



GUIDE FOR TEACHING BASIC RESEARCH CONCEPTS AND SKILLS

INTRODUCTION

This guide is intended as a resource for teaching the concepts and methods of research to students. It will help you show students how to frame questions, then do research to answer them in a systematic and productive way.

RESEARCH: A CRITICAL SKILL

The ability to do research well is a critical skill for students growing up in the Information Age. Learning to conduct research teaches important thought processes -- analysis, organization, evaluation and problem solving -- that they will use throughout their lives.

Today, television, newspapers, radio, magazines, and the Internet constantly bombard us with more information than anyone can possibly use or remember. Students have at their fingertips the wisdom of the ages and the accumulated knowledge of millions of individuals – as well as an overwhelming amount of misinformation, propaganda and pure nonsense. The ability to sift the important from the irrelevant and to find clear answers in a sea of data has become an important survival skill, one that students will be able to use in almost all aspects of their lives. That is what research is all about.

WHAT IS RESEARCH?

Students often think of research as "something scientists do", a complicated and mystifying activity that generally takes place in a laboratory. Depending on which movie they see, research can either lead to wondrous breakthroughs, like time travel, or terrible catastrophes, like giant lizards stomping large cities. Of course, neither one of those scenarios is an accurate picture of real research.

In its most basic form, research is asking a question and gathering information to answer it. It's something most of us do frequently in our personal lives and in our jobs. Students should understand, however, that genuine research is marked by certain characteristics that set it apart from casual, random information gathering.

Research is a process -- a way to answer questions by systematically and purposefully collecting and evaluating relevant information. That process insures that you get the best possible answer to your question. Once you have mastered the process, you can apply it to a myriad of questions in any field of knowledge.



BACKGROUND RESEARCH

The most common type of research is background or resources research. When you do background research you are looking for answers that someone else has already found or for existing information that will allow you to decide the answer for yourself. This is the type of research that most students do in the course of their educations. At its most basic level, it involves consulting reference books to answer a simple question. At the highest level, it may require sophisticated searches for obscure information and careful interpretation of the data. Background research is also the first step in experimental, or observational, research, the second type of investigation, sometimes referred to as the scientific method.

A young student may wish to know why skunks are black and white. An encyclopedia or a book on wildlife will tell her that the black and white coloration is a warning to potential predators that the skunk should be avoided. A more advanced student may then want to know more about the evolutionary basis for warning coloration, seeking information in textbooks or popular books on the subject. A student at a still higher level may be led into related topics, such as Batesian mimicry, in which a harmless species mimics a dangerous one, often tricking predators into avoiding it. That student may begin with textbooks, but may also end up by reading original research papers, or at least summaries of them in specialized books on the topic.

These students will be going through different levels of the same background research process. The process has five steps.

1) Selecting a topic

The topic is the subject of the research question. It is best to narrow the subject down as far as possible when starting a research project. The most common mistake students make is to select a subject that is too general, such as "animals" instead of "skunks".

2) Identifying the research question or questions

This is the most important step of the entire process. Repeat: this is the most important step of the entire process. As someone once said, an imprecise question has an infinite number of possible answers.

A research question must be clearly and carefully defined, which generally means that it must be narrowed down to a very specific query. For instance, rather than asking, "Why are animals colored like they are?", it is better to ask "Why is a skunk colored black and white?", or better yet, "What is the evolutionary advantage to a skunk of being black and white?"

The first question is so broad that it would require at least a chapter in a text book to cover all the possible answers. In the end, the "right" answer would depend on which



species you were talking about. The second and third questions are specific enough to have definite answers.

Research questions must also be answerable. This may sound obvious, or even silly, but it is an important point. Some questions do not lend themselves to objective answers. An example is Bill Cosby's comic question, "Why is air?". A good research question should lead to an objective answer: that is, one that relies on facts or on theories that are supported by facts. Opinions or speculation are no substitute for information.

Other questions cannot be answered because we don't yet have the knowledge. There are several theories about how and where life started on Earth, for instance. We don't know enough to say which one, if any, is true.

3) Selecting and evaluating resources

In our age of information technology, there are myriad sources to consult. Two points students should consider:

- are the information sources reliable? and
- are they appropriate?

Both of these points will be discussed in more detail later.

4) Collecting data

If the research question is stated properly, it should be easy to decide which information to collect: only that which will help answer the question. One mistake for students to avoid: going into their data collection with a preconceived idea of what the answer is. If they think they already know the answer, they may unconsciously ignore or discard data that contradict their answer. An open mind is a critical tool for a good researcher.

5) Determining an answer

Hopefully, there will only be one answer to the question. However, it is not uncommon to find that there are different opinions, even among experts, because of a lack of conclusive evidence. "We don't know" (or better yet, "They don't know") is a valid answer, but it should be followed by a summary of the possible answers and the evidence for each. The student's answer may not be the final answer, but it should be the best answer that can be obtained from the existing information. Science has many more unanswered questions than answered ones, and very few final answers.

OBSERVATIONAL/EXPERIMENTAL RESEARCH

Observational, or experimental, research is a special type of investigation that follows a carefully defined set of steps known as the scientific method. It is what many people think of when they talk about scientific research.



The steps of the scientific method are: background research (often not mentioned); forming a hypothesis, designing a research strategy; collecting data; analyzing data; preparing results; discussing results; and conclusions.

This guide is not designed to help you show students how to conduct experimental or observational research. But it is important for them to understand that background research is the first step in the basic process that drives human discovery. The concept of process is the critical idea that students need to understand when doing research.

Two examples will show the importance of process in doing research.

A few years ago, a Wildlife Conservation Society scientist made an exciting discovery. One day, while watching the Indian elephants at the zoo, she noticed that she sometimes felt slight vibrations in the air, a bit like those made by a stereo when the bass setting is very low. She knew from her studies that whales communicate with each other over very long distances, using noises far too low in pitch for humans to hear. She also knew that elephants seem to have an uncanny ability to find each other and to coordinate their movements in the bush, even when they are widely separated. She wondered whether elephants might be using very low sounds -- too low for human hearing -- to keep in touch over long distances.

Further background research showed her that no one else had suggested this idea, so she designed a study to test the hypothesis. Using special equipment, she recorded wild elephants in the African bush while tracking their movements. When she analyzed her data and prepared the results, she concluded that elephants did, indeed, seem to communicate over distances of as much as two and a half miles through sub-audible rumbles. When she was sure of her data and her conclusions, she published them in a scientific journal, explaining exactly what she had done, what the results were, and what conclusions she had drawn from those results. (It is important for students to understand that research is not conducted to prove a theory or hypothesis, but to test it. Good research requires an open mind.)

Now consider the well known story of the scientists who, in 1989 announced that they had discovered a nuclear fusion process that operated at normal temperatures. So-called "cold fusion", which could provide almost unlimited cheap energy for the world, had been a dream for decades. The study filled the news media for weeks and the two were hailed as heroes. However, questions began to pop up from other scientists, who questioned the methods used by the two men and the conclusions they drew from their experiments. Significantly, although numerous other scientists tried to repeat the experiments exactly as the two men described them, no one else (including the two original scientists) was able to get the same results. Today, cold fusion remains as far from reality as it was before their announcement.



EVALUATING RESOURCES FOR RESEARCH

As mentioned earlier, students have access to an overwhelming amount of information. Not all information is equal, however. Students must learn to distinguish valid information from opinion, hearsay or misinformation, all of which are common, especially on the Internet. Good research requires not only an open mind, but also a healthy skepticism.

There are two important questions to ask when evaluating an information source. The first of these is: How good is the information? Stories, hearsay and one-time observations are never as good as data obtained from a controlled study or extended observation. An article that says, "I felt sick after taking an aspirin" is not as useful as one that cites a medical study that found that 11 out of 113 patients felt sick after taking aspirin.

Accounts from someone who is an expert are generally more reliable than those from someone who is not. Newspaper stories about scientific subjects are often unreliable: few reporters have the training or background necessary to report accurately on science. Furthermore, they are often rushing to meet deadlines, so they end up sacrificing accuracy and depth for speed and simplicity.

The second question students should ask about information is: How reliable is the source? There are a number of points to consider when assessing an information source.

Is the information firsthand? Secondhand? First-hand information is original with the person providing it – the results of an experiment or an observation. Secondhand, thirdhand or whateverhand information is someone else's account of that information. It may be accurate or it may be different from the original. Think of information as a photograph. If that photograph is copied on a copy machine (a "second generation" image), it loses some of its detail and color. A copy of the copy (third generation) will be even less like the original. A tenth-generation copy may retain only the general outlines of the original. The closer data are to the primary source, the more reliable they are likely to be.

Another way to demonstrate this idea is to have students play the game where a sentence is given to one student, who whispers it to the next student, and so forth until it has been passed all through the class. The original sentence and the last student's version are then written on the blackboard and compared. There are almost always differences. (It is not unusual for some students to deliberately alter the sentence as they pass it along. This is not only unavoidable, but can actually reinforce the point of the exercise: in the real world, people often deliberately alter information to suit their own purposes.)

If the information is not firsthand, is there reason to believe that the source is reliable? If the information is written, what are the author's qualifications to write on this subject? Does he or she identify the sources of his or her information?



The information may be in an encyclopedia or a textbook, which are generally considered reliable sources for students (although not always up to date). Or it may be from a popular book about animals or nature. In that case, it becomes a matter of judgment. The important point is that students stop to think about whether the information can be trusted.

Does the source rely on generalities such as "studies have shown" or "scientists have proven"? Statements like these can't be relied on unless the person using them cites the studies or names the scientists, at the least.

Could the source of the information be biased? If the information is part of a controversial issue, it is important for students to know which side, if any, the source is on, since this might bias the information. It is not uncommon, for instance, for industries to provide teachers with "educational materials" (often free) that are little more than disguised propaganda.

Obviously, the standards for evaluating information will be very different for students at different levels. Teachers should adapt the principles discussed above to the levels of their own students. It is important, however, to start all students thinking about the quality and reliability of the information they are receiving.

STARTING POINTS FOR RESEARCH

Your school library and your local public library should have many reference books on animals, ecology and conservation. A good reference librarian will direct students to the proper materials for their subjects and grade levels. Standard encyclopedias are often good starting places; for more detailed information about animals, students might want to look at Grzimek's Animal Life Encyclopedia, a set of 13 volumes published in the 1970's but still very useful. Many encyclopedias are also available on CD-ROM (such as the Eyewitness Encyclopedia of Nature) or even online (Encyclopedia Britannica). Your local zoo may have a library that students can visit; it might include the very helpful ZooBooks series on selected animal topics (or visit www.zoobooks.com). Students should always cite the sources of their information so that readers can corroborate their facts.

GUIDELINES FOR STUDENTS USING THE INTERNET/WORLDWIDE WEB:

- 1) Check to see if the information you have accessed is from a reputable source. Remember: anyone can post anything on the Internet and much of the available information is unreliable. Reputable sources include:
those that represent well known institutions, organizations, libraries or universities;
those that are electronic forms of well known print magazines or journals, such as National Geographic Magazine, Wildlife Conservation or Scientific American.
- 2) The Internet is a fluid medium and information changes often. When accessing information from a reputable site, students should make sure that the information is up to



date and current. In most cases, they should see a date associated with the presented information.

3) When citing information from a website, students should provide the full web address and the date they accessed the site.

The best way to start a search for information on the Worldwide Web is with a search engine. There are many such engines: among the most recommended are Northernlight.com, Fastnet (alltheweb.com), Dogpile.com, Google.com, altavista.com and Askjeeves.com (which gives answers to questions submitted, rather than keywords).

Suggestions for types of questions

In suggesting questions for your students or in evaluating their questions, it may be helpful to use the National Science Education Content Standards for the Life Sciences as a starting point.

Some sample questions might be:

Content Standard #1: Structure and Function in Living Systems

Q.: How do a tiger's stripes help it survive?

Q.: How does a bat find insects in the dark?

Content Standard #2: Regulation and Behavior

Q.: Why do wildebeests live in large herds?

Q.: Why do wildebeests migrate?

Content Standard #3: Populations and Ecosystems

Q.: Why are there many wildebeests and relatively few lions?

Q.: How do so many kinds of grass-eaters all live together on the African plains?

Content Standard #4: Reproduction and Heredity

Q.: Why are wildebeest babies able to run almost as soon as they're born?



Q.: Why are wildebeest babies all born at almost the same time?

Content Standard #5: Diversity and Adaptation

Q.: Whales are descended from animals that lived on the land: how did they change when they went back to the sea?

Q.: Why is the modern horse so large when the original horse was only the size of a dog?

(For an excellent discussion and illustration of these five content standards, see *Wildlife Wise: Wildlife News for Teachers*, Vol. 11, No. 2, published by the Bronx Zoo Education Department.)

General points:

- Research questions need to be specific and answerable.
- Research questions should also be appropriate to the student's level of knowledge and understanding. A question that involves evolutionary theory might be enlightening to a good high school student, but it would be inappropriate for a typical fifth grader.
- A good question should also stretch and extend the student's knowledge and understanding of the world.

Good luck to you in guiding your students through their research endeavors!