(adapted with thanks and credit to Professor John W. Chinneck, Carleton University, Ottawa, Canada)

How to Organize your Research Paper

Prof. John W. Chinneck
Dept. of Systems and Computer Engineering
Carleton University
Ottawa, Canada

What Research is All About

The distinguishing mark of research is *an original contribution to knowledge*. Your paper is a formal document whose sole purpose is to prove that you have made an original contribution to knowledge. Failure to prove that you have made such a contribution generally leads to failure.

To this end, your paper must show two important things:

- you have identified a worthwhile problem or question which has not been previously answered,
- you have solved the problem or answered the question.

Your contribution to knowledge generally lies in your solution or answer.

What the Paper is All About

Because the purpose of the paper is to prove that you have made an original and useful contribution to knowledge, the examiners read your thesis to find the answers to the following questions:

- what is this student's research question?
- is it a good question? (has it been answered before? is it a useful question to work on?)
- did the student convince me that the question was adequately answered?
- has the student made an adequate contribution to knowledge?

A very *clear* statement of the question is essential to proving that you have made an original and worthwhile contribution to knowledge. To prove the originality and value of your contribution, you must present a *thorough* review of the existing literature on the subject, and on closely related subjects. Then, by making *direct* reference to your literature review, you must *demonstrate* that your question (a) has not been previously answered, and (b) is worth answering. Describing how you answered the question is usually easier to write about, since you have been intimately involved in the details over the course of your graduate work.

Always remember that a thesis is a *formal* document: every item must be in the appropriate place, and repetition of material in different places should be eliminated.

A Generic Thesis Skeleton

1. Introduction

This is a *general* introduction to what the thesis is all about -- it is *not* just a description of the contents of each section. Briefly *summarize* the question (you will be stating the question in detail later), some of the reasons why it is a worthwhile question, and perhaps give an overview of your main results. This is a birds-eye view of the answers to the main questions answered in the thesis (see above).

2. Background Information (optional)

A brief section giving background information may be necessary, especially if your work spans two or more traditional fields. That means that your readers may not have any experience with some of the material needed to follow your thesis, so you need to give it to them. A different title than that given above is usually better; e.g., "A Brief Review of Frammis Algebra."

3. Review of the State of the Art

Here you review the state of the art relevant to your thesis. Again, a different title is probably appropriate; e.g., "State of the Art in Zylon Algorithms." The idea is to *present* (critical analysis comes a little bit later) the major ideas in the state of the art right up to, but not including, your own personal brilliant ideas.

You organize this section *by idea*, and not by author or by publication. For example if there have been three important main approaches to Zylon Algorithms to date, you might organize subsections around these three approaches, if necessary:

> 3.1 Iterative Approximation of Zylons
> 3.2 Statistical Weighting of Zylons
> 3.3 Graph-Theoretic Approaches to Zylon Manipulation

4. Research Question or Problem Statement

Engineering theses tend to refer to a "problem" to be solved where other disciplines talk in terms of a "question" to be answered. In either case, this section has three main parts:

> 1. a concise statement of the question that your thesis tackles
> 2. justification, by *direct* reference to section 3, that your question is previously

unanswered
3. discussion of why it is worthwhile to answer this question.

Item 2 above is where you *analyze* the information which you presented in Section 3. For example, maybe your problem is to "develop a Zylon algorithm capable of handling very large scale problems in reasonable time" (you would further describe what you mean by "large scale" and "reasonable time" in the problem statement). Now in your *analysis* of the state of the art you would show how each class of current approaches fails (i.e. can handle only small problems, or takes too much time). In the last part of this section you would explain why having a large-scale fast Zylon algorithm is useful; e.g., by describing applications where it can be used.

Since this is one of the sections that the readers are *definitely* looking for, highlight it by using the word "problem" or "question" in the title: e.g. "Research Question" or "Problem Statement", or maybe something more specific such as "The Large-Scale Zylon Algorithm Problem."

5. Describing How You Solved the Problem or Answered the Question

This part of the thesis is much more free-form. It may have one or several sections and subsections. But it all has only one purpose: to convince the examiners that you answered the question or solved the problem that you set for yourself in Section 4. So show what you did that is *relevant* to answering the question or solving the problem: if there were blind alleys and dead ends, do *not* include these, unless specifically relevant to the demonstration that you answered the thesis question.

6. Conclusions

You generally cover three things in the Conclusions section, and each of these usually merits a separate subsection:

1. Conclusions
2. Summary of Contributions
3. Future Research

Conclusions are *not* a rambling summary of the thesis: they are *short*, *concise* statements of the inferences that you have made because of your work. It helps to organize these as short numbered paragraphs, ordered from most to least important. All conclusions should be directly related to the research question stated in Section 4. Examples:

1. The problem stated in Section 4 has been solved: as shown in Sections ? to ??, an algorithm capable of handling large-scale Zylon problems in reasonable time has been developed.

2. The principal mechanism needed in the improved Zylon algorithm is the Grooty mechanism.

3. Etc.

The Summary of Contributions will be much sought and carefully read by the examiners. Here you list the contributions of *new* knowledge that your thesis makes. Of course, the thesis itself must substantiate any claims made here. There is often some overlap with the Conclusions, but that's okay. Concise numbered paragraphs are again best. Organize from *most* to *least* important. Examples:

1. Developed a much quicker algorithm for large-scale Zylon problems.

2. Demonstrated the first use of the Grooty mechanism for Zylon calculations.

3. Etc.

The Future Research subsection is included so that researchers picking up this work in future have the benefit of the ideas that you generated while you were working on the project. Again, concise numbered paragraphs are usually best.

7. References

The list of references is closely tied to the review of the state of the art given in section 3. Most examiners scan your list of references looking for the important works in the field, so make sure they are listed and referred to in section 3. Truth be known, most examiners also look for their own publications if they are in the topic area of the thesis, so list these too. Besides, reading your examiner's papers usually gives you a clue as to the type of questions they are likely to ask.

All references given *must* be referred to in the main body of the thesis. Note the difference from a Bibliography, which may include works that are not directly referenced in the thesis. Organize the list of references either alphabetically by author surname (preferred), or by order of citation in the thesis.

8. Appendices

What goes in the appendices? Any material which impedes the smooth development of your presentation, but which is important to justify the results of a thesis. Generally it is material that is of too nitty-gritty a level of detail for inclusion in the main body of the thesis, but which should be available for perusal by the examiners to convince them sufficiently. Examples include program listings, immense tables of data, lengthy mathematical proofs or derivations, etc.

Comments on the Skeleton

Again, the thesis is a formal document designed to address the examiner's two main questions. Sections 3 and 4 show that you have chosen a good problem, and section 5 shows that you solved it. Sections 1 and 2 lead the reader into the problem, and section 6 highlights the main knowledge generated by the whole exercise.

Note also that everything that *others* did is carefully separated from everything that *you* did. Knowing who did what is important to the examiners. Section 4, the problem statement, is the obvious dividing line. That's the main reason for putting it in the middle in this formal document.

Getting Started

The best way to get started on your thesis is to prepare an extended outline. You begin by making up the Table of Contents, listing each section and subsection that you propose to include. For each section and subsection, write a brief point-form description of the contents of that section. The entire outline might be 2 to 5 pages long. Now you and your thesis supervisor should carefully review this outline: is there unnecessary material (i.e. not directly related to the problem statement)? Then remove. Is there missing material? Then add. It is much less painful and more time-efficient to make such decisions early, during the outline phase, rather than after you've already done a lot of writing which has to be thrown away.

How Long Does it Take to Write a Thesis?

Longer than you think. Even after the research itself is all done -- models built, calculations complete -- it is wise to allow at least one complete term for writing the thesis. It's not the physical act of typing that takes so long, it's the fact that writing the thesis requires the complete organization of your arguments and results. It's during this formalization of your results into a well-organized thesis document capable of withstanding the scrutiny of expert examiners that you discover weaknesses. It's fixing those weaknesses that takes time.

This is also probably the first time that your supervisor has seen the formal expression of concepts that may have been approved previously in an informal manner. Now is when you discover any misunderstandings or shortcomings in the informal agreements. It takes time to fix these. Students for whom english is not the mother tongue may have difficulty in getting ideas across, so that numerous revisions are required. And, truth be known, supervisors are sometimes not quick at reviewing and returning drafts.

Bottom line: leave yourself enough time. A rush job has painful consequences at the defence.

Tips

Always keep the reader's backgrounds in mind. Who is your audience? How much can you reasonably expect them to know about the subject before picking up your thesis? Usually they are pretty knowledgeable about the general problem, but they haven't been intimately involved with the details over the last couple of years like you have: spell difficult new concepts out clearly. It sometimes helps to mentally picture a real person that you know who has the appropriate background, and to imagine that you are explaining your ideas directly to that person.

Don't make the readers work too hard! This is fundamentally important. You know what few questions the examiners need answers for (see above). Choose section titles and wordings to clearly give them this information. The harder they have to work to ferret out your problem, your defence of the problem, your answer to the problem, your conclusions and contributions, the worse mood they will be in, and the more likely that your thesis will need major revisions.

A corollary of the above: *it's impossible to be too clear*! Spell things out carefully, highlight important parts by appropriate titles etc. There's a huge amount of information in a thesis: make sure you direct the readers to the answers to the important questions.

Remember that *a thesis is not a story*: it usually doesn't follow the chronology of things that you tried. It's a formal document designed to answer only a few major questions.

Avoid using phrases like "Clearly, this is the case..." or "Obviously, it follows that ..."; these imply that, if the readers don't understand, then they must be stupid. They might not have understood because you explained it poorly.

Avoid *red flags*, claims (like "software is the most important part of a computer system") that are really only your personal opinion and not substantiated by the literature or the solution you have presented. Examiners like to pick on sentences like that and ask questions like, "Can you demonstrate that software is the most important part of a computer system?"

A Note on Computer Programs and Other Prototypes

The purpose of your thesis is to clearly document an original contribution to *knowledge.* You may develop computer programs, prototypes, or other tools as a means of proving your points, but remember, the thesis is *not* about the tool, it is about the contribution to knowledge. Tools such as computer programs are fine and useful products, but you can't get an advanced degree just for the tool. You must use the tool to demonstrate that you have made an original contribution to knowledge; e.g., through its use, or ideas it embodies.

Back to author's homepage.