

Hints for Writing a Technology Research Paper

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Abstract

This paper provides hints for undergraduate students faced with writing research papers for technology classes. Ideas, tips, and guidelines are presented and practical examples are shown when appropriate. This paper is formatted according to manuscript format as defined by the American Psychological Association's style guide and may be used as a formatting example for assignments that specify APA manuscript format. Guidance given in this paper should be taken secondary to any direction provided by your instructor.

Hints for Writing a Technology Research Paper

Introduction

Research papers are usually assigned to expose the student to a specific topic in much greater depth than is possible in an average lecture-based class. Research paper topics are typically relevant but slightly tangential to the core classroom material. Writing a research paper properly requires the student to search for, find, and read a variety of different resources about the subject. Students get access to opinions besides what they hear from the instructor and they get practical experience with the difficult task of formal writing.

Instructors and schools both feel that research papers are very important. Typical colleges and universities have writing requirements for all upper-level classes. The ability to collect information from many sources and synthesize it into a coherent written work is a major goal. Many people would consider this ability to be what defines a "college person" from someone who has not been to college. Any student who is serious about school should be serious about their writing and should always take maximum pride in anything that has their name on it.

At the undergraduate level, there can be a lot of confusion about what the instructor expects from the student. Frequently, the student finds himself with a vague topic and a staggering length requirement packaged up in an incredibly short deadline. The perceived pressure to create something flawless causes many students to wait until the last minute. Sometimes the pressure is so great that otherwise good students will resort to cheating by

copying part or all of a reference or another student's paper. What doesn't always get said is that it is OK to be less-than-perfect.

An undergraduate research paper should have a few flaws in its logic. It should have some grammatical inconsistencies. It should have a few citation mistakes. It should be a little less polished than most think. Most of all, it should be a learning experience. The student should learn about the topic and about the writing process every time a research paper is written. The student should also learn from mistakes and should be happy to accept a lower grade and advice on what to change next time. A student should never be content with a low grade and no explanation, but a student should also not get a perfect score and not know how it got that way. Accept that your writing ability is a work in progress, just as you as an undergraduate are a work in progress. Do not take this advice to mean that deliberately shoddy or lazy work is acceptable.

Working with Topics

Sometimes your life is easy and you are given a firm topic with clear guidelines. Most times, you find yourself struggling to just figure out what is expected from you. When starting a research paper, identifying a clear and firm topic is the first major hurdle.

Choosing a Topic from a List

You will frequently be asked to choose a research paper topic from a list provided by your instructor. How do you choose a topic when you have never heard of anything on the list? Or even worse, how do you choose a topic when all options provided are equally boring or uninteresting? Unfortunately, if you are faced with a choice of equally dull topics your best bet

may be to flip a coin, throw a dart, or just take the first one on the list. You can always ask if you may choose your own topic, but be prepared to discuss what you have in mind.

If you don't know anything about some or all of the topics, you can do a quick survey relatively easily using the World Wide Web (WWW). Use a search engine like <http://www.google.com/> and enter a possible topic title along with words like beginner, tutorial, explanation, introduction, how-to, or other words that might help to find a simple description of the technology being addressed. If you spend five minutes per topic doing this, you should be able to assemble a very elementary understanding of all provided topics. Along the way, it is likely that you will encounter some facet of a particular topic that peaks your interest.

What to Do When You Must Choose Your Own Topic

Choosing your own topic, especially if you do not already know something about the technology being discussed, can be a more difficult task than actually writing the paper. Situations are different, but if appropriate you should ask for suggestions from the instructor and talk with fellow students about what they have chosen. If there is no clear choice for you and you are feeling lost, just talking with classmates may ease your fears since there is a good chance that others feel the same way.

If you do not have the opportunity to talk to classmates, you can try talking to your instructor. Try asking for example topics, what kinds of topics other students have done in the past, or what area is most appropriate for you based on your work in the class so far. Your instructor may not be approachable for some reason or you may be told that the challenge of choosing a topic is intended to be part of the learning process, leaving you no closer to a solution.

If you have talked with classmates and your instructor and are still at a loss, then you may end up turning to the textbook. For example, you could treat the table of contents of your textbook as a list of topic suggestions. A computer textbook chapter titled "Computing Security" could have subheadings that suggest research paper topics like

- "Digital Security Challenges"
- "History of Computer Crime"
- "Personal Computer Security"

Not only have you found a working topic for your research paper, but you have identified your first reference.

How to Establish the Scope of a Topic

Many research paper topics are vague and could lead to whole books by themselves. Others may be so specific that they could not possibly need more than a single page to cover in detail. When choosing a topic, it is very helpful to have a topic that is focused enough to give you guidance while loose enough to give room for modification as you write. Before you write the first word of your paper, you should establish the scope of your topic to give yourself guidance and boundaries. Scoping a topic may include setting limits, such as

- Limits of time, stating that you are going to discuss development of a technology between certain dates
- Limits of depth, stating that you will only discuss detail to the point where a person of some skill level will understand your paper
- Limits of breadth, stating that you will cover specific aspects of the technology, acknowledging that others will not be covered

- Some combination of the above

Defining the scope of your paper early will help to prevent you from writing the wrong paper. It is common for a student to start writing a paper about a particular topic and then get off on an interesting tangent that ultimately makes the whole paper about something else. If you say to yourself at the beginning that you will work within certain boundaries, then you will have a better chance of focusing on your topic.

Writing a Topic Proposal

Occasionally you will be asked to write a proposal for a research paper or a project. This is more common in situations where you choose your own topic. This is also almost exclusively found in upper-level classes where a certain degree of expertise and experience with writing is assumed. For most people the first topic proposal they ever write is one of the most difficult assignments they have ever done, but this is because the idea of a proposal is a little foreign. In practice a proposal can be made up of two parts, "introduction" and "scope."

A topic proposal is usually a written agreement between you and your instructor, defining what your research paper will cover. If you are choosing your own research paper topic and writing a proposal for the paper there is a good chance that your topic is new to your instructor, so it is important to introduce the topic first. The proposal should give just enough information so that the instructor can be acquainted with the subject's major points.

The second part of the proposal defines what you will do. It is a common mistake to try to actually "do" what you will do, instead of stopping with the definition. This is what makes a proposal so hard for people. An easy way to look at it is to compare writing a proposal to planning a weekend driving trip. We are going to go for a trip, but we have to be back by dark.

We want to spend at least four hours in whatever city we visit so we need to factor in driving time there and back. We want to visit a city with a museum and a cathedral. This defines our trip, but it doesn't say anything about where we will go! For example, if our trip originates in Stuttgart, Germany, we could easily get to Munich, Zurich, or Strasbourg in a day. All three cities meet the distance, museum, and cathedral requirements, but our proposal does not mention them. We merely define what we will do, what limitations we have, but we do not *do* what we will do.

The shortest, simplest proposal will thus have two paragraphs to cover the introduction and scope. A larger research paper will have a larger proposal, obviously, and a proposal for a project will have more detail about proposed experiments. Even if a proposal is not required, you may find that writing one first will clarify to yourself what it is you are trying to do. An example of a proposal is shown in Figure 1.

Topic Proposal: "Home Computer Security"

Andrew Seely

Class Number and Term

Date

Security has always been a key concern for members of any society. Historically, security has been an issue of physical proportions, where people have been worried about protecting their bodies, their families, their possessions, and their homes. Computers have become pervasive in our culture as the tools used to process information, and as a result information has come to have a very tangible value even though information itself is an intangible quality. The value of information has increased such that even non-technical people have computers in their homes and process a large amount of information that has value. This information is at risk of loss from a criminal element or act of God and so must be protected like any other valuable.

This paper will present a detailed overview of the key risks every home computer user should be aware of every time the computer is turned on. Social issues, legal ramifications, and practical safeguards will be examined in terms of the novice personal computer owner's experience. A comparison between corporate computer security practices and home user threats will be made, allowing conclusions to be made about the relevance of industry security practices to the average user.

Figure 1. A simple example of a research paper proposal.

What to Do When Your Topic Is Too Big or Too Small

One of the most important structural aspects of your paper is its balance. If your paper addresses three different aspects of a technology, for instance, relatively equal weight should be given to all three aspects. You know your topic is too broad if you start writing a ten page paper with three main points and end up writing eight pages about the first point. You know that your topic is too narrow if you have written all you know about all three points and you only have three pages.

When you find yourself in the first situation you have three courses of action: You can keep within your length limit and cram the remaining information into an unbalanced space, you can go over your length limit and give equal weight to all points, or you can re-scope your topic. While not always possible, the last option is really the best. If you re-define your paper topic, even in the latter stages of writing, to fit the material you have then you will be turning in a balanced paper with good coverage of the topic. Undergraduate research paper topics almost always evolve as you write the papers anyway, and you will likely find that the paper you turn in is not the paper you thought you were going to write when you started. Acceptance of this fact, combined with flexibility, will allow your final product to be something you can turn in with pride.

The second situation is a little more difficult. Having too much is easy, as you can shave something off. Having too little is a challenging situation. In this case, the only viable solution is to expand your topic. Take your current topic and see how it fits into a bigger picture; if you can identify other topics that are similar in subject and scope to your own, you can incorporate them into your paper. For example, if your original topic is "Hand-held Devices and Computer Circuitry" and your research has left you with a paper that is 75% short, you could expand your topic in two easy directions. "Aspects of Hand-held Devices" could include your current work on computer circuitry as well as video displays, user interfaces, and battery technology. Choosing additional topics like this and modifying your topic to include the broader scope will give you what you need to present a balanced paper that meets minimum length requirements. You could also modify this topic along the circuitry idea, exploring aspects of computer miniaturization or alternative processing paradigms.

Writing an Outline and Dealing with Minimum Length

Writing an outline may be the single most helpful thing you can do when you are faced with writing a research paper of a certain length. There are a few tricks you can use to make the outline easier to create and more useful to use.

Pages and Headings

Instructors like to assign a minimum length to ensure that a topic is adequately researched, proving that the student read enough sources and did enough outside study to really learn something independently. Students tend to like length guidelines as it gives them a goal; a paper with no length qualification seems like a giant hole waiting to suck you in. If your assignment does not specify a length and you do not know what to do, ask for advice. Your instructor may make a suggestion of what lengths are typically submitted or how long a particular paper might be given a similar topic and scope. Be prepared to answer questions about your scope; writing an informal topic proposal for your own sake may answer this question for you. Once you are relatively sure of the length you will attempt to write, you can lay out an outline to provide structure towards that length.

The balance and length of the paper are directly related. If you have three points for your topic, you will want to devote a similar amount of space to each point. If you are writing a ten page paper, you might want to spend two and a half to three pages per point, leaving one to two and a half pages for introduction, conclusion, summary, recommendations, etc. If you are writing three pages per main point, you could determine three aspects of each point that are worth detailing. One page for introductory discussion, one page for summary and conclusions,

and nine pages of body results in eleven pages, very close to the stated length of ten pages. If you make each one of these "pages" an outline bullet, you have successfully made the transition from writing a ten-page paper to writing ten one-page papers.

Dividing Your Topic into Manageable Subtopics

After your topic has been decided, the best thing to do is attack it with a divide-and-conquer approach. No one writes a good ten-page research paper in one sitting, and you should not even try. Keeping in mind the need to maintain balance, you should attempt to divide your topic into two to five different subtopics, each of which should be divisible into two or three aspects. For example, say your topic is "Personal Computer Security". Since it is obvious from the hundreds of computer security books already available that you could write a whole book on personal computer security, you would first scope your topic down to something like "Computer Security for the Home Computer User." Using this topic, brainstorm all the possible subtopics you can think of in ten or twenty minutes. You may come up with subtopics like "keeping your kids out of your email," "safe shopping on the internet," "preventing theft of computer hardware," "backing up essential files," "virus protection," and "system upgrades." When you have a long enough list, stop and throw out anything that is obviously inappropriate. With the rest, choose the top three or four to be your main subtopics.

For each subtopic, decide on two or three things that you will discuss. For example, "keeping kids out of your email" may give you discussions about "discretionary access methods," "user authentication issues," and "challenges of multi-purpose computers in multi-user environments." "Safe Shopping" could be discussed in terms of "the bad guys," "specific risks for the casual user," and "relevant laws." "Virus protection" could be approached as "types of

viruses," "how viruses spread and who creates them," and "preventative measures and event recovery." Assuming that your paper will have an introductory section and a conclusion, summary, or recommendations section, you have all you need for a solid outline like the one shown in Figure 2. Notice how the A, B, C headings can be written independently, making your paper a collection of closely-related short papers.

Title: Computer Security for the Home User	
I.	Introduction
II.	Keeping the kids out of your email – a discussion of user access challenges
	A. Discretionary access methods
	B. User authentication issues
	C. Challenges of multi-use computers in multi-user environments
III.	Safe shopping
	A. The 'bad' guys
	B. Specific risks for the casual user
	C. Relevant laws
IV.	Virus protection
	A. Types of viruses
	B. How viruses spread and who creates them
	C. Preventative measures and event recovery
V.	Summary and conclusions
VI.	References list

Figure 2. Example of a working outline for a ten-page research paper.

The Difference between Summary, Conclusion, and Recommendations

Summary, conclusion, and recommendations are three very different ideas that are frequently confused by undergraduate research paper writers. Be sure to use the correct technique if one is specified in your research paper assignment. You are probably safe to use your best judgment if there is no specification, but any research paper should end in a clear and clean fashion. A typical research paper should have a summary. The summary should not be a

copy of the introduction, but should concisely restate the arguments of the body of the paper.

The introduction, on the other hand, should be a broad-stroked overview of the general topic that presents what main points will be developed in the body. For example, the introduction of our security paper may introduce the concept of security in the computing world in general, identify the home user as a particular segment of the population of computer users, and then raise specific points, the primary subtopics that are vital to the home computer user's concept of security. The summary, on the other hand, would focus on the subtopics, perhaps showing how they work together in a cohesive model of focused computer security.

While a summary is just a final presentation of the primary sections of your paper, a conclusion may introduce a new idea, but only if it is based strictly on the contents of the body of the paper. A basic rule of thumb is that you can say something new in a conclusion, but you can not introduce new references. Conclusions are the result of the synthesis of the basic knowledge explained in the body of your paper. For example, your paper on computer security in the home may discuss the topics and subtopics we have outlined, but it may leave out some over-arching point that can be concluded from what you have said. You may discuss proper access control methods, good online shopping practices, and wise virus protection measures in the body of your paper, but it is in the conclusions section where you might make a statement, solely supported by the arguments in the body of your paper, that corporate security standards are relevant to the home computer user because the home computer user must face a similarly large range of threats.

A recommendations section introduces your opinion into your research paper. Based on what has been covered in the home computer security paper, for example, you could make a reasonable recommendation that a home computer user use anti-virus software with certain

features or that the user's operating system be updated with security patches at certain intervals. The conclusions section makes a new point that can be easily derived from what you have said in the body, but the recommendations section makes new points that can be easily argued or disputed, though in general they should be firmly grounded in your paper. Avoid frivolous recommendations or recommendations that may become quickly obsolete. Poor recommendations may be for home users to throw away their computers to avoid security problems, a recommendation that undermines your whole paper, or that a new computer should cost at least \$1,000 in order to get all the security benefits, a recommendation that is rooted in a volatile consumer market where prices change rapidly without warning. Not every paper needs a recommendation section and some may even be made worse with it. Avoid making recommendations unless the assignment specifically calls for them.

Writing an Abstract

An abstract is a simple one-paragraph overview of your whole paper. Formatting guidelines typically specify how long an abstract should be, with maximum lengths usually around 300 words. An abstract should touch upon all the top-level main points. It should mention the main focus of the research paper. It should state any methods of experimentation used and any conclusions drawn. If recommendations exist in the paper, the abstract should say that the paper will provide recommendations but it should not detail what they are. The key to an abstract is the "top-level" view of it, with main points, key methods, results, and precious little else. You must be careful not to write your paper all over again in your abstract while still creating a comprehensive overview of what you have written.

Most research papers will not require an abstract. Even though some formatting guides specify where they go and what they look like, you should not write an abstract for your research paper unless specifically instructed to do so. An abstract serves the same purpose as a cover letter for a resume, helping someone who must quickly assess relevance of your work. Typically, an abstract is used in papers that are intended for publication or papers that are very long.

When you are writing an abstract, think of it like this: Someone you do not know and will never meet is looking for a research paper that contains information that may be found in your work. This person has hundreds of papers to read, and so is only reading abstracts to find papers that seem close. Your abstract should give a good enough overview of your paper to allow it to be selected if it is indeed relevant.

On rare occasions you may be tasked to write an abstract for a research paper you haven't written yet. This is not an easy task. Consider how you have learned to write an outline without writing the paper. The abstract may be written in the same way, but with some speculation on your part. Use your outline to write the abstract, taking the main Roman numeral points for the bulk of your abstract and extrapolate to what you expect your conclusions to be. An abstract written before the paper does not need to be perfect, but it does need to be pretty close to what the paper will be.

Doing Research

Unless you have personally created, invented, or developed everything in your research paper, you will need references or sources to back up your work. A research paper without sources is ultimately nothing more than a personal opinion.

The reason for references is so that you may say things that are "true" without any responsibility for just how "true" they are. If you are writing about physics, for example, and you say that gravity affects an object with acceleration of 9.8 meters per second per second without a citation or a description of an experiment that you did, then you could have just made it up. Forget for a minute that this figure is commonly known as the correct number; without a repeatable experiment in your paper, your reader must take your word for it. What if you decided to round up to make the math easier to follow: 10 m/s^2 rather than 9.8 m/s^2 ? Now you are stating as fact something that is quite wrong, and your reader may never know. This causes any "fact" in a research paper to be read with mistrust by an experienced reader unless there is a repeatable experiment described to support the fact or there is a citation to another source that may be considered trustworthy.

While it seems tedious at first, you should attempt to have a source for everything in your research paper that you state as a "fact." The most common student complaint is that the resulting research paper is not "mine," it is just a collage of other information. This is exactly correct; a research paper is a collage. If your paper is 75% cited work collected from other sources, you may well have written a brilliant paper. The collection of established knowledge into your paper is itself an act of creativity, since you have identified a unique slice of previous work in terms that are important to you. This collection, combined with any conclusions that you may make from it, is your unique, creative work.

Initial References Survey

The initial survey of references should not be a high-impact effort. You know what your topic is and you have a good idea of the main points you will be addressing. Your next task is to identify all the resources you may be using. Visit the library, the Internet, and the online journal database provided by the school. Put your hands or eyes on every resource that appears to be relevant to your topic. If you end up with more than 20 or 30 sources, start being picky about them. As you identify sources, write down proper citations for them, maybe with a note about where exactly on the shelf you found it. For example, I have found a book for my computer security paper. I would make a reference citation for the book in my notes along with an annotation showing where I found it in the library, as shown in Figure 3.

Smith, B. (1999). *Corporate and private computer security*. Springfield, MA: Merriam-Webster.

In the school library, eighth rack, third shelf from the bottom. Call number XXX.

Figure 3. Working references gathered during initial reference survey.

Notice that you don't have to check out the book or even pull it off the shelf. You are doing an initial survey solely to find out what is available.

Types of References

Your research paper assignment may specify a minimum number of references of different types: books, journals, magazines, Internet sites, etc. If this is the case, the intention is to expose

you to different levels of knowledge and to ensure that you create a balanced, well-covered research paper. Different types of publications have different target audiences, adhere to rigorous scientific methods to differing degrees, and generally will cover the same topic in different ways. If you only use one type of reference, then you are only using a single point of view. Books, for example, are usually older due to the length of time it takes to write and publish them, but their content is typically trustworthy. Books should be considered very conservative, since authors will have an expectation that a book may be in use for many years and so will try not to say anything that may become outdated or wrong. Scientific journals are rigorously reviewed for correctness before publication and typically represent the cutting edge of research for a field, but journals tend to be very difficult to read since they are written by and for scientists doing a particular type of work. Magazines are written for a general readership and may not take much time to verify information. Magazines should be considered very informal, but they do represent public opinion and the very latest trends. This may be appropriate for your research paper, but magazines should never be your only source of information. Information found on the Internet should always be approached with hesitation, since anyone from a world-class scientist to a second-grader's puppy can have a web page and say anything they want.

Narrowing Down the Scope

Once you have a good list of possible references from your survey, you can begin to create what will actually become your references list. First assess your working list for length. Is it really long, really short, or about right? Does it have a good balance of reference types? Is everything on the list relevant to your research paper? Remove anything that you know immediately you will not use. Your working list should probably be 25% to 50% longer than

your minimum number of references to allow you to remove the things that you won't use. If possible, quickly revisit all of your references and give a quick glance at introductions, abstracts, back covers, and just flip-through to see if you can remove it from the list. Ensure that everything on your list appears to be directly relevant to your research paper in some way.

Some references are less valuable than others. While including a magazine or newspaper article to give your paper currency is a good idea, exclusively using magazines or newspapers in your reference list will cause your paper to have the same academic weight as a magazine or newspaper. Unless you are studying the impact of popular press on your topic, you probably do not want this. Be especially critical of sources from the Internet and any sources without an identifiable author. Consider it in this way: When you use a reference to back up a "fact," you are transferring responsibility for the proof of that "fact" to that reference. If you transfer the responsibility for all of your facts to references that themselves do not make any attempt to back up their statements, then your own statements are supported by nothing. You may write a great paper, but if your references are informal and unofficial then your research paper is nothing more than a house of cards.

One of the biggest mistakes you can possibly make is to use an Internet site for a reference when that site is the homework of another student, even if that student is at a different school. Even though that student's homework, research paper, or whatever is on the Internet, you can not and should not assume it is a good source. What if you are looking at an 'F' assignment? Just because it comes up in an Internet search engine's results does not make it true. Look for publication details, look for citations, and look for authorship information. In short, look for accountability. You can be sure your instructor will.

Creating an Annotated Bibliography

Once you have surveyed the available literature and done initial cuts of superfluous references, you are ready to make an annotated bibliography. The annotated bibliography is an alphabetical list of all references that you might use along with notes for each showing what that reference might contain for your paper. Take your revised list and revisit every source on it. Read introductions, prefaces, abstracts, tables of contents, and skim over the first few pages. Get a feel for what the reference contains that may be relevant to your paper, and then write down what you think under a proper citation for that reference as shown in Figure 4.

Smith, B. (1999). *Corporate and private computer security*. Springfield, MA: Merriam-Webster.

In the school library, eighth rack, third shelf from the bottom. Call number XXX. This book compares computer security issues as seen by businesses and home users ... exactly what my paper is about! The table of contents lists a chapter on Internet security, which seems to have a "ten most valuable practices" list that I can quote in my paper. A lot of key computer security terms are defined in the first chapter. This book doesn't really exist.

Figure 4. Creating an annotated bibliography.

Do this for every reference on your working list to create a complete annotated bibliography. This annotated bibliography may be a requirement for your paper, but it will not be a part of your final product. If an annotated bibliography is assigned, it is likely that the instructor wants to ensure that you are using the correct types of references and proceeding in a coherent fashion with your work.

The Difference between References, References Consulted, and Bibliography

In the course of writing your research paper, you are going to use a wide variety of resources in a number of different ways. You may have some resources that you directly quote word-for-word. Others you may use as primary sources of ideas. Still others you may just read for general background information. You may identify even more resources that you do not use at all but that you know have more detailed discussions of certain points.

The format of your final research paper will reflect how you use these various references. If you quote something word-for-word or if you use something as a primary source, you should have an inline citation in the body of your paper that correlates to a work in your references list. Every inline citation must have an entry in the references list and every entry in the references list must be cited at least once. If you use a source for background knowledge but it is not cited anywhere in your paper, you should list it on a separate "References Consulted" page. If you feel that your paper would benefit from a display of references that are important but not necessarily directly part of your work, you can include a separate "Bibliography" page to list relevant work that you do not use at all in your paper. A bibliography page is probably best avoided unless specifically requested in the assignment. You should not include an annotated bibliography in a final paper unless explicitly instructed to do so.

Writing the Report

The actual content of your paper will be made up of your own words but will be based firmly in the sources that you have painstakingly collected along the way. By the time you get to the writing stage, you should have a pretty good idea of the length, balance, and content of your paper. At this point, you will begin to read your sources to find the points that you are hoping to

make in your paper. Except in certain circumstances where it really highlights your arguments to use a direct quote, everything you write should be in your own words. The trick here is to "synthesize" the information that you are reading; take the facts and figures and narrative that you find in your sources and make it your own, internalizing the information. Imagine you are playing a game where you have to read a page from a random book and then tell a partner what it says without looking back at what you read. This is similar to how you should write your paper; while you use a primary source to gather the ideas, you should put that source down and work strictly from your notes to write your paper in your own words.

Language Style

For a technology research paper, you should probably avoid the first person voice. While technology papers may end up all sounding dry and boring, you are presenting a technical argument where merit is based on clarity. Allow your facts to speak. Then allow your conclusions to speak. Your readers will formulate their own opinions about your work. Ultimately, the true relationship is between your presented facts and your reader; "you," the author, have no place in the paper. For example, the effect of gravity may be stated in a dry, neutral, yet concise and factual tone, "The effect of gravity is 9.8 m/s^2 . (Sears, Zemansky, & Young, 1987)" Or it may be stated in a first-person tone, "I read in 'University Physics' by Sears, Zemansky, and Young that gravity has an effect of 9.8 m/s^2 ." While it may be true that "you" read it, there is nothing added to the discussion of gravity by mentioning this fact. For a technology research paper, the former example is better because it is complete yet concise.

When writing a technology research paper, you should take care with your use of language. Instructors' preferences and formatting guides may differ so ask if you are unsure, but in general

you should avoid the use of contractions. Use "do not" instead of "don't," "it is" instead of "it's," etc. Avoid the use of "parenthetical asides." If the content of the parentheses is directly related to the rest of the sentence, just separate the phrase with commas instead of parentheses. If the aside is really not relevant, is an opinion, a joke, or a "see what I mean" statement, just omit it. If you are using bulleted or enumerated lists, every list should have more than one entry. If your list only has one item, then it is not a list and should be incorporated into a regular sentence. Above all, be consistent throughout your paper. If you abbreviate something in one place, abbreviate it everywhere. If you use a phrase that starts "First ...," be sure that there is a follow-on "Second ..."

Grammar and Punctuation

While it has been stated that a technology research paper should allow facts to speak for themselves, it is also true that writing style is vital to saying anything. Writing a paper of any kind is ultimately about conveying some information to someone. If the reader can not understand the facts presented, then regardless of how important those facts are the paper is a failure. Command of technical facts makes one a good technician, but command of the English language and the ability to convey those facts makes one truly valuable.

While your paper may seem dry and boring, with facts "speaking for themselves," you can still pay close attention to your use of English. Be consistent with punctuation and avoid overuse of commas or semicolons. If in doubt, ask your instructor for guidance on the use of single-quotes and double-quotes. Do not use sentence fragments, dangling prepositions, or split infinitives. Ensure that all pronoun references are clear. Take care with words that are

frequently used incorrectly, such as "insure," which refers the act of taking out an insurance policy, instead of "ensure," which refers to the act of being sure that something is correct.

Technical Content, Definition of Obscure Terms, Acronyms

You should have a good idea of who the audience is for your paper. While you can assume that a technology research paper will be read by people familiar with the technology, you should not assume that everyone knows everything. Be sure to introduce any terms or concepts that are specific to your technology. To return to our computer security paper, you might write something like

Firewalls are considered to be the best, easiest, and cheapest security measure available to home computer users (Pfleeger, 1997).

In this sentence, the term "firewall" is not defined. Unless it has already been introduced in the paper, it should not be assumed that the reader would know what it is. Instead, write the sentence with a brief definition.

Firewalls, software or hardware devices that limit network traffic to authorized computers based on the type of connection those computers are attempting to make, are considered to be the best, easiest, and cheapest security measure available to home computer users (Pfleeger, 1997).

Acronyms should always be defined on first use, and the definition should precede the acronym. When writing a sentence that has a first-use acronym, you do not want to say

NAV (Norton Anti-Virus) is an example of a popular security product that is used by large companies yet is affordable for the home user.

Instead, you should write

Norton Anti-Virus (NAV) is an example of a popular security product that is used by large companies yet is affordable for the home user.

And then use the acronym for the rest of the paper.

Your Opinion and Its Place in Your Paper

While you are writing your paper, you may find yourself not only using your own voice but also including your own feelings on your topic. You are certainly authorized to have an opinion, and in fact the writing assignment should cause you to think quite a bit about different aspects of the topic. But you should make every attempt to remove your own opinion from your writing. If you are writing about new advances in computer security, you may well think that a certain consumer security product is really "cool," but that is what you think based on what you have learned about the computer security field. Your goal with the research paper is not to tell your reader what you think, it is to tell your reader all the relevant facts in such a way that she independently comes to the same conclusion you did.

Let the facts guide your paper and remember that every reader will have their own opinion that only they can form. A research paper with opinions in it "feels" less serious. While your facts may all be in order your opinion will make the facts feel less factual, undermining your work. The only place your paper should involve an opinion is in a "recommendations" section, where you give your opinion on what may happen in the future, what might be the best choice, etc.

When to Quote and When to Cite

Since a large part of your paper will be ideas, facts, and concepts derived from multiple sources, it stands to reason that your paper will need a lot of citations. A citation is the correlation of the idea you just used to the source from which it came. It is not uncommon for a single paragraph to have three or more citations to different sources. You are on the safe side to use a citation if it is possible to use one, even if it seems to make your paper seem less creative. Every citation you use in the body of your paper must have a matching reference in your references list so a reader can easily verify your facts or find more information about your topic.

Occasionally, you may find a passage in a source that is perfect for your paper. The inclusion of a direct quote may enhance your paper, setting it off in a way that really brings your topic to life. Be sure that you enclose the entire word-for-word inclusion in double-quotation marks if it is one to three sentences or present it as a block quote if it is longer. In either case, a citation for the quote is essential. A short quote would be in the current paragraph, like this: "If a prose quotation runs no more than four lines and requires no special emphasis, put it in quotation marks and incorporate it into the text." (Gibaldi, 1999, p. 103) Alternately, a longer

quote would be block quoted. Note that a block quote does not use quotation marks but still requires a citation.

If you need to quote two or more paragraphs, indent the first line of each paragraph an additional quarter inch (or three spaces). If the first sentence quoted does not begin a paragraph in the source, however, do not indent it the additional amount. Indent only the first lines of the successive paragraphs. (Gibaldi, 1999, p. 104)

Plagiarism is the act of using ideas from sources without proper citations. You may have an excellent paper with a good references list, but if you have failed to quote and cite in the body of your work you have created a paper that is not complete.

Other Eyeballs during the Writing Process

Plagiarism rules are typically defined by your academic institution but enforcement is usually done at the classroom level. It is common to be working under a policy that rigorously insists that only you may ever see your paper until after it has been turned in for grading. It is a really good idea to locate and read your institution's policy and ask your instructor for guidance. From a certain point of view, every paper should have at least one additional reader to review grammar, spelling, and formatting before it is turned in. After you have been writing a paper for six or eight weeks, you tend to miss a lot of small things that can prevent a good paper from being great. Extra eyeballs catch this kind of thing, but check with your instructor first to be sure it is acceptable. It is better to have a mediocre paper with perfect ethics than a perfect paper with tainted ethics, and it is the instructor's policy that determines the scope of those ethics.

Formatting Styles

Every paper you write should be written according to a style guide. This style guide could be a mainstream one like that published by the American Psychological Association (APA) or the Modern Language Association (MLA), or it could be a set of guidelines provided by the instructor. If you are ever faced with a research paper assignment that does not define a style guide, ask your instructor for guidance. If you are told that it is your decision, choose something official and stick with it. This will ensure that your paper is at least consistent with itself.

APA and MLA

The APA and MLA style guides are not the only formal guides available, but they are probably the styles you are most likely to encounter. If you gain the understanding that all style guides provide definitions for the same types of things, then you will be able to use any guide easily. Style guides actually give you two things. Most obviously, a style guide provides the specification for proper and consistent formatting of a paper. What students many times miss is the writing advice that these guides also provide. The APA guide, for example, has a whole chapter dedicated to "Expressing Ideas and Reducing Bias in Language" (Publication Manual of the American Psychological Association, 2001). While the average undergraduate research paper already takes more time than the average undergraduate student has, every student would benefit from reading these sections of the style guides.

When using a style guide, you will probably quickly find the section that you need. This section will likely be the part that defines the many different ways to create proper references for different types of sources. Bookmark this section and highlight the formats that you are using most frequently. Get a feel for how in-text references are made and make a habit of making proper citations early. It may be easiest to leave layout issues like fonts and spacing until your paper is nearly finished, especially with modern word processors that can change the entire work with a few mouse clicks.

Some schools have an institutional preference for a particular style. If this is the case for your school, you would be wise to purchase your own copy of that guide promptly. Other schools leave the choice up to the individual instructor. Instructors have varying tastes and come from diverse backgrounds, and you are likely to be required to use whatever style they had to use in graduate school. It is unreasonable to expect every student to buy every style guide available, but it would be smart to at least know where the various mainstream guides can be borrowed.

The more you use any particular style guide, the more you will find your writing to be consistent and mature. Formal writing is not learned overnight. It comes from exposure and practice. There is great value in consistent formal writing, value that extends outside of the classroom. People with excellent writing ability are frequently chosen for leadership positions since they have proven their ability to communicate clearly and effectively. Take the time to learn these skills not just for your grades, but also for your career.

Questions You Should Be Asking

1. If you are choosing your own topic: You should be asking what other students have done in previous classes, what example topics are available, and what might be best for you considering the quality of work you have done in the class so far.
2. If your assignment does not explicitly specify a style guide: You should be asking if the instructor has a preference and if the school has a standard.
3. If your assignment does not specify an acceptable length or number of references: You should be asking what the instructor considers minimums for appropriate coverage of the topic.
4. If your assignment is given at the beginning of class and due at the end of class with no milestone points: You should be asking if it is acceptable to turn in a rough draft early to be sure you are on the right track.
5. If you get a poor grade on your final paper: You should be asking for a detailed explanation so you can do better next time.
6. If you get a very good grade on your final paper and you are not sure why: You should be asking what made your paper good.
7. If you are feeling stupid: You should be talking to your classmates to see how they are doing with the assignment. Even if you are the only one having problems, talking to your fellow students will give you a feeling for how to proceed.

Summary

While writing a research paper can be the most daunting element of any class, it can be made easier by following the steps demonstrated in this guide. The key to writing the

research paper is not the world's best topic or a reference list with a hundred books on it.

The real key is adhering to a step-by-step, methodical, patient plan of action. Decide on your topic first and do not even think about writing anything until you have it. Create an outline, keeping it simple enough to be flexible yet detailed enough to give you something to work with. Write a topic proposal, even if it is just for your own benefit, so you know what it is you are actually trying to accomplish. Collect your potential resources and read them.

Finally, divide your paper into a collection of related smaller papers based on your outline and write them, remembering to cite your sources throughout your paper. Take pride in your work; it is your name on the cover!

References

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