

Mathematical Writing with \LaTeX

Jeffrey Clark (clarkj@elon.edu)

Rose Cordero

Lauren Hamilton

Shannon Hill

Brian Neiberline

Jessica Pollard

Raymond Singletary

Ashley Trent

Elon College

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Abstract

During Elon College's three-week Winter Term, the first author taught a course on Mathematical Writing with the remaining authors as students. We describe the components of the course, including a web-based tutorial on \LaTeX .

1 Introduction

I (Clark) first came across Knuth's class notes [2] on his course on Mathematical Writing several years ago, and became very excited by it. I definitely wanted to teach a course like this myself.

I had the opportunity to do so this past Winter Term. (Elon's Winter Term classes meet three hours a day for three weeks each January.) We had a good group of sophomores and juniors who were interested in improving their writing skills. After consultation with my colleagues, I designed a course that would provide writing experience and support to students in an intense workshop environment.

I did not want word-processing problems to stand in the way of their writing, so I put together a web-based tutorial on \LaTeX . (\LaTeX is a very powerful system for constructing mathematical documents, is widely-used, and has freeware implementations that we have installed in our computer labs.) The tutorial focussed on basics and practice, and permitted direct electronic submission of student work from any web browser. (You may visit a version of the tutorial at frodo.elon.edu/cgi-bin/latex5.cgi.)

To provide variety, the first hour of most classes was spent discussing a topic, the second in the lab practicing \LaTeX , and the third was spent

in writing and discussion. Wherever possible, I had the students work in pairs.

I required as texts Gillman [1], which I had found helpful some years before, and Van Leunen [4], which I had encountered via Knuth [2], and which would serve as a more general resource for my students.

The students were asked at the beginning of the semester to choose a mathematical topic that interested them and write a term paper on that topic. There was no requirement as to depth other than length: the paper was to be approximately ten pages long, and thus would require thought as to its structure. Students were asked to meet with me to discuss their topic before committing to it, then to prepare an outline and first draft for review before submitting their term paper on the last day of class. We discussed the papers in class, and the authors read aloud their drafts prior to submission.

The term paper assignment required an introduction, titled sections, a conclusion, and a bibliography containing at least two print references.

In addition to the term paper, there were several short paper assignments for each class, usually on the topic of the day.

2 Student Summary of Course Content

2.1 Abstracts

A reader might have to choose between several papers. It might be useful to have a separate page that summarizes the work you have done. By doing this, a reader can pick and choose a paper filled with information that he wants to read about. This summary is known as an *abstract*.

An abstract is used primarily to lay out a paper's main content. With its use of keywords, the abstract briefly establishes the purpose of the paper. In doing this it tends to give away major topics that would most likely not be mentioned in the introduction. Although both the introduction and abstract are used to motivate the reader, the abstract tends to give more information about the later sections of the work.

2.2 References

The use of references in a paper can serve different purposes depending on your point of view. By point of view I mean that it depends on whether you are the reader or the writer. As a writer, a reference can keep you honest. In keeping you honest it ensures that the information that you are presenting is correct. It also gives praise to your source for writing the information.

On the other hand the reader may view this source as a window of opportunity to gain further knowledge on the subject. Through this knowledge the reader will be given the ability to judge the information freely and make their own interpretation. Each reference used can serve a different purpose, depending on what aspect of the paper you are discussing. This should give your reader the opportunity to go back and trace every portion of your work without difficulty.

2.3 Conciseness

First of all, it is important to note that “concise” does not mean “short”. To be concise, you must check to see that everything on the page has a purpose, including every word, sentence, paragraph, and section. Superfluous words make your paper seem shorter, because there is less content. You must be direct and to the point with your reader. As Gillman [1] points out, “concise” means that you don’t waste words.

2.4 Revision

The revision process is one of the most important topics when writing. A paper/document always becomes better after some kind of revision. Michael Jordan did not become the player that he is the first time he stepped on the court. It took time to refine the skills he had since childhood. A paper works the same way—it is not going to turn out perfect the first time. Keeping this in mind, the following are some subtopics related to the revision process.

After a draft is complete, the author might want to look back at each paragraph and write (on a separate piece of paper) its themes. By doing this, the author will see the organization of the paper. At the same time, if it is difficult to write a theme then the paragraph probably isn’t a good one. Another reason for this exercise is for the author to develop sections and place the paragraphs accordingly. Without organization, no paper is complete and without revision it is hard to achieve organization. Also while revising, the author may rearrange words and sentence to produce clarity or smoothness.

2.5 Audience

Before beginning to write, an author must first decide the type of audience for the paper. The type of reader determines the style of writing. The various kinds of audiences indicate many different styles of writing available to the author.

Often papers are directed toward an editor or a grader. Although this audience does not need in-depth explanations, it requires a demonstration of understanding from the writer. A repetition of definitions and theorems will not indicate an understanding unless they can be used correctly.

An audience may also be made of peers, but it is important to know their mathematical background. An audience of fellow math students shares common knowledge with the author. This allows the author to include more complex ideas and reduce the amount of explanation for simpler ideas. However, for a non-math peer audience, a lot of preparation is required of the author. Attention must be paid to detail with respect to wording, explanations, and the number of symbols used. Some papers will be aimed at audiences of informed members. These audiences demand less background information. A heavier reliance on symbols is allowed.

With the wide or general audiences, the challenge of maintaining interest arises. The author must find a middle ground to keep interest, while avoiding confusion. A good strategy is to include something for

everyone. Accommodate the less-informed members of the audience with generalization and good explanations of the ideas in the paper. Include more complex ideas in a separate section for those that have enough background. This provides the advanced readers with an opportunity for more information on the topic, while allowing other readers to skip this section that may not interest them.

2.6 Proofs

A proof is a way to convince the reader that a claim is true. It is written to explain the writer's logic to the reader. Proofs are arguments with the reader to show the validity of the subject.

Proofs are valid or invalid. An invalid proof has poor structure and content. A valid proof includes enough information for the reader to be convinced that the subject or claim is true. It also has good supporting structure leading to the conclusion. A good proof is able to explain its every step to an arbitrary degree of understanding.

It is important to identify the main theorems and algorithms of your proof to form an outline. These tools are verified when applied to the proof. Including few computations in a proof, and eliminating the simple steps is also important to writing proofs. Every proof should have a conclusion where the question or claim is answered or verified. Remember it is essential to refrain from wasting words in this part, so be sure your words and ideas are clear. It is crucial that you do not bore the reader.

Proofs can be written in paragraph form or in outline form. When outlining a proof, it is important to start with the main ideas. For each level under the main ideas to the proof, detail becomes more complex and the level of understanding depreciates. When writing proofs in paragraph form, be sure to use words instead of symbols whenever possible. Being consistent with your notation at all times is important. Never start or stop a sentence with a variable because it may confuse the reader. Remember to always use sentences whether words or symbols are used. Variety of words and sentence structure are important to writing good proofs.

2.7 Symbols

A symbol is defined as something that stands for something else. In writing, symbols are usually used to abbreviate complex ideas. With symbols clarity and consistency are needed so the reader better understands the paper. Keeping this in mind, symbols should not begin a sentence that follows another sentence ending with a symbol.

Roman and Greek letters are used in mathematics as symbols for various purposes. For example, the Roman letters j , k , l , m , and n are frequently used to depict integers; while x and y are used as real numbers. The Greek letter θ is often used to stand for an angle measurement.

Symbol usage should remain consistent. The use of different letters (a, b, c) versus letters with indices (a_1, a_2, a_3) is left to the writer's discretion. However, these should not be mixed in the same equation. By remaining consistent with symbols, the reader can better see the pattern in the formula.

3 L^AT_EX Tutorial

The tutorial included the following sections. Much of the information came from [3].

- Introduction
- Symbols
- Bibliography and Compound Expressions
- Sections, Accents, and Changing Font Style
- Tables, Arrays, and Lists
- Multiline Equations
- Business Letters
- Slides
- Spacing
- Mathematical Symbols
- Negations
- Boxes and Cross-references
- Tables of Content and Abstracts

4 Strengths

Students listed the following as strengths for the course:

- We used writing exercises (see Appendix A) from Van Leunen on a daily basis. The exercises helped us all to think about how to vary our syntax, choice of words, perspective, etc.
- Whenever possible, we read to each other from our writing. This helped us to spot awkward wordings and syntax, as well as get a sense of flow.
- While there is another class at Elon to teach proof technique, it was helpful having a class discussing how to revise and improve proofs.
- Writing our own manual for using L^AT_EX will make it easier to use later.
- The L^AT_EX tutorial sessions helped break up the long class.
- It helped to visit the library and discuss the different collections.
- It was helpful to practice writing abstracts.
- Practicing revising someone else's work made it easier to see what goes on in revision.
- The course should be offered regularly.

5 Improvements

One of my goals for the course that was not achieved was to expose my students to a variety of mathematical writing styles. In a three-week course, there was a limit as to what I could expect for reading assignments. I hope that the next time I teach this course, it will take place during a regular semester, so that reading well-written mathematics will become a major component of the class.

In a survey given at the end of the term (see Appendix B), students recommended the following:

- Don't force all writing activities to be done with a partner.
- Make sure revision assignments are meaningful.
- Motivate proof outlining.
- Avoid repetition in L^AT_EX practice and summary assignments.
- Allow some writing assignments to be done on other text systems (that could be used at home, etc.).
- The reading and critiquing of each others term papers should have been spaced out.
- Make the web tutorial easier to navigate.

6 Conclusion

This course serves a clear need, namely that of our students to accumulate experience in writing skills. Other mathematics departments, if they are not already doing so, should consider a similar sort of course for their majors.

A Exercises

The following exercises were adapted from ones by Mary-Claire van Leunen, and are quoted from [2].

- Take a two-paragraph passage from one of our texts and replace at least three words in every sentence with others that mean approximately the same thing.
- Choose a word and write a thesaurus entry for it.
- Take a two-paragraph passage from one of our texts and change the syntax in every sentence without changing the meaning of the sentence.
- Take a sentence of at least ten words and re-write to change the emphasis in as many ways that you can.
- Write a three-sentence paragraph that is correct grammatically but that has no meaning.
- Compose a paragraph with your eyes closed.

B Class Survey

This is the first time that this course has been taught. If it has been useful for you, then we will attempt to offer it regularly for other mathematics majors and minors.

Please answer the following questions. I will not read the answers until after your grades have been turned in.

1. What aspects of lecture delivery did you find helpful? What aspects of lecture content did you find helpful? What could be done better?
2. Which group activity was the best? Which group activity was the worst? Why?
3. Which in-class writing assignment was the best? Which in-class writing assignment was the worst? Why?
4. Which out-of-class writing assignment was the best? Which out-of-class writing assignment was the worst? Why?
5. What part of the L^AT_EX tutorial was most helpful? What would you recommend changing?
6. List the three most important class activities; why were they important to you?
7. List the three least important class activities; why weren't they important to you?
8. What were your expectations for this class? How did those expectations change? Were those expectations met?
9. Describe any discoveries that you made about mathematical writing.
10. What suggestions would you offer to a student taking this course the next time it is offered?

References

- [1] Leonard Gillman, *Writing Mathematics Well*, The Mathematical Association of America, 1987.
- [2] Donald E. Knuth, Tracy Larrabee, and Paul M. Roberts, *Mathematical Writing*, The Mathematical Association of America, 1989.
- [3] Helmut Kopka and Patrick W. Daly, *A Guide to L^AT_EX 2 ϵ* , Addison-Wesley, 1995.
- [4] Mary-Claire van Leunen, *A Handbook for Scholars*, Oxford University Press, 1992.