Possible Organization for Writing a Thesis including a LaTeXFramework and
Examples

by

A Graduate Advisor
B.Sc., University of Lethbridge, 2006

A Dissertation Submitted in Partial Fulfillment of the
Requirements for the Degree of

MASTERS OF SCIENCE

in the Department of Computer Science

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ABSTRACT

The use of neural nets has been around since the nineteen sixties, it fell out of favor and has returned to a state of interest recently. Computational systems based on the bilogy of the neurvous system have been increased in complexity over the years as the the compuational power of the time increases.

Brain Computer Interfaces (BCI) stated in XXXX with SOMEONE This is the future.

There is no claim that this is the *best* or *only* way to structure such a neural network. Yet in the majority of cases it serves extremely well as a sound basis which can be customized according to the requirements of the researchers and the topic of research. Additionally some examples on using the system are included as a bonus for beginners.

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I would like to thank:

Star Trek, YouTube, Piper, and Gerri Elder, for supporting me in the low
moments.

Yvonne Coady, for mentoring, support, encouragement, and patience.

NeuroDevNet, Mitac and Cebas Visual technolog, for funding me one way
or another.

*I believe I know the only cure, which is to make one's centre of life inside of one's
self, not selfishly or excludingly, but with a kind of unassailable serenity-to decorate
one's inner house so richly that one is content there, glad to welcome any one who
wants to come and stay, but happy all the same in the hours when one is inevitably
alone.*
Edith Wharton

DEDICATION

Thanks to Basil for keeping my lap warm while I write my thesis.

Chapter 1

Introduction

The main goal of this document was to set up competently the Latex framework for a thesis document at UVic, with all the assorted details of front pages, numbering and so on. In order to present such a template to other users, the content has been filled from the guidelines of an experienced graduate advisor and supervisor on how to write a thesis in the first place.

The Latex framework given in these files should work in the Windows, Mac and Unix environments. In Windows, the development environment is MikTex, available as a free download from the web page at *miktex.org*. Miktex includes all the tools for LaTeX, without a convenient editor. I have been using *WinEdt* which is still the best as far as working in a well integrated manner with MikTex, even if one has to pay a small price. *WinEdt* is available from *winedt.com*. The corresponding package for the Mac is MacTex, available from *www.tug.org\mactex*. Please note that in the actual file with the LaTeXcode there are extra local comments referring to small differences between platforms. This is especially crucial for the insertion of figures of any type (see also Chapter 3).

The package *BibTex* is used for the automatic bibliography and it is incorporated in the MikTex package. The style of bibliography exemplified is this document is the "plain" one, most often used in science theses. This is shown by the entry *plain* in the *bibliographystyle* command which can be found in the top file, namely *mainthesisUVIC.tex*. Substitute the appropriate bibliography style for your needs by finding the correct parameter. In order to help you there is a PDF file entitled: "InformationOnBibliographyStyles.pdf" in the same folder as the top file *mainthesisUVIC.tex*.

The title pages are correctly formatted according to the guidelines. However the superset is given here as a template for a Ph.D. dissertation and adjustments must

be made for a Master's thesis accordingly.

When presented with the task of having to write a large document reporting on the work done for the thesis portion of a graduate degree most people have anxiety attacks. It seems that the research work has been done, probably with great competence, yet one feels totally lost on how to approach the writing part - unless of course one is a writer to start with. While I am not at all the expert, I have experience both in writing documents and in supervising many graduate students. I have developed a simple enough structure which guides me and my students most of the times fairly well. We then customize it for different audiences and situations. The content of this pseudo mini thesis summarizes the structure I use.

This document, however, is *not at all* a Latex manual. There are a few examples sprinkled here and there of various commands. However no explanations or full examples are given for how to use Latex itself. That is most certainly left to the user!

Starting at the very beginning, my first step is to set up the formatting framework before the content itself, just like the frame of a building is the sustaining structure. By having the content only in bullet points which can be moved and changed at will I can have a whole document which will always compile and be ready for presentation. I ask my student to prepare mock chapters which contains only these bulleted lists to be used for discussion. The bulleted list I had for this chapter is as follows:

1. State the dual purpose of this document (just mention briefly);

2. State what this document is not (just mention);

3. Describe what I think should go in the Introduction in general;

4. Describe what I think should not go in the "Introduction" chapter in general;

5. Describe the structure of the document.

When the writing for a chapter is particularly long, it might be better to have some, if not all, sections in separate files. It makes it a lot easier to find possible errors in Latex as well, since the command to input a file for a separate section can always be commented out. When looking at the *.tex* file itself for this introduction chapter you will notice that there are 2 sections, namely "How to Start an Introduction" and "Is a Review of All previous Work Necessary Here?" which are included as separate files, immediately following this paragraph.

1.1 How to Start an Introduction

What is the difference between an "Introduction" and the "Background" for a thesis? Should they be together? What about the review of the work from other people?

These are important questions which must be discussed between a student and the supervisor.

My view is that the introduction should be exactly that: a short introduction, not the history of the problem, its content and all its solutions to date. One major ingredient *must* be a marketing angle, such that the reader becomes deeply motivated to continue on with the rest of the document. When I referee an article I usually read the abstract, the introduction and the conclusion. At that point I expect to be able to state to someone else what the work is about, what seems to be the new advancement and how interesting I think it will be to read the rest.

My main statement about the introduction is: *"keep it short and write it last"*. The main features should be as follows:

1. 3-4 pages at most;

2. Start with a VERY short statement of the problem (2-3 sentences) - the problem should be stated, not described, as there will be a whole chapter for that;

3. State why the problem is important, its impact, how well it has been studied recently, its application (3 sentences) - this should be again a brief motivation, leaving a full impact description to later in the document;

4. Give a sketch of the new approach - there will be a whole chapter with all the details, now just impress the reader about what is the new approach, just as you would do if your boss asked you at work during an elevator ride;

5. Sketch the main new ideas of the new approach - again briefly, just get the reader interested;

6. Give a short statement regarding the results, nothing too elaborate, but certainly you should blow your horn and make sure that the reader is intrigued;

7. Interspersed in all the writing above do not forget the marketing angle, trying to suggest forcefully why the reader should keep reading;

8. Give an outline of what is to come in the organization of the thesis overall - you will find one below for this document.

Finally the strong suggestion is write the introduction chapter last. It will be faster, you will know what to say as the rest is already there, and the abstract, introduction and conclusion will be a mirror and complement of each other. You may well ask where to start writing your thesis. My view is included in the organization below.

1.2 Is a Review of All Previous Work Necessary Here?

Many people like to place in the introductory chapter a review of the work from everybody else on the same problem. I find this utterly boring and counter-productive. If I am an expert in the field I probably know all this and could even write it better, so the last thing I want to read at the beginning is a history of research. If I am not an expert in the field, I would prefer to read up all the details of the problem itself and understand its context before I can even take in any ideas of what others have done.

Secondly, often when talking about the work of others one includes a bit judgment on it. This may be necessary, as the pivot of the new work may indeed be that there was an open problem left unsolved by the other researchers. Yet it is hard not to sound negative, to describe the work of others stating that their solution did not include some important part without denigrating. If one of those researchers is a reader and perhaps an examiner, they do not want to start reading by being told that their own work is inadequate.

I suggest a general summary of no more than 3-4 paragraphs of the work in the area with references, just to give the impact of the importance of the problems to be solved. Use then a "just-in-time" approach, where the relevant work of another researcher is described when needed in a particular step of the exposition of the problem or of the new solution. I normally place a much more extensive review of the work of others after I have presented my solution and the results of my experimental or formal proof work, so that I can analyze and compare effectively without boring repetitions and without writing a literature review on a subject. Many good articles in journals follow this scheme and most grant organization ask for a literature review to be included at the end of an application. First they want to be impressed with the proposal for new work!

A similar logic should be applied to background knowledge and definitions. This is especially true in a scientific thesis where often one find a whole set of mathematical definitions lumped together in chapter 1, yet not used until chapter 6, by which time the reader has completely forgotten it and needs to shuffle back with irritation. Use again a "just-in-time" approach and give definitions and explanations locally, the first time they are needed.

1.3   My Claims

Something must be new in this work, no matter how small, since you are getting a graduate degree for it! Tell me about it clearly and succinctly right now, just as you did in the abstract. Make an impact here. How about something like the following box:

I make *four* claims which my dissertation validates:

My new algorithm to solve the problem of interpreting EEG signals for the control of a computer includes these the use of a set of neural nets that do a fourier transform. whose practical applicability can be proved both formally and empirically:

1. Liquid state machine;

2. Fourier transform modules for electrodes;

3. everything is much easier to understand, and therefore, easier to implement correctly.

Claim 1 and claim 2 are *quantitative* - they will be proven by experiment.
Claim 3 is *qualitative* - they will be demonstrated by argument.

1.3.1   The Importance of My Claims

Some very important positive consequences arise from the validation of the above claims. It is these consequences that comprise a significant positive contribution to research in the field of whatever the field is.

Claim 1 implies that:

1. Something profound which applies to:

   - something excellent;

   - something important.

2. Something else just as profound.

Claim 2 implies that:

- Repeat as above if necessary and useful.

The consequence of claim 3 is that:

- There must be something good coming out of all this work!

1.4   Agenda

This section provides a map of the dissertation to show the reader where and how it validates the claims previously made. Here is where I am also presenting my own style of organization which may be totally different from what your supervisor thinks. However, trust me, this is a good solid beginning for a structure. Your supervisor may ask you to change it, but will still appreciate what you have! For each of the chapters below I also give a short summary of what the main focus should be and then I expand on it a bit within the chapter itself.

Chapter 1 contains a statement of the claims which will be proved by this dissertation followed by an overview of the structure of the document itself.

Chapter 2 describes in details the open problem which is to be tackled together with its context, its impact and the overall motivation for the research overall.

Chapter 3 gives the new research, its methodology, the algorithms involved, the new solution, the new work done. Formal proofs and arguments are made here. This is the first of the two contributions expected in a thesis for a graduate degree.

Chapter 4 is where the experiments and the methodology for them is fully described. The first part includes all details of how the empirical side of the research has been conducted. Note that not every thesis has this empirical portion.

Chapter 5 includes the evaluation of the data presented above and the comparisons with the work of others, to show how much better the new approach is. This is the second of the two contributions expected in a thesis for a graduate degree. Note that this part could be consolidated into the chapter above.

Chapter 6 contains a restatement of the claims and results of the dissertation. It also enumerates avenues of future work for further development of the concept and its applications.

The list above is not complete. Chapter 3 actually includes a lot more, as I could not resist placing in it a few LaTeXexamples to help you along. This document is not a primer for LaTeX, but there is no harm done in giving a little help.

Chapter 2

The Problem to be Solved

A number of neurological disorders can leave a person with diminished ability to communicate and function in the world. Individuals with Parkinson's Disease, Amyotrophic lateral sclerosis, or individuals locked in syndrome[] fit in to this category. The standard set of interaction tools that a human uses to interface with the world requires our brains to generate the correct gross and fine movements to complete an action.

It is possible to gather the signals that the brain makes to initiate action planning and execution of movements. There are a number of methods for this ranging from noninvasive to subcellular alteration. Every method has its drawback.

Optogenetics - Invasive injection that requires you to add genes and alter your brains genome. Invasive addition of hardware to read out the signals.

Microelectrode array[]Is a set of electrodes that is set up in a pattern, usually a two dimensional grid, that is implanted into the brain. MicroElectrode arrays have the advantage of being able to record in both high temporal and spacial resolution. With this high temporal and spatial resolution it is possible to determine the patterns of firing that correlate with the aspect of movement. Local Field Potentials give the electrodes access to neurons in a volume of [].

Positron Emission Tomography[] (PET) - Is the the use of an injected radioactive analog of a biologically active molecule[], coupled with gamma ray detectors to detect the metabolic activity in a tissue. When scanning the brain areas that are actively processing information exhibit greater use of resources. The use of the radionuclide is the connection between the activity of the brain and the detection of the gamma rays. Problems with such a system is that they are relatively large uses a ring of photomultiplier tubes. Also requires a computer tomography scanner to correlate

with the users individual cortical structure. Radiation from the radionuclide while coming from a short lived radioisotope is still able to cause cellular damage. A system like this would not be a suitable for long term use as a brain computer interface. Lower spatial resolution due to the positron traveling through the tissue of interest until it collides with an electron.

Functional Magnetic Resonance Imaging[] (fMRI) - uses Magnetic resonance Imaging[] which uses a large magnet to polarize all the spins of the electrons[citation] of an atom. A smaller magnet is used to resonate an atom of choice by using an appropriate resonant frequency. This causes an emission of a radio signal that is recorded and interpreted by a computer. The computer then creates an image of the locations of the emissions of the radio signal which corresponds to the structure of material in the scanner. fMRI uses the Blood Oxygen Level Dependant[] (BOLD) signal to detect where activity is occurring in the brain. The BOLD signal is a measure of the difference between the oxyhemoglobin and deoxyhemoglobin. As in PET where neurons use the glucose and have to uptake more when they are active, In fMRI the neurons are using their oxygen and uptaking more from the blood. There is a difference in the magnetic susceptibility of the proteins. This difference can be measured and this gives the location of the activity in the brain.

The problems with fMRI for a BCI are: The scanners have to be fairly large. This is due to the primary magnet of an MRI being large enough to generate a sufficiently powerful magnetic field. due to the magnetic field being so strong the area that the magnet is housed in has to be free of materials that could interfere with the magnet or could attract the material with catastrophic effects on the magnet. The radio signals are also relatively weak so electromagnetic shielding is needed to get the best results. The temporal and spatial resolution are one second resolution, one mm voxels. Some signals can be used to determine the mental state [][This paper] of a user which in turn can be used to control some forms of BCI [This paper 1, keyboard].

[1]

1. *Italics* Item one

2. Item X

3. Last Item

Chapter 3

The New Approach and Solution

This is where you go all out and tell us all about your new discovery and research related to the problem in the previous chapter. No arrogant sweeping statements which cannot be fully justified, but no false modesty either. You must impress your reader that you have accomplished something.

Simply summarized, this chapter should be comprised of at least two main sections, each with appropriate subsections. The first section should describe:

- what the new approach is;

- what is really totally new;

- what is incrementally new;

- what you built upon.

The second part should describe fully how the new approach works, both with the overall theoretical exposition (e.g. an algorithm) and with as many examples as necessary for clarity. Remember that if the reader does not understand fully, you will get a lot of questions and doubts. Good examples, good figures, good diagrams with super clear tutorial explanations can be a joy to read and make even a small contribution appear to be more impressive. Are you afraid that if you are too tutorial your work will not seem as deep and difficult? Only shallow people will make such a superficial evaluation, have trust instead in the wisdom of your supervisory committee.

Use at least one good example throughout, and even better if this is one of the examples you used in Chapter 2 to describe the original problem.

By the way, this would be the first chapter I would write. This is what I know best right now, as I just finished working on it. It is clear to me and on the tip of my fingers. Start with your strengths! The second chapter I would write is the next one about the experiments, followed closely by chapter 2 describing the problem. It may not seem intuitive to you, but it works and it is the most productive way I ever found to finish a document.

3.1 Some LATEX Examples

A Latex document is composed of two parts: the Preamble, and the Document Body. The *Preamble* is the site for inclusion of all document set up commands: definition of new commands, inclusion of prebuilt packages, template declaration, etc. The *Body* is where the document content is placed.

3.1.1 Preamble

The Preamble refers to the input which precedes the documents contents. It is the area where the author determines the general template for the document using the **documentclass**[*options*]{*doc style*} command. For example, \documentclass[11*pt*]{*article*} declares that a document will follow the *article* document class, and have 11pt font.

If the document requires support of any library packages they must be included in the preamble using the **usepackage**{*package name*} command. For example, \usepackage{graphicx} is the command needed to include the graphicx package.

3.1.2 Document Body

The document body is the area which follows the Preamble. It is defined by the **begin**{*document*} and **end**{*document*} commands. The content of a Latex document is declared in the document body. Input which appears after the \end{document} command is ignored.

3.2   How to Number Pages

To number the pages of a document use the **\pagenumbering**{*style*} command. Numbering is defined in the documents preamble. There are several different *styles* to choose from.

Numbering Style	Output
\pagenumbering{arabic}	1, 2, 3, ...
\pagenumbering{roman}	i, ii, iii, ...
\pagenumbering{alph}	a, b, c, ...
\pagenumbering{Roman}	I, II, III, ...
\pagenumbering{Alph}	A, B, C, ...

Table 3.1: Page Numbering Styles

The numbering of pages for a thesis is, however, much more complex than for an article and, in fact, the *book* class has been adopted. Make changes to those settings only if you are really familiar with LaTeX.

3.3   How to Create a Title Page

A title page can be either on a separate page or integrated directly into the first page of the document. It is defined by three declarations, followed by the **\maketitle** command as illustrated below.

```
\title{Title of Paper}
\author{Author(s) of Paper}
\date{Publication Date}
\maketitle
```

The article document class defaults on an integrated title page. To make a separate title page, use the **titlepage** option with the \documentclass[*titlepage*]{*doc style*} command.

For this thesis style the title page has been completely formatted for you. Just insert the various names of people in the supervisory committee, the title, your name and so on in the location where the *dummy* entries exist right now and you will be done. I would suggest to avoid doing any other changes unless you are absolutely sure!

3.4   How to Create an Abstract

To create an abstract, place contents of abstract between the **begin**{*abstract*} and **end**{*abstract*} commands.

3.5   How to Create a Table of Contents

The **tableofcontents** command automatically generates a table of contents from all section headers. The default behavior for the article document class is to produce an integrated table of contents. However, the document can be altered to generate the table of contents on a separate page using the **newpage** command (see section Formatting Extras).

For this thesis template a special command has been added, namely the **textTOCadd**. You can find it in the file *macros/style.tex*. It has to be explicitly called for an insertion into the Table of Contents and it is already in place appropriately for the existing sections and subsections.

3.6   How to Create Sections

Creating sections, subsections, and subsubsections is completed using the \section{Section Name}, \subsection{Subsection Name} and \subsubsection{Subsubsection Name} commands, respectively. Each sectional division is numerically labeled with respect to it's placement in the section hierarchy. For example, this section was defined with the code:

```
\section{How to Create Sections}
Creating sections, subsections, and ...
```

It is useful to give a label using the **label** command to a section or subsection if a reference to it is made, so that the reference will be automatically updated should the structure of the document change.

3.7   How to Create a List

Lists can be either enumerated, non enumerated, or descriptive. Each element of a list is termed an 'item'.

loc	Purpose
l	left justified column
r	right justified column
c	centered column
		vertical rule

Table 3.2: Table Example

1. enter the list environment with the \begin{*list style*} command.

2. define each item with the \item command for non\enumerated lists, or \item[*label*] for descriptive lists.

3. terminate list environment with the \end{*list style*} command.

3.8   How to Insert Tables, Figures, Captions, and Footnotes

The table and figure environments contain input blocks which cannot be split across pages. Rather than divide the input of either of these environments, the contents are relocated, or floated, to a location in the document which optimizes page layout with the surrounding document content.

3.8.1   Tables

Tables are created in the tabular environment. A single parameter is used to define the number of columns and item justification pertaining to each column. The single parameter is a combination of the following ones shown in Table 3.2.

\\ and & are used to define rows and columns, respectively. A table can either have the contents of its rows and columns lined or not. Each line used to construct the table must be individually specified, using | and \hline for vertical and horizontal lines, respectively.

Table 3.2 was generated with the following input:

```
\begin{center}
    \begin{tabular}{|l|l|} \hline
    l & left justified column   \\ \hline
```

```
        r & right justified column  \\ \hline
        c & centered column          \\ \hline
        $|$ & vertical rule          \\ \hline
    \end{tabular}
    \end{center}
```

You will want to include your table in the "List Of Tables" section at the beginning of your thesis. To do this you enclose the above table inside a table environment like so:

```
    \begin{table}
        \begin{center}
        ...
        \end{center}
        \caption{Sentence describing table.}
        \label{unique:label}
    \end{table}
```

The caption is the text that appears underneath the table. It should be short and precise. The label is a unique label that you can use to refer to the table within your document. You can use the \ref{label} to insert the table number into your text as in Table 3.2. In the example above you would use as in:

```
    I am referring to Table \ref{unique:label}.
```

3.8.2   Figures

The first step to including an externally prepared image into a document, is to declare the graphixs package into the documents preamble. Integrating the image can be done using the figure environment. Enter and exit the figure environment with the **\begin{figure}**[*loc*] and **\end{figure}** commands, respectively. The *loc* dictates the placement of the included image, and can be any of the following:

h here: location in text where the environment appears

t top: top of the page

b bottom: bottom of the page

p page of floats: on a separate page with no text

For organizational purposes, it is best to have keep all figures in a folder together. I usually label the folder as "*Figures*" (with great creativity) and I placed it in the same directory as the topmost main *.tex* file. Include the image into the document with the **\includegraphics**[*dim*]{path to image} command. *dim* dictates the magnitude of the `height` or `width`. The image is scaled proportionally. An example and its resulting output follow below.

$$\text{\textbackslash begin\{figure\}}[h]$$
$$\text{\textbackslash centering}$$
$$\text{\textbackslash includegraphics}[height = 1in]\{\texttt{LinuxPenguin.eps}\}$$
$$\texttt{\textbackslash caption\{The Linux Penguin\}}$$
$$\texttt{\textbackslash end\{figure\}}$$

Why is the output for the figure not shown? Because inserting figures into LaTeXis not that simple and it is highly dependent on the system you are using together with the type of figure. This is not the place to dwell upon the inconsistencies which can make your life difficult. Suffice it to say that the original LaTeXand its tools was geared to accept *.eps* files for figures and it still maintains that expectation if one compiles using a *Latex to dvi to (pdf or ps)* series of commands. On the other hand, if one uses the *Latex to pdf* direct path, then files of other types are perfectly fine (e.g. *pdf, jpg, gif, etc.*).

If you are interested, look at the actual file for this section namely "sec_latexhelp.tex" and consider the set of lines commented out just above this paragraph. There are two examples of insertion of figures, the first with the *.eps* version and the second with the *.pdf* version of the same picture (of a penguin). Delete the comments from one of the two sets and use the appropriate tools.

To refer to a figure, the same approach used for tables should be used, namely a `\ref{label}` command which includes the unique identifier label for that figure, as in:

```
I am referring to Figure \ref{unique:label}.
```

3.8.3   Captions

Captions for tables and figures are created using the **\caption**{caption goes here}. Captions are automatically numbered with separate counters for tables and figures. **\caption**{caption contents} can only be used in the Figure or Table environment.

3.8.4 Footnotes

Footnotes are inserted with the **footnote**{footnote contents} command. This footnote[1] is generated as follows:

```
...This footnote\footnote{this is a footnote} is generated...
```

3.9 How to Alter Font

3.9.1 Type Style

Roman Family is the default type style. The types style can be modified using the following commands.

Command	Output
\textit{Italic Characters}	*Italic Characters*
\textsl{Slanted Chartacters}	*Slanted Characters*
\textsc{Small Cap Characters}	SMALL CAP CHARACTERS
\textbf{Boldface characters}	**Boldface characters**
\textsf{Sans Serif Characters}	Sans Serif Characters
\texttt{Typewriter Characters}	Typewriter Characters

3.9.2 Type Size

The font size can be modified using the following commands.

Command	Output
\tiny{tiny font}	tiny font
\scriptsize{scriptsize font}	scriptsize font
\small{small font}	small font
\normalsize{normalsize font}	normalsize font
\large{large font}	large font
\Large{Large font}	Large font
\huge{huge font}	huge font
\Huge{Huge font}	Huge font

---

[1]this is a footnote

3.10   Math Mode

To incorperate mathematical content into a document, Latex provides three different environments: Displaymath, Math, and Equation. Brief descriptions for each environment, and environment short cuts are displayed in the table below.

Environment	Function	Shortcut
`math`	displays an in-text formula	\ (...\ )
`displaymath`	displays an unnumbered formula	\ [...\ ]
`equation`	displays a numbered formula	N/A

The following examples, using Einstein's famous $e \doteq mc^2$ equation, illustrate how to include a formula into a document.

```
...Einstein's famous \( e \doteq mc^{2} \) equation, illustrate...
```

```
\[e \doteq mc^{2}\]
```
$$e \doteq mc^2$$

```
\begin{equation}
   \doteq mc^{2}
\end{equation}
```
$$e \doteq mc^2 \tag{3.1}$$

3.11   Formatting Extras

The following table illustrates some formatting tips for perfecting the layout of a Latex document.

Command	Purpose
`\hspace{`*len*`}`	insert a horizontal space of length *len*
`\vspace{`*len*`}`	insert a vertical space of length *len*
`\mbox{`*text*`}`	ensure that *text* is not split over multiple lines
`\\`	new line
`\newpage`	start new page
`\pagebreak`	insert a page break
`%`	precedes comments

Chapter 4

Experiments

Assuming you have some experimental results to support your claims this is where all the data is reported. There are a few issues you should consider before dumping a lot of stuff here, or it will lose its effectiveness.

First of all you must describe precisely the experimental setup and the benchmarks you used. In any scientific discipline an experimental result is only good if it is reproducible. To be reproducible then somebody else must have sufficient details of the setup to be able to obtain the same data. Thus the first section in this chapter is a super precise history of the decisions made towards experimentation, including mentions of the paths which became infeasible. The setup must be valid and thus your description of it must prove that it is indeed sound. At times, terrifying times, when writing this section, both supervisor and student realize belatedly that something is missing and more work needs to be done!

The second portion of this chapter is dedicated the the actual results. At least two issues arise here:

1. Should all the data be reported here or should some be placed in the Appendix?

2. Should this be an exposition of the raw facts and data or should it include its analysis and evaluation?

There are no definite answers here, but I follow a few rules.

Should all the data be reported here or should some be placed in the Appendix?

- If there is a large number of tables of data, it might be better to present here only a handful of the most significant ("best") results, leaving all the rest of the data in the Appendix with proper linkages, as it would make the chapter

so much more easily readable (not to mention limiting the struggle with a word processor for the proper placement of tables and text).

- Use an example throughout, call it a "case study" to make it sound better, so that all the data and results are somehow linked in their logic, and even better if this is one of the examples you used in Chapter 2 to describe the original problem.

- Highlight in some manner the important new data, for example the column of your execution speed where all the numbers are much smaller. Make the results highly easy to read!

- It is normally expected that data should be presented only in one form and not duplicated, that is, you are not supposed to include both a table of raw numbers and also its graphical representation from some wonderful Excel wizard. I tend to disagree. I would not wish to see every results repeated in this manner, but some crucial ones need to be seen in different manners, even with the same information content, in order to show their impact. One good trick is to place the more boring tables in the Appendix and use wonderful graphs in this chapter.

- This is the one chapter where I would splurge and use colour printing where necessary, as it makes an *enourmous* difference.

Should this be an exposition of the raw facts and data or should it include its analysis and evaluation?

- Is the evaluation of the data really obvious? For example you have 10 tables to show that your chemical process is faster in development and gives purer material - you may simply need to highlight one column in each table and state the obvious.

- Most results are not that obvious even if they appear so. Moreover this is where you are comparing your *new* results to data from other people. I usually describe other people's work at this point and make comparisons. That is why I prefer to talk about the analysis and evaluation of the results in a separate chapter.

- There is absolutely no clear structure here which is best.

Chapter 5

Evaluation, Analysis and Comparisons

For a Master's research this chapter represents the critical part where **you** are truly evaluated to determine whether you should be given your degree. Even more so for a PhD. Consider carefully what the University calendar states regarding the expectations for a master's thesis, paraphrased here.

1. *A Masters thesis is an original lengthy essay.* The main implication here is that the essay is original, that is, it is completely newly written by you and does not contain any writings from others unless precisely quoted. Any paraphrased items must be cited.

2. *It must demonstrate that:*

    - students understand research methods;

    - students are capable to employ research methods;

    - students demonstrate command of the subject.

3. *The work may be based on:*

    - original data;

    - original exercise from scholarly literature;

    - data by others.

4. *The work must show that:*

- appropriate research methods have been used;

- appropriate methods of critical analysis supplied.

5. *The work must contain:*

- evidence of some new contribution;

- evidence of a new perspective on existing knowledge.

Only the last point uses the attribute *new* and it refers almost entirely to giving a new perspective and analysis, even if based on data from others. This truly implies that this current chapter on evaluation and analysis of results is the most important and must be written with care. You are demonstrating here that, even if given data and methods from others, your skills of critical judgment and analysis are now at the level that you can give professional evaluations.

Things are slightly different for a PhD. According to the Graduate Calendar:

a doctoral dissertation must embody original work and constitute a significant contribution to knowledge in the candidate's field of study. It should contain evidence of broad knowledge of the relevant literature, and should demonstrate a critical understanding of the works of scholars closely related to the subject of the dissertation. Material embodied in the dissertation should, in the opinion of scholars in the field, merit publication.

The general form and style of dissertations may differ from department to department, but all dissertations shall be presented in a form which constitutes an integrated submission. The dissertation may include materials already published by the candidate, whether alone or in conjunction with others. Previously published materials must be integrated into the dissertation while at the same time distinguishing the student's own work from the work of other researchers. At the final oral examination, the doctoral candidate is responsible for the entire content of the dissertation. This includes those portions of co-authored papers which comprise part of the dissertation.

The second paragraph makes it clear that one must emphasize what is new and different from others, without arrogance, yet without being too subtle either. The first paragraph implies that for a PhD it is required that one approached an important open problem and gave a new solution altogether, making chapters 3, 4, 5 all part of the body of research being evaluated. In fact at times even the problem may be entirely new, thus including chapter 2 in the examination. This is in contrast to a Master's degree where the minimum requirement is for chapter 5 to be original.

Chapter 6

Conclusions

My first rule for this chapter is to avoid finishing it with a section talking about future work. It may seem logical, yet it also appears to give a list of all items which remain undone! It is not the best way psychologically.

This chapter should contain a mirror of the introduction, where a summary of the *extraordinary* new results and their wonderful attributes should be stated first, followed by an executive summary of how this new solution was arrived at. Consider the practical fact that this chapter will be read quickly at the beginning of a review (thus it needs to provide a strong impact) and then again in depth at the very end, perhaps a few days after the details of the previous 3 chapters have been somehow forgotten. Reinforcement of the positive is the key strategy here, without of course blowing hot air.

One other consideration is that some people like to join the chapter containing the analysis with the only with conclusions. This can indeed work very well in certain topics.

Finally, the conclusions do not appear only in this chapter. This sample mini thesis lacks a feature which I regard as absolutely necessary, namely a short paragraph at the end of each chapter giving a brief summary of what was presented together with a one sentence preview as to what might expect the connection to be with the next chapter(s). You are writing a story, the *story of your wonderful research work*. A story needs a line connecting all its parts and you are responsible for these linkages.

Appendix A

Additional Information

This is a good place to put tables, lots of results, perhaps all the data compiled in the experiments. By avoiding putting all the results inside the chapters themselves, the whole thing may become much more readable and the various tables can be linked to appropriately.

The main purpose of an Appendix however should be to take care of the future readers and researchers. This implies listing all the housekeeping facts needed to continue the research. For example: where is the raw data stored? where is the software used? which version of which operating system or library or experimental equipment was used and where can it be accessed again?

Ask yourself: if you were given this thesis to read with the goal that you will be expanding the research presented here, what would you like to have as housekeeping information and what do you need? Be kind to the future graduate students and to your supervisor who will be the one stuck in the middle trying to find where all the stuff was left!

Bibliography

[1] Cliff Atkinson. *Beyond Bullet Points: Using Microsoft Office PowerPoint 2007 to Create Presentations That Inform.* Microsoft Press, 2008.

[2] Wayne Booth. *The Craft of Research.* University of Chicago Press, 2003.