeled or organized, and the items and tools that will be used to structure the setup.
- The next paragraphs of the methods section should detail what is done on “Day 1" of the experiment. Day 1 is the first day that data are collected. In this description, use the scientific vocabulary you learned about your entity while doing background research. For example, when describing how the angle of a plant stem will be measured, use the technical scientific terms for plant structures, such as *internodes, petiole, node, and blade*. If the data collection methods will be repeated, you can tell the reader how often and with what experimental groups the methods will be used-for example, ”The procedure will be repeated for a total of four trials for each amount:0 milliliters, 15 milliliters, 30 milliliters, and 45 milliliters.

Frequency of Data Collection and Number of Trials

When writing the methods section, you might ask (as many students do), How often should I collect data?” or "How many trials do I have to do with each group?” The answers to those questions depend on two factors

1. The variation in the entity being studied. Organisms or objects that have a greater chance of variation in the data collected than other entities might require more trials or measurements taken for longer periods of time. For example, to account for sensitivity of protists, you should use more organisms to begin with and as much data should be recorded

as is reasonable. However, for a study comparing altered catapults, where there is less chance of variation in the data, you may need to collect fewer data points. However, the more data or trials you have for each level of the independent variable, the more confidently you will be able to state the results.

2. The speed at which data are available. For your experiment, decide how quickly you expect changes will occur and plan your data-collection days accordingly. For example, for bacteria growth, you may choose to collect data every day (maybe even every 12 hours) for the first week. But for a slower-moving experiment, or one that includes trials that you determine, you may only need to collect data every two to three days to get appropriate data for your analysis. Your background research and pretrials should help you make this determination.

Describing Your Data Collection

Answer the following questions. Then, in your methods section, use your answers to describe your data collection.

- How will data be collected?
- How will measurements be taken?
- How will the data be measured or obtained?
- What tools and techniques will be used?
- How will qualitative observations be recorded (if applicable)?
- How often will data be collected and recorded?
- How long will the experiment last?
- How does your research design address potential extraneous variables (address each variable individually)?

After you have carefully described how data will be collected, describe the hourly, daily, weekly, or monthly tasks that you will need to complete to maintain the environment in which the experiment is taking place. What measurements or observations, such as temperature or humidity, will you record throughout the experiment?

You may be asked to rewrite the methods section several times until your teacher is confident that the research design has been developed enough to give you the best chance at testing what your hypothesis is predicting. The methods section of your proposal can be challenging, but it is a critical part of the experimental research process. Receiving repeated feedback from your teacher will keep you from having serious problems later when you are collecting and analyzing the results.

Appendixes

Appendixes (note that the preferred spelling for the plural of appendix is appendixes, not appendices), which are found at the end of the proposal or final paper, can be any items that are too big to fit into the context of the paper, such as large tables, figures, survey questionnaires, or safety or ethical documentation.

If your research included using surveys or questionnaires, you must include as an appendix the actual survey questions that you plan to administer. If your experiment required that you submit

documentation to an Internal Review Board (IRB), Scientific Review Committee (SRC), and / or Institutional Animal Care and Use Committee (IACUC), the signed approval documents or consent or assent forms themselves must be included in the appendix (see www.societyforscience.org/ isef/document).

You may not begin any of your research until all forms have been I approved by the committees. (See Chapter 1 for more detail about safety and ethical documentation.) In the methods section, be sure to refer the reader to the documents located in the appendix.

Scientific Writing

Students, young researchers, and even Veteran researchers often believe that scientific writing should be filled with technical, terminology-filled jargon, long sentences, and the passive voice. None of these assumptions are true. Good scientific writing is concise ar_t'd accurate and uses as few words as necessary. You should never write a sentence of 15 words if the same thought could be Written in 9. For example,

> ***Wordy****: in the present report, the results of an experiment are described in which coffee and tea drinkers were tested to see whether-*
>
> ***Better****: We tested coffee and tea drinkers to find out whether*

If "technical references to equipment or scientific vocabulary cannot be avoided, do not assume that the reader knows everything you have learned; therefore, explain terminology the first time it appears in your paper. For example, if you used a centrifuge to do your experiment, explain what a centrifuge is the first time you refer to it.

Writing a scientific paper is actually more similar to writing a paper for English class than you might have thought. Many of the skills you have learned in English apply to your research writing, such as paragraph organization, construction of strong topic sentences, and proper spelling and grammar. However, there are some misconceptions of scientific writing that must be clarified.

The "voice'' of research writing is a topic of dispute among scientists (Day and Gastel 2006). A sentence can be written in active voice or passive voice. In active voice, a subject performs the action. This type of sentence uses an active verb with a clear link to the subject. For example, "We or ["the researchers"] heated the solution to 44°C." The individuals (we) who performed the action (heated) are clear. In passive voice, the emphasis is put on what was done rather than who did it. The previous example written in passive voice could be, "The solution was heated to 44°C." Who performed the action is left out of the sentence entirely. In years past, passive voice was always used in scientific writing. According to scientists of that time, passive voice helped the reader focus on what was done, not on the individual who did it. (For that reason, the passive voice is sometimes still preferred for methods sections.)

Since the late 199os, however, editors of scientific journals have come to prefer the use of active voice. This switch to active voice naturally led to the dispute of whether or not pronouns should be used in scientific writing. In the case of passive voice, the pronouns I, us, or we can be avoided. Active voice, on the other hand, requires that pronouns be used. Although some researchers prefer passive voice,

others think it results in awkward sentences and a pompous tone. (For more on the different uses of active and passive voices go to www.biomedicaleditor.com/active-voice.html.)

Table 5.1 highlights the different types of writing and when each style is appropriate. Notice the use of second person is never acceptable in scientific writing.

Your science teacher will determine the voice you should use (active or passive) and whether or not you will be allowed to use pronouns. Researchers trying to publish their papers professionally must refer to an individual journal's author requirements before beginning to write because STEM journals have varying requirements for scientific writing. Many STEM-based journals indirectly advise authors to write in the active voice by referring writers to a style manual that supports active voice. Some journals' style guides ask that passive voice be used in the methods section but that active voice be used in all other parts of the paper. The style guides of the following professional associations (all having to do with science) recommend the use of pronouns and active voice as much as possible, but accept passive voice with the absence of pronouns as appropriate for methods sections: American Institute of Physics (AIP), American Chemical Society (ACS) American Medical Association (AMA), and American Psychological Association (APA).

Table 5.1

Use of Active Versus Passive Voice and of Pronouns in STEM Research Papers

Sample Sentence	Voice and Pronoun	Comment
"I will remove the ball hearing."	Active voice First person pronoun {Future tense)	Appropriate when writing a proposal.
"I removed the ball bearing."	Active voice First person pronoun (Past tense)	Appropriate when writing the final paper.
"The ball bearing will be removed."	Passive voice No pronoun [Future tense)	Appropriate when writing a proposal, especially in the methods section.
"The ball bearing was removed."	Passive voice No pronoun (Past tense)	Appropriate when writing the final paper, especially in the methods section.
• "You should remove the ball bearing." • "Remove the ball bearing."	Second person Directive	Never appropriate. These sentences are written as directions For someone else to follow rather than as an indication of what the researcher intends to do or has done.

Chapter Questions

1. What is the purpose of writing a research proposal? Who benefits from your writing of a research proposal?
2. Why must the methods section in a proposal be so detailed?
3. How might pretrials apply to your own research project?
4. Why do you think scientists and journal editors disagree about various aspects of scientific writing?

Chapter Applications

It's time to write your first draft of your proposal. You can expect your teacher to have you write the proposal several times until you have shown him or her that you have done adequate research, that your research design is appropriate for testing your hypothesis, and that you have taken appropriate safety and ethical issues into account. As you receive feedback, think carefully about the questions and comments posed by your teacher. Remember all suggestions are meant to help you sharpen your ideas as well as your writing.

If working with others on your STEM research project, hold a meeting to discuss group members' strengths and assign tasks as you did before conducting background research. Document your discussion in writing and have each member sign. Then turn the document in to your teacher for accountability. Once your teacher approves your proposal, the next step in the research process is to prepare a laboratory notebook. Chapter 6 shows you how to do that.

References

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