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LaTeXnics: The effect of specialized typesetting software on STEM students' composition processes

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Abstract

Undergraduate science, technology, engineering, and mathematics (STEM) students are often trained to use technical typesetting software in order to produce authentic mathematical prose, though little research exists about how this writing technology impacts students' thinking and computation process. Drawing upon survey and interview research conducted at two liberal arts institutions, the authors investigate student writing practices across several undergraduate mathematics courses that required the use of LaTeX (a common markup language allowing users to specify the appearance of text and its layout on the printed page). This article presents findings about how the use of LaTeX slowed down students' writing process, encouraging greater revision and reflection as well as allowing students to identify errors in their work at more than one stage in the process. We also explore the affective learning outcomes of STEM students using typesetting software, including increased feelings of confidence and professionalization. This article seeks to contribute to the growing conversation about how STEM students transfer knowledge about writing across disciplines.

Keywords: Computer-Mediated communication; STEM writing; Writing process; LaTeX; Markup languages; Typesetting tools

1. Technical tools for technical writing

One of the most difficult aspects of digital writing in mathematics and related scientific disciplines is the heavy use of technical symbols and notation. Traditional writing technologies, such as Microsoft Word or Open Office Suite, impose tight constraints that can make technical notation and pagination difficult or impossible to render effectively for multiple audiences. Much like the typewriter brought greater formalism to writing in the 1800s, LaTeX and other typesetting tools enable individuals to produce more professional, attractive, and rhetorically effective mathematical writing.

In 1978 Donald Knuth, a Stanford University mathematician and statistician, developed TeX, a typesetting system whose goal was to allow easy production of portable high-quality documents that could include all manner of symbols, formulary, or pagination. TeX allowed the user to control nearly every aspect of document production, from fundamental

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features like page size, margins, spacing, and justification to the form of characters and symbols both common and arcane. TeX's reach was extended in the late 1980s when Leslie Lamport, a colleague of Knuth's at the Stanford Research Institute, developed LaTeX, a markup language enabling the user easier application of TeX's powerful but low-level, and therefore user-unfriendly, typesetting commands. Lamport distinguished the two programs in this way:

> LaTeX adds to TeX a collection of commands that simplify typesetting by letting the user concentrate on the structure of the text rather than on formatting commands. In turning TeX into LaTeX, I have tried to convert a highly-tuned racing car into a comfortable family sedan. (as cited in Dickinson & Oman, 1989, p. 99)

Like other markup languages (e.g., HTML), LaTeX comprises a large number of built-in commands that allow the user to specify the appearance of text and its layout on the printed page. Additionally, LaTeX provides the means to render thousands of predefined specialized characters and to create user-defined characters. LaTeX is now ubiquitous in many technical fields: Few scholars in mathematics, computer science, physics, or engineering make it past their first year of graduate school without becoming proficient in its use (Knuth, 1984; Lamport, 1994; Spivak, 1990).

Today the software used to edit and compile LaTeX is easy-to-find and freely available from a number of open-source software developers such as LyX, MacTeX, and MiKTeX. Some programs, like Texmaker (Brachet, 2014), are *editors*, front-end applications enabling the writer to manipulate LaTeX source code as in a more conventional word processor. Other programs, like MiKTeX [http://miktex.org/] (Schenk, 2015), are *distributions*, software packages that come equipped with, among other applications, both an editor and a *compiler*, the software used to generate a readable file, usually in PDF or PostScript format, from input source code. MacTeX [http://tug.org/mactex] (TeX Users Group, 2015) is another distribution, designed for and used with Macs and packaged with the TeXshop editor [http://pages.uoregon.edu/koch/texshop/]. Other LaTeX-related applications include "what-you-see-is-what-you-get" ("WYSIWYG") editors like LyX [http://www.lyx.org] and text editors (like Emacs and vi), which are not specifically designed for use with LaTeX.

Undergraduate science, technology, engineering, and mathematics (STEM) students are often trained to use LaTeX, though little research exists about how this writing technology impacts students' thinking and computation process. Japanese educators Kaneko and Takato (2011) explored how the use of geometry graphics produced with LaTeX enhanced pedagogical effectiveness in the linear algebra classroom, especially in terms of stimulating students' intellectual abilities (p. 147). Through interviews and problematic simulation exercises of teenage students, Kaneko and Takato showed that LaTeX graphics enabled students to visualize an end product so that the students could more easily reason algebraic problems (p. 146). This research, while relevant to our project, focused on LaTeX solely as a pedagogical tool to be used by the teacher; the authors did not consider how composing in LaTeX could impact students' cognitive abilities.

Other LaTeX specific research highlights the "literate programming" potential of the software to enable greater visualization of scientific data and, thus, communicate more professionally when publishing within technical writing (Greenlaw, 2012) and STEM fields (Barnes et al., 2013; Dickinson & Oman, 1989; Ince, Hatton, & Graham-Cumming, 2012). Imke Durre (2008) named LaTeX as an "assistive technology" that advanced the potential of the visually impaired to "read" and compose digitally important statistical data (p. 990). Additionally, LaTeX's independent portability is celebrated across disciplines for its ability to foster collaboration of researchers over massive amounts of data. Historian Urs Dietrich-Felber (2004), for instance, discussed the use of LaTeX in coding complex structures of data that could be used by other historians as an open-source database with multiple organizational patterns. Quiney and Wilson (2005), quantum chemists, concurred with Dietrich-Felbert that LaTeX provided "a convenient scheme to manage, implement, and document large collaborative, computational projects" (p. 435). Like most writing on LaTeX, though, the chemists and others mention the time and labor investment of developing one's literacy in structuring and understanding codes. The majority of the scholarship on LaTeX use focuses on the mechanics of the software program and/or how to use LaTeX in tandem with other software to achieve discipline-specific communication outcomes (Ndong et al., 2012; Oksüz, Güdükbay, & Cetin, 2008).

In this paper we begin to fill the gap in scholarship on LaTeX use within the classroom as a pedagogical tool for teachers as well as a learning tool for students. We wish to examine how LaTeX use influences students' cognitive and affective learning processes and how students transfer knowledge about writing across disciplines. Three research questions guided our study: