Writing in the Age of LaTeX

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Technical writing, and mathematical writing in particular, is a complex and difficult task. While a number of excellent articles have been devoted to mathematical writing, few if any address issues concerning the use of computer technology. The aim of the present article is to draw the reader's attention to existing works on mathematical writing, to offer some suggestions on writing in general which are tangentially computer-related (such as concerns that arise in LaTeX typing but not in plain typing), and to voice some opinions on the proper use of computers in typesetting (not necessarily in this order). LaTeX is a powerful tool which can be used creatively or detrimentally, but the young writer who has never encountered or pondered issues of technical writing (e.g., this author five years ago) is far more likely to exploit the detrimental capacity. There is danger of becoming infatuated with the capabilities of LaTeX, especially the bewildering variety of fonts and symbols, and neglecting less glamorous but more important aspects of writing such as style, diction, clear communication of ideas, and accurate citation of existing work, not to mention the more subtle aspects of typography such as proper line breaking, spacing, and numbering. In the age of LaTeX especially, authors must devote thought to the mechanics of writing and formatting or suffer the consequences of producing literature that is ugly as printed work and is difficult to read, cite, and use.

Computer technology has revolutionized the production of mathematical literature. From an author's point of view, the two most important developments are editing (in the sense of word processing) and typesetting capabilities, including previewing. The inconvenience of typing is evoked by Krantz [7], who describes Stephan Bergmann's hilarious modus operandi, and Halmos [3, pp. 143–144], whose tribulations simply need not occur today. More importantly, however, computer typesetting has brought the formatting—as opposed to writing—of mathematical papers into the author's realm of control: LaTeX gives the author complete freedom to locate symbols on a printed page. The flipside of this freedom is the responsibility to act competently as a typographical compositor. In order to produce material that is attractive and easy to read, it is helpful to have some idea of the nature of typographical composing. The gist can be gleaned from Halmos [2, 3] and Doob et al. [1], who describe the pre-LaTeX typesetting process. Many things have changed since [1], a manual of mathematical style, was written, but most of the advice is quite relevant if the reader substitutes "TeX typist" for "compositor". Chapters 11 and 12 of Knuth [5] describe more systematically the mechanics of typographical composition and merit perusal.

The writings [1, 2, 3] and the articles of Mermin [10, 11; reprinted also in his book *Boojums all the way through*, Cambridge Univ. Press, 1990, pp. 63–73] raise many important issues involving technical writing. (Mermin is a physicist, and his views are relevant to mathematical writing as well.) The beginning writer who seeks out these works will better appreciate the perils and pitfalls of technical writing and will vividly appreciate the debt owed to Knuth, Lamport, Spivak, and other contributors to TeX and LaTeX.

To paraphrase Halmos [3], it is the author's responsibility, not the referee's, to see that the content of a paper is factually correct. Nonetheless, in order to eliminate ambiguous or incorrect wording, journals might routinely submit accepted articles to copyediting (distinct from refereeing) *by someone with mathematical train-*

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ing. This proviso is crucial: Unfortunately, it is not uncommon for a nonmathematician to replace a theorem by a more pleasant-sounding falsehood, or for a professional editor to apply "rules of writing" that undo carefully crafted passages. Halmos [3] and Mermin [10] give specific examples from their own experience.

Errors are bound to occur in any written work, but misstatements of results (including ambiguous wording) are less forgivable than typos. Some common causes of badly stated results are misplaced or misused existential quantifiers and omitted hypotheses. Avoid use of the word "any" as an existential quantifier; use "each", "every", or "some" instead. The following example, paraphrased from Halmos, illustrates why.

If $f(x) = x$ for any x, then f has a fixed point.

Here the ambiguity is easily—perhaps unconsciously—resolved, but in a less familiar or simply more complex situation (especially where the author has overused LaTeX, as here) it may not be:

$$(*) \qquad \alpha(X) = 0 \text{ for any } \alpha \in H^0_{\bar\partial}(M, T^{1,0}M^*) \Longrightarrow X = \bar\partial^\sharp f, f \in C^\infty_{\mathbf{C}}(M).$$

The author's intent may ultimately be deciphered, but the cumulative effect is to detract from the article's utility as a vehicle for communicating mathematical information. Proofreading by someone other than the author always reveals mistakes ranging from misspellings or lapses of grammar to ambiguous wording and the occasional bald falsehood. Rereading one's own work after a week or two of not looking at it is equally revealing. The result of shirking is visible and permanent.

The remaining points and suggestions either have not been addressed by previous authors or are worth repeating in the context of computer typesetting. They range from good writing habits and stylistic preferences to suggestions for useful reading and opinions on labelling and numbering.

1. The mathematical author must be a careful writer, for much of the power of mathematics lies in its precision. If only for this reason, authors should avoid rushing their work into print. Computers facilitate rushing in at least two ways: It is possible to edit a manuscript quickly and carelessly with a computer (yielding a badly written but otherwise presentable manuscript), and the manuscript, once written, is easy to distribute electronically. The pressure to publish is greater than ever, but this should not override the need to write well.
2. It is nearly universal for the abbreviation "cf." (from the Latin *conferre*) to be used instead of "see", but the two are not interchangeable. A good rule of thumb is to read " cf." as "compare with". For example, "see" in relation to a result clearly indicates citation, while "cf." suggests originality.
3. If appropriate, page numbers or other specific information should be given when referencing other work. This makes the reader's task easier and keeps the author honest. Routinely citing "well-known" results creates an impression of scholarly laziness. A more serious consequence is raised semi-facetiously in a recent letter by Stéphane Collart to the *Mathematical Intelligencer* (vol. 17, no. 1, Winter 1995, p. 3). She suggests there is a "Heisenberg Principle in Mathematics: You can know either the definitions or the theorems, but not both at the same time." In other words, it is important to cite only results that actually exist.
4. The use of authors' initials in square brackets for bibliographic referencing (e.g., [J-S] or [Jo-Smi]) is unhelpful as a labelling system, especially if there are many references; the reader may have difficulty locating an item in the bibliography because the labels are alphabetized according to the authors' names, which are of course unknown to the reader until the item is located. Additionally, this system is distracting; the reader is left guessing who the authors are each time a new reference appears. This unfortunate method was used in a recent encyclopedic volume (here unnamed), compromising its ease of use. Indeed, this author has not been able to determine how the entries in the bibliography are ordered.

   One standard format in other scholarly fields is that for the first appearance of a reference, the authors' names are written out in full followed by a number in square brackets (Jones and Smirnov [18]), and the number alone ([18]) is used for subsequent references. LaTeX is amenable to this convention; indeed, an author must expend effort *not* to use it. The author might refresh the reader's memory if a reference has not occurred for several pages. In encyclopedic works with hundreds of references, the rule may be bent so that each author's works are numbered separately; see Kobayashi [6] (bent rule) and Mumford, Fogarty, and Kirwan [12] (unbent rule).
5. An author should strive to convey ideas with a minimum of notation while clearly delineating conceptual elements; just the opposite of $(*)$ above. This old advice does not suggest notation should be avoided; a certain amount is needed for precision and brevity. However, a barrage of notation will

deter all but the most diligent reader. Littlewood [9, pp. 31–34] contrasts by vivid example what he calls a "civilized" and a "barbaric" proof. Since LaTeX brings the power to write barrages of notation easily within the author's grasp, it is prudent to consider possible alternatives before sampling LaTeX's "menagerie of mathematical symbols" ([8, pp. 44–45]; see also [1, pp. 443–444]).

Notation should be chosen carefully to communicate ideas before writing is begun. This advice, due to Halmos [2], helps guard against attachment of useful letters or symbols to specific concepts (Halmos cites the use of "xyz-space" instead of the preferable $\mathbf{R}^3$) and against notation that does not reflect the logical structure of the material (such as using $x_{i_1 \cdots i_k}$ and $x_{i_{1 \dots k}}$ for unrelated quantities, or of having the value of y_t at $t = 0$ differ from y_0).

6. Lamport [8], particularly pp. 5–8, is highly recommended to all (potential) users of LaTeX. A small sampling is quoted here.

> The purpose of writing is to present ideas to the reader…. If, while writing, you spend a lot of time worrying about form, you are probably misusing LaTeX (p. 8).

In other words, do not alter LaTeX's style parameters just because it is easy to; they were designed by a professional and work very well. This is not to say LaTeX is perfect (see item numbering below, for example), only that it should not be modified without good reason.

7. Beginning users of TeX, whether they type mathematics or not, will find much of value in Chapters 1–6, 9, and 14 of Knuth's *TeXbook* [5]. TeX performs the role of compositor, but as a computer program it needs to be told what to do in certain circumstances. This is especially true of line breaking, the subject of Chapter 14. A good human compositor will not break lines of text at certain points because the effect would be distracting to the reader. A good TeX typist recognizes bad line breaks and tells TeX not to make them.

Chapters 18 and 19 of the *TeXbook* ("The Fine Points of Math Typing" and "Displayed Equations" [5]) are essential reading for good mathematical typing and deserve careful study. Spacing in mathematical typesetting is delicate, but not difficult to learn. Since there is a good chance a professional compositor will never see the manuscript, it is the author's responsibility to produce copy worthy of the label "camera-ready". A simple but common mistake is to use math italics where Roman should be used. Another is to put equations in paragraph mode when displaying might be more appropriate and vice versa.

8. Load external fonts only as a last resort; they tend to cause difficulty to recipients of electronic manuscripts. In addition, recipients will be thankful if all occurrences of external fonts occur in macros where they can be redefined.

The blackboard boldface font is unnecessary. Lecturers use it because it is not possible to write boldface in chalk, while users of computer typesetting are not so constrained. The symbols **N**, **Z**, **Q**, **R**, and **C** for the standard sets of numbers are not indelibly attached to any other concepts—indeed, they are rarely used for anything else—while blackboard bold is inconvenient and not attractive.

9. The purpose of numbering items in a document is to make them easy to find when they are cited later in the document or used by future scholars. LaTeX's default numbering is not ideal in this respect; encountering Remark 5 followed by Proposition 8, equation (14), Lemma 10, Theorem 2, and equation (15) is not going to help the reader find any of these items later. Happily, LaTeX makes it easy to number different environments (theorems, remarks, definitions, and so on) with the same numbering; see [8, pp. 57–59]. To generate equation numbers within sections, one method (with no claim of elegance) is:

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\renewcommand{\theequation}
{\thesection.\arabic{equation}}
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The counter "equation" takes the value $k.n$ for the nth equation in section k. It is necessary to reset the "equation" counter to zero each time a new section is begun. This assignment of LaTeX counters is compatible with [8, pp. 57–59].

The nature of the document (short research note, long article, monograph, textbook), the subject matter, and of course the author's tastes will influence the way items are numbered. For a research article, the intent is usually to separate original results from cited results (perhaps by using letters instead of numbers) and to number the "milestones" of the paper serially within sections (to spare the reader from flipping through pages to find whether Remark 4 comes before or after Proposition 6). For books or expository writings, Hartshorne [4] and Kobayashi [6] may be consulted as examples of successful numbering (and for stylistic and typographical inspiration as well).

10. The previous item discusses noncontroversial aspects of numbering; authors seem to agree that numbering is for the reader's convenience. It is the implementation of this goal that has generated the most varied and heated responses from readers of early versions of the present article. With respect to numbering displayed equations, responses literally ranged from "number none" to "number them all", with both opinions strongly held. The state of affairs to avoid is summed up by Mermin [11], who is specifically addressing the numbering of equations, though he captures mathematical writing (at its worst) in general:

    > Our knowledge is acquired implicitly by reading textbooks and articles, most of whose authors have also given the problem no thought.

    Since consensus—and therefore a standard format—is impossible, the best course of action is to consider the motivations for various possibilities so that each author can make a purposeful decision.

    Mermin [11] is a good starting point for debate. He gives three rules for incorporation of mathematics into a document, taken here in reverse order. The last addresses a problem that does not exist in mathematical literature, the refusal of physics editors to punctuate equations. His larger point is that equations should be treated as prose. This author was surprised to find that anyone might argue the contrary.

    Mermin's second rule is a simple but helpful gesture of consideration from author to reader: When referring to an equation, use a brief verbal description in addition to a number. For example, write "substituting the L-series (2.4) into the area formula (1.7) and using the recurrence relation (2.5) …" rather than "substituting (2.4) into (1.7) and using (2.5)…"

    Mermin's first rule, "Fisher's Rule", is to number every displayed equation. His reason is that the author cannot know in advance if it will be necessary to refer to a specific equation or whether some future author (or the referee) may wish to do so. This is offered in contrast to "the heresy [called] Occam's Rule", which is only to number equations which are later referenced in the text, or the "Fisher-Occam Rule", which is to number equations which *might* be referenced later.

    A LaTeX hacker can write code which will cause an equation number to be generated if and only if the equation is later referenced, which bypasses the Fisher-Occam Rule. I wish, therefore, to defend Occam's Rule itself.

    Many equations are displayed only because their content is too long or high to fit conveniently into a paragraph (matrices, commutative diagrams, and sets in braces come to mind), not because they are of special interest. Others are intermediate steps in a calculation which cannot be avoided. Most of the remainder are displayed for local emphasis, but will not be referenced. None of these equations requires a label. Numbering each displayed equation leads to large equation numbers, most of which are never used. More importantly, an equation number signifies the author's opinion that the display is particularly important, a distinction which is lost under Fisher's Rule.

    Regarding inconvenience to the reader, editors and referees generally refer to specific lines of text when making suggestions or corrections in hard-copy manuscripts, and displayed equations need not be an exception. The future scholar who wishes to cite a displayed equation—numbered or unnumbered—does the reader a serious disservice by not rewriting the equation into the document. According to Mermin's own good advice, the author should remind the reader verbally of the content of an equation already in the reader's hands. It makes even more sense for the author not to burden the reader with a trip to the library to locate information from an outside reference.

    The suggestion from the "no numbers" end of the spectrum is to associate each important displayed equation with a numbered item (be it a lemma, theorem, definition, or remark) and to number equations locally (as in "equations (1)–(3) following Theorem 4.2") when numbering cannot be avoided.

    A smaller, and final, concern is whether to put equation numbers on the left or right. A number on the right interrupts the flow of prose less than one on the left and takes less vertical space on the page. TeX is also better at accommodating right-hand numbers. On the other hand, numbering on the left puts all the labels in the same margin, making them more uniform and easier to find. This typographical issue deserves at least a modicum of thought.

It is this author's belief that the main purpose of the literature is to serve as a scholarly reference body. With the current progress of technology, it is increasingly the burden of authors to ensure that the literature is able to perform this service. TEX, LATEX, and their macro packages give mathematicians tremendous power and flexibility to typeset mathematics. They are also capable of things which are not merely unnecessary in mathematical writing, but are actually detrimental. The computer-driven revolution in mathematical typesetting should be used by authors to create documents which are beautiful in form as well as content, which are pleasant to read (see Mermin's closing lines in [10]), and which record with dignity and elegance the mathematical progress of our time.

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References

[1] J. L. Doob, L. Carlitz, F. A. Ficken, G. Paranian, and N. E. Steenrod, *Manual for authors of mathematical papers,* Bull Amer. Math. Soc. **68** (1962), 429–444.

[2] P. Halmos, *How to write mathematics*, Enseign. Math. **16** (1970), 123–152. Reprinted in Halmos, *Selecta, expository writings*, Vol. 2, Springer, New York, 1983, pp. 157–186.

[3] ____, *I want to be a mathematician*, Springer, New York, 1985.

[4] R. Hartshorne, *Algebraic geometry*, Graduate Texts in Math., vol. 52, Springer, New York, 1977.

[5] D. E. Knuth, *The TEXbook*, Addison-Wesley, Reading, MA, 1986.

[6] S. Kobayashi, *Transformation groups in differential geometry*, Ergeb. Math. Grenzgeb., vol. 70, Springer, Berlin, 1972.

[7] S. Krantz, *Mathematical anecdotes*, Math. Intelligencer **4** (1990), 32–38.

[8] L. Lamport, *LATEX*, Addison-Wesley, Reading, MA, 1986.

[9] J. E. Littlewood, *A mathematician's miscellany*, Methuen, London, 1953.

[10] N. D. Mermin, *What's wrong with this prose?*, Phys. Today **42** (1989), 9–11.

[11] ____, *What's wrong with these equations?*, Phys. Today **42**(1989), 9–11.

[12] D. Mumford, J. Fogarty, and F. Kirwan, *Geometric invariant theory*, 3rd enlarged ed., Ergeb. Math. Grenzgeb., vol. 34, Springer, Berlin, 1994.