

Elements of Technical Writing Style

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This guide provides a list of grammatical rules that are often violated by theses read by the author. Also included are common editor's marks for indicating needed manuscript changes, a suggested standard of mathematical notation, and example outlines of a dissertation and a praxis.

1 Rules of Grammar and Punctuation

The following are some rules of grammar and punctuation that are often ignored by thesis preparers. It will please your advisor and committee members (and, hence, make your job easier) if your manuscript does not include such errors.

1. If two adjectives are logically connected, create a compound adjective by adding a hyphen. For example, use *large-scale optimization*, not *large scale optimization*. An easy test is: if the adjectives can be used by themselves, a hyphen is not needed. In our example, “large optimization” and “scale optimization” do not make sense; therefore, a hyphen is needed to create a compound adjective.
2. *That* and *which*. Use *that* for restrictive clauses, and *which* before nonrestrictive clauses.
 - (a) A restrictive clause is one that limits—or restricts—the identity of the subject in some way. When writing a restrictive clause, introduce it with the word *that* and no comma. *Example: The paper that Ted wrote had no grammatical errors.* This is a restricted version of the sentence: *The paper had no grammatical errors.*
 - (b) A nonrestrictive clause may tell us something interesting or incidental about a subject, but it does not define or restrict the meaning of the subject. When writing a nonrestrictive clause, introduce it with *which* and insert commas around the clause. *Ted's paper, which was about birds, had no grammatical errors.*
3. Use serial commas when listing three or more items by placing a comma before the conjunction. *Example: The problem set was solved using programs A, B, and C.*
4. Always spell out integers less than 12. Never start a sentence with a number.
5. Dashes and hyphens.
 - (a) The *em* dash—supposedly the length of the letter *M*—is used to insert an explanatory or amplifying element into a sentence, such as in this one. This symbol is entered by --- in L^AT_EX and by pressing Alt-0151 in Word on a PC keypad.
 - (b) An *en* dash (–) is used for periods of time when you might otherwise use *to* (as in *pages 99–102*) or for combining compounds, such as the

Texas–New Mexico border because “New Mexico” is a compound adjective. It is entered by -- in L^AT_EX and by Alt-0150 in Word on a PC keypad.

- (c) A hyphen (-) is used for compound modifiers (e.g. primal-simplex algorithm) and for splitting a word at the end of a typed line. All keyboards have a hyphen key.
 - (d) No spaces appear before or after each of these punctuation marks.
 - (e) Minus signs are not dashes. They appear in mathematical formulas (e.g. $x - y = z$) and are entered as hyphens within a mathematical formatting environment, which will generate the proper symbol.
6. Do not indent text following mathematics-only displays if the writing relates to the equation. For example, consider the following expression

$$F = ma$$

where F is the force, m is the mass, and a is the acceleration of the mass.

- 7. Periods and commas go inside of quotation marks, and outside of parentheses when enclosing a parenthetical statement.
- 8. Define an acronym before using it, and define it only once. *Example: Data Envelopment Analysis (DEA) was invented by Abe Charnes, Bill Cooper, and Ed Rhodes.* Define all technical terms clearly for non-technical readers.
- 9. Do not use copyright or trademark symbols, such as “©.” They are no longer required by law and are unnecessary distractions.
- 10. When to italicize, underline, boldface (TBA)

2 Organization and Style

Dissertations and praxes tend to follow conventions in their organization. Appendices B and C provide suggested outlines for each thesis type.

- 1. The overriding principle: consistency, especially in bibliographies and references.
- 2. All items in a “Reference” list must be cited. Not all items in a “Bibliography” section must be cited.
- 3. A chapter cannot have only one section. A section cannot have only one subsection. A subsection cannot have only one paragraph. A paragraph cannot have only one sentence.
- 4. Do not use underlining, except in mathematical statements. Underlines are for use by persons using a typewriter that cannot print italics.

5. All figures and tables should appear on the first referencing page or an adjacent page. No reader likes hunting for a referenced item.
6. Seek to maintain good “flow” throughout your thesis. *Flow* describes how writing holds together and moves from one idea or point to the next. Organization of ideas, the use of connecting words within and between paragraphs, editing, and repeated revision help improve flow and make writing much more readable. (See [9] for further suggestions.)
7. Formula numbering and referencing (TBA)
8. When to quote versus cite (TBA)
9. Citations: when, how (TBA)
10. Captions on tables, figures (TBA)
11. Referencing figures and tables (TBA)

3 My Personal Stylistic Preferences

It is this author’s opinion that manuscripts written in the following way are more likely to be approved for publication, funding, or a positive decision by a doctoral committee.

1. Present-tense, third-person narratives. Present tense is more persuasive than past or future tense; the past is over and the future may not happen, so readers tend to downgrade those ideas. Use of the first person moves the reader’s focus onto the writer and away from the point being made. Instead of *I/We solved this set of problems and found that algorithm A was better*, try *Algorithm A is demonstrably better for this set of problems*.
2. Documents created with the L^AT_EX document preparation system [4].
3. The mathematical notation described in Section A. You are free to use this notational statement in your manuscript, verbatim. Citation of the document that you are reading would be nice, but is not required. Other notational systems are fine, as long as they are familiar to the readers, well-documented, and followed to the letter.

4 Other To Do’s

Before submitting your manuscript, have you:

1. Processed your manuscript with an electronic spelling-checker program?

5 Editing Marks

Typesetters and editors have developed a series of marks used to indicate changes that are needed in a given manuscript. Below are a series of such marks that the author uses, most of which are standard, some of which are his own shorthand.

In some cases, part of the edits include notations in the left margin space.

△ A space, or blank character.

<i>it</i>	<u>a</u> <i>Italicize</i> the underlined text.
<i>no it</i>	<u>a</u> Remove the italics from the underlined text.
<i>bf</i>	<u>a</u> Boldface the underlined text.
<i>no bf</i>	<u>a</u> Remove the boldface from the underlined text.
<i>uc</i>	<u>a</u> change the underlined text to upper case.
<i>lc</i>	<u>A</u> change the underlined text to lower case.
	¶ Begin a new paragraph at this point.
	<u>a</u> ⌢ Remove space, to form “ab.”
	<u>a</u> ^c ⌢ Insert text at the point noted (e.g., to form “acb”).
	<u>á</u> Remove the text.

6 Further Reading

There are two classic books on writing that all authors will enjoy. The 1959 classic known as *Strunk and White* [7] is a highly readable, pithy, 78-page guide to good composition and can improve anyone’s writing skills. The ultimate answer book for all writing questions is *The Chicago Manual of Style* [1], whose clear examples and clean organization provide welcome clarity to students and authors.

There are a number of online sources for writing improvement ideas, which can be found by searching on a specific topic. Some examples include [2] and [8].

SMU doctoral students need to follow the guidelines published by the university’s Graduate Office [6]. Resources include a L^AT_EX style file and document preparation and submission instructions.

The author appreciates receiving notice of any needed corrections to this document. Such changes would include examples of not following the advice given herein.

A Mathematical Notation and Conventions

This section describes the notational conventions that will be used throughout this manuscript. Specifically, the representations of and operations on sets, scalars, vectors, and matrices are addressed.

Sets are denoted by italicised uppercase Latin and Greek letters. The set created by removing element e from set S is given as $S - e$ and $|S|$ is the cardinality of S . The set of real number is denoted by \Re or \mathbb{R} and the set of integers and nonnegative integers by \mathbb{Z} and \mathbb{Z}^+ , respectively. For an ordered set T , the relative position index of element $e \in T$ is the integer $\iota(e, T)$, where $1 \leq \iota(e, T) \leq |T|$, or $\iota(e)$ where the set membership is obvious. An ordered subset of ordered set T , consisting of the i^{th} through the j^{th} elements, is given as $\Upsilon(T, i, j)$.

Matrices are denoted by bold uppercase Latin and Greek letters. The element in the i^{th} row and j^{th} column of the matrix \mathbf{A} is denoted by a_{ij} or $a_{i,j}$. Also, \mathbf{a}_i and \mathbf{a}_j are vectors containing the i^{th} row and j^{th} column of \mathbf{A} , respectively. An identity matrix is given as \mathbf{I} .

Vectors and scalars are denoted by lowercase Latin and Greek letters with vectors in boldface and scalars italicized. The i^{th} element of the vector \mathbf{x} is given by x_i . The vector of all zeroes is denoted by $\mathbf{0}$, a vector of all ones by $\mathbf{1}$, and a vector of all zeroes except for ones in positions m through n by $\mathbf{1}_n^m$.

Row and column vectors are not distinguished notationally, and the product of a vector and a matrix is interpreted such that the vector's dimensions are conformable for the operation (i.e., a vector appearing immediately to the left of a matrix is treated as a row, otherwise as a column). Similarly, unless transposition is indicated, the product of two vectors will result in a scalar (i.e., the left vector is a row, the right vector is a column).

B A Praxis Outline

The SMU Lyle School of Engineering Graduate Catalog [5] describes the requirements for a praxis as follows.

As a culmination of the doctoral program, the candidate must perform a suitable engineering praxis (practical engineering study) embodying the results of a significant and original investigation and write a praxis report. The scope of the praxis may be broad or narrow and may involve engineering design, development, or any other major category of engineering and applied science work. The praxis should demonstrate an original application of advanced engineering and scientific techniques to practice, hence it must involve the development and application of mathematical models.

The project may focus on a well-defined practical problem or on a more general theoretical development that is relevant to current engineering practice. If the focus is a practical problem, economic

considerations must also be incorporated in the praxis. If the focus is more general, the Supervisory Committee will determine whether or not economic aspects will be required.

Superior scholarship, including recognition of both previous and current work in the subject area, is required. The praxis report should be suitable for publication in an academic-quality journal.

The praxis report must make an original contribution to the practice of engineering or applied science, and is expected to be a mature and competent piece of writing. Being the result of engineering and management practice, it should have strong technical and quantitative content, embody a managerial dimension, and demonstrate the use of the highest standards of scientific investigation and reporting. The praxis report format must follow the University guidelines as indicated in the *SMU Guidelines for Preparation of Theses and Dissertations*.

Most of the praxes evaluated by this author generally follow the same general structure. While each one is different, a student would not go wrong by using this outline:

1. Introduction and Overview

- (a) Short introduction, briefly describing the problem addressed, the approach used, and type of results sought
- (b) Context: Sets the stage, provides the roots of and motivation for the problem being solved
- (c) The Problem: A high-level description of the specific problem(s) addressed
- (d) Literature Review: a summary of works on or related to the problem that have been published. Include short summaries of highly relevant publications and provide citations for all papers, books, or articles found in the literature that are related to the research topic.
- (e) The Approach: The methods used in this research to address the problems, the type of models employed, the types of analysis used.
- (f) Expected Contributions: The value of this research and the anticipated contributions to knowledge and advances in practice. Explain how this work is different from and superior to what has appeared in the literature to date.

2. Problem Description and Solution Approach

- (a) Mathematical Notation and Conventions: See Section A for an example.
- (b) Problem Definition: an in-depth definition of the research project or problems addressed. Clearly specify the scope—what is covered and what is not.

- (c) Formulations of the Model or Algorithm: if mathematical models are key to the development, carefully define each one using your notation and document their differences.
3. Experimental Design This section describes states research hypotheses to be tested and describes how the study will use empirical data to address them and draw its conclusions. This section relies on the use of statistical experimental design principles and methods covered in the degree's coursework.
- (a) The Experiment: Response variable, factor descriptions and levels, hypotheses investigated
- i. Response variables and performance evaluation criteria. What quantitative measures were used to evaluate the test cases, such as: execution time, closeness to optimality, number of defects, percentage of outcomes that were defective (e.g., unsolved problems, blocked requests, unacceptable solution values)
 - ii. Factors to be explored, and levels. List of user parameters and values used and how they were chosen. Examples:
 - A. Factor ϕ was set at levels 0, .5, .8, and 1.
 - B. Topologies tested were these six models: ...
 - C. Factor x was fixed at a value of 10 (was not varied) for all tests; the value was chosen because ...
 - iii. The hypotheses to be tested. Examples:
 - A. H_0 : method A has the same average performance as method B
 - B. H_0 : problem size n does not affect runtime t
 - C. H_0 : there are no significant differences in blocking rates between network topologies
- (b) The Design: What evidence is used, how evidence is gathered, number of observations, randomization
- A network simulator was developed that used inputs of topology, traffic arrival rate, user parameters, ... and gave outputs of ...
 - A random problem generator, NETGEN [3], was used to create sample problems with predetermined characteristics (e.g., average node degree, arc capacities, etc.)
 - Computing environment where deployed (machine type, speed, memory available, OS, operating restrictions such as run time limits, ...)
- (c) The Analysis: How the data is analyzed, what test statistics are used, what significance level (α , probability of Type I error) is used to draw conclusions Example statistical criteria: number of replications (and justification), ANOVA type(s) employed, and Tukey's test of significance.

4. Experiment Test Results and Analysis

- (a) Summary of Test Data: Tables of statistics, and possibly raw data. Usually summary data such as average performance by category, and some results from statistical software.
- (b) H_0 -by- H_0 or factor-by-factor statistical analysis and conclusions. Example hypothesis outcomes:
 - i. H_0 #1 was rejected, since the ANOVA showed significant differences in average performance between methods A and B
 - ii. H_0 #2 was rejected, since there were significant differences (with an α of 0.05) between average runtimes for different values of n
 - iii. H_0 #3 is accepted, since the average blocking was the statistically equivalent across all topologies, when all other factors are held constant

Single-factor analyses may precede multi-factor analyses.

- (c) Findings, Practical Implications, and Recommendations Drawn from the Experimental Results

Note that some praxes address several problems. Each may be described in a separate chapter that covers topics 2b–4c for its specific case.

5. Conclusions and Future Research

- (a) Summary of Findings and Conclusions Reached by the Study
- (b) Contributions of the Research: Why This Work Is Important¹
- (c) Future Research: Next Steps, Extensions, and Additional Research Ideas Flowing from This Effort

C A Dissertation Outline

The SMU Lyle School of Engineering Graduate Catalog [5] describes the requirements for a dissertation as follows.

The dissertation format must follow the Guidelines for Preparation of Theses and Dissertations. Each student is also expected to submit articles for publication in reputable journals and conferences appropriate to the field of research. The most clearly distinguishing characteristic of a program leading to the Ph.D. degree is the requirement that the candidate write a dissertation embodying the results of a significant and original investigation. The dissertation is expected to be a mature and competent piece of writing and must make a significant and novel contribution to the engineering or applied science discipline. The work it reports may be basic scientific research, engineering research or creative design.

¹If not included, committees will insist that it be added or assume that the research has little or no value.

Many of the dissertations evaluated by this author generally follow the same general structure. Typically, the first chapter describes what is to come: the problems addressed, a literature review, and a preview of the novel approach that has been developed, and a justification of the work in terms of expected contributions to the world's knowledge.

The introduction is followed by a series of three or more chapters, each of which has been published (or is publishable) in a scholarly journal. The thesis concludes with a chapter summarizing the results, explaining their value or contributions, and suggesting further important research that would build on this work.

While each dissertation is different, the following is a familiar outline:

1. Introduction and Overview
 - (a) Short introduction, briefly describing the problem addressed, the approach used, and type of results sought
 - (b) Context: Sets the stage, provides the roots of and motivation for the problem being solved
 - (c) The Problem: A high-level description of the specific problem(s) addressed
 - (d) Literature Review: a summary of works on or related to the problem that have been published. Include short summaries of highly relevant publications and provide citations for all papers, books, or articles found in the literature that are related to the research topic.
 - (e) The Approach: The methods used in this research to address the problems, the type of models employed, the types of analysis used.
 - (f) Expected Contributions: The value of this research and the anticipated contributions to scholarly knowledge and advances in practice. Explain how this work is different from and superior to what has appeared in the literature to date.
2. Individual Research Sub-Topic The manuscript should contain at least three sub-topics. Each sub-topic writeup is publishable independently from the others.
 - (a) Problem Description and Solution Approach
 - i. Mathematical Notation and Conventions: See Section A for an example.
 - ii. Problem Definition: an in-depth definition of the research project or problems addressed. Clearly specify the scope—what is covered and what is not.
 - iii. Formulations of the Model or Algorithm: if mathematical models are key to the development, carefully define each one using your notation and document their differences.

- iv. Special Considerations: Any calibrations, value estimations, or tuning needed for the approach, what settings were used and how they were arrived at.
 - (b) Experimental Design This section describes how the study will use empirical data to address stated hypotheses and draw its conclusions. This section relies on the use of statistical experimental design principles and methods covered in the degree's coursework. See details in outline parts 3–5 in Section B above.
 - i. The Experiment: Response variable, factor descriptions and levels, hypotheses investigated
 - ii. The Design: What evidence is used, how evidence is gathered, number of observations, randomization
 - iii. The Analysis: How the data is analyzed, what test statistics are used, what significance level (probability of Type I error) is used to draw conclusions
 - (c) Experiment Test Results and Analysis . (See also Section B details.)
 - i. Summary of Test Data
 - ii. Single-Factor Analysis and Hypotheses Results
 - iii. Multi-Factor Analyses and Hypotheses Results
 - iv. Findings, Practical Implications, and Recommendations Drawn from the Experimental Results
 - (d) Summary of Findings and Conclusions Reached in This Chapter (See also Section B details.)
3. Conclusions and Future Research
- (a) Summary of Findings and Conclusions Reached by the Study
 - (b) Contributions of the Research: Why This Work Is Important²
 - (c) Future Research: next steps, extensions, and additional research ideas flowing from this effort

References

- [1] *The Chicago Manual of Style, 16th Edition*. University Of Chicago Press, 2010.
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²If not included, committees will insist that it be added or assume that the research has little value.

- [3] D. Klingman, A. Napier, and J. Stutz. NETGEN: A program for generating large scale capacitated assignment, transportation, and minimum cost flow network problems. *MANAGEMENT SCIENCE*, 20(5):814–821, January 1974.
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