PERFORMING A LITERATURE REVIEW

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Abstract – This report is intended as a guide for teachers and engineering students when conducting research is part of course-work requirements. Discussion includes a description of a literature search, the purpose of a literature review, finding sources (especially for engineering), and a general strategy to help conduct an efficient and productive literature search. Using tools such as this report, students can become more pro-active about their research projects. Teachers can use this report, among other tools, to begin dialog with their students about expectations for research assignments.

Two key steps in a literature search are i) finding sources and ii) synthesizing information. Each of these is addressed in two of the major sections in this report, as well as how the literature search relates to the entire research process. Then pertinent information is repeated in the summary section for your convenience. An annotated reference list is included for ease in finding other useful guidance.
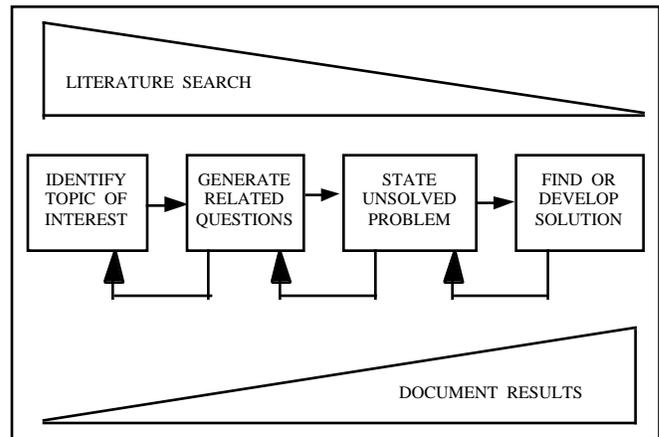
INTRODUCTION

What Is A Literature Search

The literature search is a very significant step in the research process. The basic stages in a typical research project are: i) identify your topic of interest, ii) perform a literature review, iii) generate related questions, iv) state your unsolved problem or hypothesis, v) find or develop a solution, and vi) document your results. We are often trained to think, approach, and describe tasks sequentially, but anyone who has earned an advanced degree in engineering (or any other field) can tell you that a sequential checklist of the process is too simplistic. Reference 1 explains "... how researchers must work at different stages of their project simultaneously [1]." The authors describe how overlapping the stages can help you understand the problem, manage complexity, and motivate changes in both earlier and later stages.

The important concept to grasp is that the literature search is not just one distinct step in a research task. It is both a step and an iterative feedback loop. Defining an unsolved problem determines what kind of literature search is appropriate, and performing a literature search helps define an unsolved problem. Because of this complexity, it is not surprising that many beginning researchers have difficulty. Figure 1 depicts the research process and some of the complex inter-relationships, including those of the literature search and documentation efforts.

FIGURE 1. Flow Diagram of Research Process.

Purpose Of A Literature Search

An introduction chapter in a research paper generally includes information gleaned from a thorough literature search. A literature search serves three important functions [2]. Reference 2 states that the literature review gives your reader background information regarding your own research, demonstrates your familiarity with research in your field, and shows how your work contributes one more piece in the puzzle of expanding the knowledge base in your field.

The important idea to convey is that you really understand what others in your field have accomplished and how your work differs from the works of others [3]. In a literature review, you demonstrate your understanding of the relevant works of others and your ability to summarize this information for the convenience of your readers. This sets the stage for you to describe what your research contribution is going to be.

FINDING SOURCES

Libraries are one obvious resource for a student performing a literature search, but there are many others as well,

including the *internet*. Regardless of the sources you use, *keep a bibliographic trail* [1]. Track titles, authors, publication information, page numbers, and possibly library call numbers (LCN), International Standard Book Numbers (ISBN), or International Standard Serial Numbers (ISSN). When searching through cyberspace, also note on-line addresses and other pertinent information so that a search can be duplicated if necessary. Also be aware that some on-line information changes daily – one day it is there, the next day it is gone. You should print it out immediately, if possible, and note the source, the "navigation" route, and the search engine you used to get to that source.

These tracking habits can help you avoid duplication of effort and speed the process of obtaining permission (to use the work of others) when needed. The time required to relocate and reacquire a source is also reduced. You will also be constructing your reference chapter as you work. Retracing these efforts by memory is very risky, so it is better if you take notes at every step.

Kinds Of Sources

Sources are generally described as primary, secondary, or tertiary [1]. <u>Primary</u>. Primary sources are "materials that you are directly writing about, the raw materials of your own research [1]." <u>Secondary</u>. Secondary sources are "books and articles in which other researchers report the results of their research based on (their) primary data or sources [1]." <u>Tertiary</u>. Tertiary sources are "books and articles based on secondary sources, on the research of others [1]." Tertiary sources synthesize and explain the work of others and might be useful early in your research, but they are generally weak support for your own arguments [1].

Primary. Examples of primary sources are data sets, computer runs, computer programs, scale models, drawings, and engineering notebooks. A well-kept engineering notebook can provide valuable information for later documentation of test conditions and assumptions, materials used, observations as well as measurements, and unusual occurrences that prompted further testing.

Secondary. Examples of secondary sources include conferences, proceedings, journals, and books. Journal articles are often the most current source of information on a topic of study that is new or subject to rapid change. Lists of references at the end of each journal article can provide leads to further sources. Engineering journals are typically field-specific. For a selected list of current journals in agricultural, chemical, civil, computer, electrical, environmental, industrial, and mechanical engineering, ask at your facility or university library for specific guides.

Tertiary. Examples of tertiary sources include dictionaries, encyclopedias, guides, and handbooks. "Dictionaries and encyclopedias are excellent starting points for research. They can provide general background information to help narrow or broaden the focus of a topic, define unfamiliar terms, and offer bibliographies of other sources. Some works include an index, which will provide excellent access to a subject [4]." Guides and handbooks cover topics such as tables, formulas, engineering fundamentals, measures and units of conversion, mathematics, statistics, and numerical calculations; these sources are especially useful during the writing phase of your research [4].

A STRATEGIC APPROACH

As a beginning researcher, two of the most common problems you might encounter are: i) not knowing where to find sources, and ii) once sources are located, not knowing how to sift or sort through an excess of information to determine what is useful to you. The following paragraphs elaborate on these two problems and describe a general plan that can help you overcome these difficulties during your literature review process.

Getting Started

A lot of time and frustration can be saved by understanding the process and the system. "Doing research consists of two basic tasks: brainstorming and researching itself. You need to know what information you will need, and you need to know where to get your hands on it [5]." "Developing the working bibliography requires knowledge of library resources, both printed and electronic, and the use of reference systems to locate sources. During early phases of research, developing a tracking method to maintain a complete record of all of the bibliographic information from your sources is advised, since you do not yet know whether it will be cited in your thesis [6]."

It is also advisable for you to construct a list of experts in your field. Such a list can be invaluable. An oral interview with an expert can produce valuable insight and possibly save you a lot of time and effort. You might try sending e-mail messages to well-known authors or lecturers. If you notice that several recent dissertations are written by students at a particular university, you might contact the authors or the authors' advisors. Given the opportunity to ask, one important question is: "If I were to pick up where you (or your student) left off, what advice would you give?"

A Search Plan

A recommended search strategy is to consider how a topic progresses through the research documentation life-cycle. One approach is to look for books that are currently accepted reference texts in your research area and find out who has cited them in recent years. Another approach is to look for original (seminal) reports, papers, or theses written by known experts and see who has cited them in recent years. For these two approaches, *Science Citations Index* (often available on CD-ROM) becomes a very important source. Implementing this strategy can help you develop a tree-like diagram or network showing not only relevant research, but possibly even how the works of others are interrelated.

By locating and reading at least the abstracts of these papers, you can begin to categorize the available papers by topic and by the authors' technical interests in a topic. Then look at the reference lists for the newer papers. This approach is especially useful because some databases might categorize differently or use different descriptors as key words. This approach should at least get you started on a good literature search.

The above advice sounds easier than it really is. Even experienced researchers often feel overwhelmed by "information overload." As technological electronic storage and retrieval capabilities continue to advance, we will all struggle with this problem. That is why it becomes very important to have a plan in mind when conducting a literature review, and to have a conceptual "blueprint" understanding of the resources available. Otherwise, you can easily become lost in your search or feel as if you are going around in circles.

What To Do If You Have Too Few Sources

If you find little or no information, your topic might be too narrow. If this is the case, it is a good idea to see what topic headings or terms any newly found information was cataloged under, so that you can use those key words in other database searches. If your search still yields little information, get help from library personnel and experts in your field of research. In particular, ask for advice about ways to expand your topic so that searches will produce some useful information.

What To Do If You Have Too Many Sources

If, on the other hand, you find volumes of information, then you need a plan to scale your search down to a manageable amount. Specific aspects of a field of study are often listed in annotated bibliographies. Journals specific to a field are good sources. Experts in your field of interest can suggest where many of your important sources can be found. It also helps to understand and categorize your sources so that you know what kind of information you have. Then you can draw on what you need without being overwhelmed by material that is interesting and related, but not necessarily critical to your own research.

Synthesizing Information

Once information is located, the next step is to summarize it into a coherent literature review section for your document. You must analyze accurately and critically. It takes a lot of skimming of books and articles to identify which sources are useful to you and in what context they are useful.

Your goal at this point is to "present an overview of what your source offers; its topic, research problem, resolution, and the outlines of its argument [1]." The abstract, introduction, and conclusion sections of each source document should contain the necessary information for you to write a good summary paragraph. It can be very counterproductive to try to read everything in detail. At first, it is more important to categorize and understand what sources you have and what might still be missing.

Summarizing and Note-Taking

Both references [7] and [1] have good advice about note-taking. Reference [7] states that the challenge is to condense others' work without distorting it. Their seven-step process includes: *i) do not write everything down, ii) create your own shortcuts and shorthand, iii) use numbers for numerical terms, iv) leave out vowels when you can, v) record all vital names, dates, and definitions, vi) mark items that need further examination, and vii) check accuracy before returning or filing the source*.

Reference [1] recommends writing and summarizing as you find sources and has a three-page section called "Quick Tip: Speedy Reading." It recommends a five-step process: *i) become familiar with the geography of the source, ii) locate the point of the argument, iii) identify key subpoints, iv) identify key themes, and v) skim paragraphs*. The book suggests that not all five steps are needed all the time. The main point is speed and efficiency, and focusing on material relevant to your own research without spending time on material that is at best only marginally related.

While taking notes and preparing condensed summaries of the work of others, you must be ever mindful of the requirement to eventually cite all "borrowed" work in your final paper. All of the sources mentioned contain discussions about direct quotations, summarizing, and plagiarism. Readers and researchers are advised to locate and carefully read about these topics from any available source in order to avoid trouble while writing.

SUMMARY

A recommended beginning search plan has been described, especially for engineering researchers. Understanding how the literature search dovetails with other steps in the research process helps form a good plan. Guidance has been given for finding sources, for determining if your topic is too narrow, and for scaling your search to a manageable amount. Useful tips have been given to help you track and summarize information so that it becomes useful for your research purposes. Hopefully, this report will help you get a "jump-start" on a good literature review and contribute to the successful conclusion of your research project.

ANNOTATED REFERENCES

[1] Booth, Wayne C. and Gregory G. Colomb and Joseph M. Williams, 1995. *The Craft of Research*. Chicago: The University of Chicago Press. From the Chicago Manual of Style publishers, this book is a concise, practical guide to mastering the art of research. The guidance helps you strategize the entire process, from understanding the uses of

research in general to editing and rewriting the final draft. Especially useful are the sections on posing questions, making and supporting claims, and writing meaningful introductions. Chapters 5 and 6 are especially helpful for the literature review.

[2] Weissberg, Robert and Suzanne Buker, 1990. *Writing Up Research, Experimental Research Report Writing for Students of English*. Englewood Cliffs, NJ: Prentice Hall Regents. This book is especially written for students of English as a second language (ESL). It describes the various sections of a research report and gives examples of convention, format, and style used in writing research reports. There are practice exercises for students.

[3] Michaelson, Herbert B., 1982. *How to Write and Publish Engineering Papers and Reports*. Philadelphia: ISI Press. This author specifically describes how important it is for you to understand how your work complements the work of others.

[4] Delzell, Barbara, Compiler, 1995. *How to do Library Research in Engineering – General*," NMSU Library. Las Cruces NM: New Mexico State University Library. This short instructional report is an excellent guide to the resources and help available to students at New Mexico State University. However, your own library or facility should have similar materials, including instructions for accessing internal and external electronic databases.

[5] Markel, Michael H., 1988. *Technical Writing Essentials*. New York: St. Martins Press. Oriented to writing effectively on the job, topics include writing roles, processes, and styles. Chapters also cover elements of reports, memos, letters, resumes, and applications. The author discusses presentation of graphic data and oral presentations. Since research and thesis writing follow similar patterns, this is a useful reference for a graduate student. Skills learned during thesis writing easily overlap and transition into the workplace setting.

[6] Slade, Carole, 1997. *Form and Style, Research Papers, Reports, Theses, Tenth Edition*. Boston: Houghton Mifflin Co. This work contains comparisons of Chicago, MLA, and APA documentation systems and is oriented toward academic writing in general. There are many specific examples for format and style, as well as discussion about writing research papers in general and presentation of data and graphics in particular. The book also contains a categorized list of general and specialized indexes useful for the literature-search phase of research.

[7] Brusaw, Charles T. and Gerald J. Alred and Walter E. Oliu, 1993. *Handbook of Technical Writing*, Fourth Edition. New York: St. Martins Press. This reference book is both a comprehensive and a practical source of information on language usage, writing procedures, and technical communication. It is alphabetically organized with extensive indexing, cross-referencing, and categorization of entries. There are sections at the beginning of the book that offer a sequential look at the writing process.

ABOUT THE AUTHOR

Lois E. Reed is a mathematician at the Naval Air Warfare Center, Weapons Division at China Lake, California since 1990. She received B.S. and M.S. degrees from Northern Arizona University in 1988 and 1989 respectively, an M.S. degree from New Mexico State University in 1998, and is currently a doctoral student in Industrial Engineering at NMSU. Ms. Reed's interests include optimization, reliability, Bayesian statistics, large-scale system dynamics, and simulation.