

# Experiences and lessons learned teaching L<sup>A</sup>T<sub>E</sub>X to university students

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## Abstract

This paper will describe our experiences and lessons learned while teaching L<sup>A</sup>T<sub>E</sub>X to a class of students (undergraduate and graduate students) during the fall 2001 semester at The Pennsylvania State University. This was a one-credit course taken by 9 undergraduate students (all were juniors or seniors) and 15 graduate students. We will discuss what material was covered in class, what resources were used in preparing the material, and what assignments were given to the students. In addition, we will discuss those materials and assignments that proved to be useful and those that were not so useful. We will discuss the lessons (both pedagogical and L<sup>A</sup>T<sub>E</sub>X-related) learned by us. In addition, based on our experiences and feedback provided by the students, we will present those lessons learned by the students and their recommendations for improving the class in the future. Finally, we will give our wisdom and recommendations to those instructors who might wish to teach a similar class at their institution.

## Introduction

We supervise the work of both graduate and undergraduate students in our group at Penn State University (PSU) and are, therefore, frequently reading, correcting, and sharing technical documents\* with these students. In addition, the work on which we collaborate with our students is generally turned into one or more journal publications. Hence, more often than we would like, we have to face the fact that almost all students are “brought up” on Micro-

soft Word<sup>TM</sup> and so their first instinct when joining our group is to use Word for all of their writing.<sup>†</sup>

While we recognize that reasonably nice output can be obtained with Microsoft Word with the proper use of its styles, equation editor, text boxes, and the like, we have found that not only do students not know how to use these tools, but they do not even know that they exist. We could, of course, either teach them to use these tools or require that they learn them on their own, but we are rather enthusiastic users and evangelists of L<sup>A</sup>T<sub>E</sub>X and are not interested in translating everything they do in

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\*When we use the term *technical document*, we mean a document with many equations and figures.

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<sup>†</sup>Amazingly, they even use Word to draw figures, but that is a topic for a different paper.

Word into L<sup>A</sup>T<sub>E</sub>X. In addition, our (rather extensive) experience with Word has been that it does not handle long documents (such as dissertations) well, does not handle floats well, is prone to file corruption, and frequently exhibits behavior that can only be explained by postulating the existence of supernatural forces. Therefore, we have a substantial incentive to teach our students how to use L<sup>A</sup>T<sub>E</sub>X in their work.

In addition, we are frequently asked by students who are taking our classes and who see the rather nice-looking course handouts that we generate using L<sup>A</sup>T<sub>E</sub>X, what we used to create the handouts. When they hear about L<sup>A</sup>T<sub>E</sub>X and the facility with which it handles technical documents, many are intrigued to learn more. These students have asked us many times if we would teach a course on how to use L<sup>A</sup>T<sub>E</sub>X.

With all of these motivating factors in mind, the stars finally aligned in the fall 2001 semester and we had the opportunity to teach a course about L<sup>A</sup>T<sub>E</sub>X entitled *Technical Documents with L<sup>A</sup>T<sub>E</sub>X* to a group of graduate and upper level undergraduate students. In what follows, we will attempt to convey not only what we taught in the course, but how we made the decisions to do what we did with the hope that this may be useful to anyone wanting to teach a similar course elsewhere.

### Class Structure and Organization

The course we taught in the fall 2001 semester was a one-credit course that met once per week for 75 minutes.\* We met in a classroom in which each student had a laptop computer with (L<sup>A</sup>)T<sub>E</sub>X and with access to the web. The required text for the course was the 3<sup>rd</sup> edition of Kopka and Daly's excellent book on L<sup>A</sup>T<sub>E</sub>X (Kopka and Daly, 1999), though we also suggested that each student obtain a copy of Grätzer's book that nicely covers  $\mathcal{A}\mathcal{M}\mathcal{S}$ -L<sup>A</sup>T<sub>E</sub>X (Grätzer, 2000). The course met 7 weeks of our full 15 week semester.

**T<sub>E</sub>X Resources at Penn State** At the time the course was offered, we had recently switched to Mac OS X as our primary operating system, but our university computing labs had not yet done so and were still running Mac OS 9. We used, and very much liked, the combination of T<sub>E</sub>XShop (Koch, 2003) as a front-end and Wierda's T<sub>E</sub>X distribution (Wierda, 2003), so we had to make the decision on what implementation of T<sub>E</sub>X to have our Center for Academic Computing (CAC) install in our computing labs. One of the authors had a little experience with

both CMacT<sub>E</sub>X (Kiffe, 2002) and OzT<sub>E</sub>X (Trevorrow, 2002), and since, at the time, CMacT<sub>E</sub>X was available for both Mac OS 9 and Mac OS X, we decided to go with CMacT<sub>E</sub>X.

Penn State has an extensive system of public computing labs and we would estimate that approximately 20% of the computers are Mac OS-based and the remainder are Windows-based machines. Since neither author had extensive experience with the installation or use of T<sub>E</sub>X under Windows, we chose not to ask CAC to install T<sub>E</sub>X under Windows since neither of us was likely to be able to answer any questions that might come up. We ended up demonstrating CMacT<sub>E</sub>X on the first day of class and told the students that they are, of course, free to install L<sup>A</sup>T<sub>E</sub>X on their home or lab computer. We told them that installations are available for virtually every operating system, though we only had experience with T<sub>E</sub>X on Macs, so if they needed help with another OS, they would have to see our web site for a list of resources.

**Administrative Details** In the advertisement for the class and on the first day of class, we told students that we would:

- Give them an introduction to the typesetting language L<sup>A</sup>T<sub>E</sub>X through the use of tutorials, example documents, and homework assignments.
- Show them how to easily write a professional-looking dissertation, conference paper, and/or journal paper. We emphasized the word “looking” because the content is up to them.
- Show them how to create a professional-looking presentation (such as this) with L<sup>A</sup>T<sub>E</sub>X.

When we taught the class, we had a combined 19 years of experience with L<sup>A</sup>T<sub>E</sub>X so it was clear that we could not teach the students everything we knew about it. In addition, our experience was almost entirely as L<sup>A</sup>T<sub>E</sub>X users and not as L<sup>A</sup>T<sub>E</sub>X programmers (though this course turned out to be a good excuse to learn a little about programming in L<sup>A</sup>T<sub>E</sub>X — more on that later), so the knowledge we would convey to the students was going to be of a very practical nature. Our goal for the course was to get the students started and to point them to the numerous other resources that are available for help with and information about L<sup>A</sup>T<sub>E</sub>X.

There were weekly homework assignments and all homework was to be handed in electronically. In addition, the students certainly needed to be comfortable with a computer.<sup>†</sup> Therefore, we told the students that they needed to be able to:

<sup>†</sup> Contrary to what many of us “old timers” think, many of today's undergraduates only know how to surf the web, send

\*The vast majority of courses at PSU are 3-credit courses that meet 2–3 times per week for a total of 150 minutes/week.

- move files between computers (i.e., either by file sharing, ftp, email, or the web);
- download, install, and launch applications (for those students wanting to install and use  $\text{\TeX}$  on their personal or lab machines);
- use a text editor.

Grades are a necessary evil in every course, and this course was no different. The grade for each student was entirely based on their homework, which was 75% of their grade, and their class attendance, which was 25% of their grade. No exams were given. We chose to make attendance a significant portion of their grade because we knew that a lot of the learning would be done in the classroom and we didn't want students to miss out on that. There was weekly homework and the students always found the next assignment at the end of the current week's lecture (more on the lecture format later). We tried to create homework assignments such that each one would not take more than 2–3 hours to complete. We told the students that if an assignment was taking them more time than that, then they were probably heading in the wrong direction and that they should see us. Despite this, when turning in an assignment, we would have some students tell us that they had spent 9 hours on the assignment and they still had not finished. We can't emphasize enough that this behavior seems to be rather common and is, most certainly, counterproductive. Therefore, it is important to stress to the students that they should not "beat their head against the wall" trying to get these things done — they should seek assistance.

We created a rather simple web site for the course where students could:

- find course announcements;
- download the course information as either a PDF file or the `.tex` course file;
- download the lectures as either a PDF file or the `.tex` course file;
- download the `.tex` source of a number of sample documents with some some reasonably complex formatting (e.g., the ad for the course, the course information, an equation sheet for a sophomore-level course, etc.); and
- find links to  $\text{\TeX}$ -related resources on the web.

The web site can be found at:

`<http://www.esm.psu.edu/courses/latex-course/>`.

Taking a cue from an old Chicago voting motto, we told students to "visit it early and visit it often".

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and receive email, and send and receive instant messages. Even seemingly mundane things like files attached to email messages will perplex some students.

Finally, we wanted students to take the course seriously and didn't want students looking for an easy one credit. We told the students that they had to want to be there to learn  $\text{\LaTeX}$  and if they were looking for an easy one credit, then they might like to find another course.

### Class Content

In creating the course material to be presented, we spent some time looking around on the web to see if anyone had created a similar course. While there were several courses that had been created, they were either in a language other than English or did not cover as much material as we hoped to do. In addition, it is generally the case that it is hard to take someone else's course notes and use them as your own. So, we decided to create the course from scratch, using experience, Kopka and Daly (1999), and Grätzer (2000) as our guides.

Largely following the order of presentation in Kopka and Daly, the seven lectures we created were entitled:

1. Introduction & Basic  $\text{\LaTeX}$
2. Displayed Text
3. Typing Mathematics in  $\text{\LaTeX}$
4. Multiline Equations in  $\mathcal{A}\mathcal{M}\mathcal{S}\text{-}\text{\LaTeX}$
5. Graphics & Floats
6. User Customization & Bibliographies
7. The PSU Thesis Package

**Introduction & Basic  $\text{\LaTeX}$**  In the first lecture, we outlined the course objectives, discussed what  $\text{\LaTeX}$  is and why it is useful for students to know it, and told the students our expectations of them. We then covered a section entitled *Getting Started with  $\text{\LaTeX}$* , in which we discussed:

- the overall structure of a  $\text{\LaTeX}$  document;
- the general structure of  $\text{\LaTeX}$  commands;
- environments and declarations;
- characters, words, sentences, and paragraphs;
- quotes, hyphens, and dashes;
- classes, class options, and packages;
- page layout (e.g., headers, footers, margins).

The last part of the first lecture was entitled *Putting it All Together*, in which we demonstrated how to put all the elements discussed previously together in order to create a typesettable document. Finally, we demonstrated how to typeset a document and view the resulting output using  $\text{C}\mathcal{M}\text{\TeX}$ . The first homework assignment consisted of exercises out of Chapters 2 and 3 of Kopka and Daly.

**Displayed Text** In the second lecture we talked about:

- understanding and changing font characteristics (i.e., `\emph`, font sizing commands, families, shapes, and series);
- centering and quoting text;
- lists;
- typewriter-like tabs, the `tabbing` environment;
- boxes (i.e., how T<sub>E</sub>X defines boxes, `\parbox`, `\rule`);
- tables (we did not cover the `booktabs` package (Fear, 2000) as it has been a recent discovery, but we will do so in the future).

The second homework assignment consisted of exercises out of Chapter 4 of Kopka and Daly.

**Typing Mathematics in L<sup>A</sup>T<sub>E</sub>X** The first two lectures were largely based on material from Kopka and Daly (1999), but Lectures 3 and 4 were largely based on Grätzer (2000). We use  $\mathcal{A}\mathcal{M}\mathcal{S}$ -L<sup>A</sup>T<sub>E</sub>X exclusively, so we began by telling the students that everything we would be covering would assume that they had loaded the following  $\mathcal{A}\mathcal{M}\mathcal{S}$ -L<sup>A</sup>T<sub>E</sub>X packages and options (American Mathematical Society, 2000).

```
\usepackage{amsmath}
\usepackage{amssymb}
\usepackage{exscale}
\usepackage[mathscr]{eucal}
```

We then discussed features of L<sup>A</sup>T<sub>E</sub>X and  $\mathcal{A}\mathcal{M}\mathcal{S}$ -L<sup>A</sup>T<sub>E</sub>X that are relevant for inline mathematics and single-line displayed mathematics. We emphasized to the students that the mathematics in a document is part of the narrative and should be punctuated as such. In addition, we discussed:

- equation numbering;
- arithmetic operations;
- superscripts and subscripts;
- resources for typesetting mathematics (Swanson, 1999; Higham, 1998);
- ellipses, integrals, roots;
- text within mathematics;
- delimiters;
- operators;
- math accents;
- spacing with mathematics;
- math alphabets and symbols (e.g., bold mathematics); and
- generalized fractions.

The third homework assignment consisted of exercises out of Chapter 5 of Kopka and Daly, but with the requirement that  $\mathcal{A}\mathcal{M}\mathcal{S}$ -L<sup>A</sup>T<sub>E</sub>X structures be used when available.

**Multiline Equations in  $\mathcal{A}\mathcal{M}\mathcal{S}$ -L<sup>A</sup>T<sub>E</sub>X** Again relying on Grätzer (2000) for source material, we then presented an entire lecture on displayed multiline equations using  $\mathcal{A}\mathcal{M}\mathcal{S}$ -L<sup>A</sup>T<sub>E</sub>X. We covered the philosophy behind  $\mathcal{A}\mathcal{M}\mathcal{S}$ -L<sup>A</sup>T<sub>E</sub>X's multiline equation structures and then went on to cover each new environment introduced by  $\mathcal{A}\mathcal{M}\mathcal{S}$ -L<sup>A</sup>T<sub>E</sub>X. We covered:

- grouping formulas and `gather`;
- splitting long formulas and `multline`;
- breaking and aligning formulas;
- numbering of formulas, equation tags, and the `subequations` environment;
- organization of equations into multiple columns via the `align` environment, the `flalign` environment, and the `alignat` environment;
- subsidiary math environments, that is, `split`, `aligned`, `alignedat`, and `gathered`;
- adjusted, multi-column math environments, for example, `matrix`, `cases`, and `pmatrix`

The fourth homework assignment consisted of two handouts: the first was two pages from a 1963 paper from a Russian mathematical journal (Melnikov, 1963) and the second was Section 8.5.1 from a book on numerical linear algebra (Golub and Van Loan, 1989). We asked the students to typeset the pages we had given them. In the case of the paper from the mathematical journal, we wanted students to *improve* the typesetting of the text and equations and in the case of the pages from the book on numerical linear algebra, we wanted the students to simply replicate the layout.

**Graphics & Floats** The fifth lecture covered the inclusion of graphics in L<sup>A</sup>T<sub>E</sub>X via its float mechanism. We covered the:

- `graphicx` package (Carlisle and Rahtz, 1999) with its `includegraphics` command and options such as:
  - `scale`
  - `width, height, keepaspectratio`
  - `angle`
  - `bb`
- `lscape` package (Carlisle, 2000);
- importing of graphics and troubleshooting;
- `color` package (Carlisle, 1999), including the `monochrome`, `dvipsnames`, and `usenames` options, and setting the color of a page and text;
- float environments: `figure` and `table`.

The fifth homework assignment asked the students to create a one-page flyer conveying any messages or advertising anything they liked. We told

them that they had learned a fair bit about L<sup>A</sup>T<sub>E</sub>X, so they should try and make it interesting and creative. We also told them that the flyer had to include some mathematics. In addition to this, the flyers were to include:

- the use of a background color for the page;
- the tasteful and artistic use of a number of colors for the text;
- the use of *at least* three different JPEG images (`.jpg`), at least one of which must be scaled and one of which must be rotated.

**User Customization & Bibliographies** Material for this lecture came out of various sections of Kopka and Daly (1999); in particular, we asked the students to read Chapter 7, Sections 4.3.6, 8.3.3, and Appendix B. In regard to customizing L<sup>A</sup>T<sub>E</sub>X, we discussed:

- counters: how to set and reset them, and how to define new counters;
- how L<sup>A</sup>T<sub>E</sub>X uses lengths and how to: set a length using either `\settowidth` or `\setlength`, define a new length using `\newlength`, and add to a length using `\addtolength`;
- the creation of user-defined commands, both with and without arguments, as well as the redefinition of commands;
- the use of the `\input` command to read in “boilerplate”;
- the scope of commands and environments defined in the preamble versus the scope of those defined within environments.

With regard to bibliographies, we began by discussing the basic and simple environment for generating a bibliography via the `thebibliography` environment. In addition, we talked about how one can change the title of the bibliography using either `\refname` or `\bibname`, depending on the class used. We also discussed the limitations and disadvantages of using the `thebibliography` environment without the aid of BIB<sub>T</sub>E<sub>X</sub>. We emphasized that BIB<sub>T</sub>E<sub>X</sub> provides a way to use a database of references (via a `.bib` file), along with a bibliography style definition (found in `.bst` files), to automatically generate bibliographies. This is useful for the following reasons:

- one can maintain any number of reference databases and BIB<sub>T</sub>E<sub>X</sub> will only use those references it needs; this is especially nice when one uses many of the same references in several different documents;
- one can use the same databases of references and the chosen `.bst` file will format them automatically.

We also briefly discussed the `natbib` package (Daly, 2000) for author-year citations and the use of End-Note<sup>TM</sup> (ISI ResearchSoft, 2002) with BIB<sub>T</sub>E<sub>X</sub>.

The sixth homework assignment consisted of exercises out of Chapters 4 and 7 of Kopka and Daly.

**The PSU Thesis Package** As preparation for this seventh and final lecture, the authors chose to undertake their first major L<sup>A</sup>T<sub>E</sub>X customization/programming project by creating a document class conforming to the *Thesis Guide: Requirements and Guidelines for the Preparation of Masters and Doctoral Theses* (The Pennsylvania State University, 2002), which is published by Penn State’s Graduate School. Among many other things, this guide specifies the detailed technical requirements that each thesis or dissertation must satisfy. These requirements include, among other things, the specification of: line spacing, font size, front matter, chapter formatting, margins, page number location, etc. All of these requirements can be rather overwhelming for students who, while trying to implement them, are also desperately trying to actually *write* their thesis. In addition, as we are all aware, L<sup>A</sup>T<sub>E</sub>X can do a wonderful job of removing the tedium of assembling a Title Page, Table of Contents, List of Figures, List of Tables, Signature Page, and all the other little things that must go into a thesis. The class we created, `psuthesis.cls`, is heavily documented, should be relatively easy for individuals at other institutions to modify, and can be found on one of the pages at the course web site (Gray and Costanzo, 2002).

Our lecture gave an overview of the thesis class and an example thesis template illustrating the use of the thesis class. There was no homework associated with this lecture.

### Lecture Format and Creation

We estimate that each 60–75 minute lecture took us anywhere from 4–6 hours to prepare. The first two lectures were prepared as slides, presented as PDF files, using Foil<sub>T</sub>E<sub>X</sub> (Hafner, 1998). We both found this to be awkward since we had to worry so much about the amount that went on each slide. It was also more difficult to show the “natural” behavior of L<sup>A</sup>T<sub>E</sub>X since, by their very nature, slides or foils are heavily modified to use larger fonts, landscape orientation, etc. Finally, the slide format impeded us from adding little tidbits and changing the L<sup>A</sup>T<sub>E</sub>X source during a lecture since, often times, the addition or deletion of one or two words would completely alter the formatting of a slide. Therefore, we decided to use the standard `article` class and create lectures that simply looked like a standard

L<sup>A</sup>T<sub>E</sub>X article. Before each lecture (sometimes only a few minutes before, but always before) we would post the `.tex` source for the lecture as well as the corresponding `.pdf` typeset output on the class web site. After each lecture, we would re-post the lecture (source and output), thus incorporating any changes to the document that took place during the lecture. Each lecture was presented by connecting a laptop to an LCD projector and using T<sub>E</sub>XShop to show the source and preview.

We tried our best not to take the entire class time to talk about L<sup>A</sup>T<sub>E</sub>X since 75 minutes is a long time to try and focus on someone standing at a computer and showing L<sup>A</sup>T<sub>E</sub>X source and output. On the other hand, as most instructors will testify, it is nearly impossible not to have one's lecture expand to fill the available time. Therefore, with only two or three exceptions, our lectures took the entire 75 minute time period. When we teach this class in the future, we will unquestionably leave more time to work with the students in the classroom.

Finally, our experience in other classes in which we used this same computing environment, that is, an environment in which each student is at a laptop that is connected to the Internet, has been that it was terribly tempting for students to surf the web, check their email, and/or instant message with their friends rather than listen to what we had to say. Therefore, we made it clear from the first day of class that students were welcome to do all of these things at the computers, they simply were not allowed to do it during our class. We found that the students generally respected our request.

### Student Response to the Class

At the end of each semester, it is the policy of our department to have students anonymously evaluate the course they are about to complete. In addition to generic questions about the instructor and the course requiring numerical evaluations, three additional questions are asked for which the students give written answers. These questions are:

- Q1. What did you like best about this course?
- Q2. What did you like least about this course?
- Q3. What suggestions do you have for improving this course?

**Question 1** Ignoring responses such as “L<sup>A</sup>T<sub>E</sub>X was explained well by the instructors”, which, while nice, doesn't really tell us much, student response to the first question emphasized:

- the utility of the web site;
- the teaching of L<sup>A</sup>T<sub>E</sub>X through examples;

- that the course assumed no prior knowledge of L<sup>A</sup>T<sub>E</sub>X;
- that L<sup>A</sup>T<sub>E</sub>X provided an alternative to Microsoft Word; and
- that they were happy to be learning a skill that would be useful in their careers.

**Question 2** To the second question, we found the following themes among the student responses:

- there was no instruction on how to use particular software packages for L<sup>A</sup>T<sub>E</sub>X;
- there was too much work for a 1-credit course;
- some of the homework took them much too long to do;
- there were numerous problems with CAC computer labs that prevented them from doing their homework; and
- the course felt rushed.

**Question 3** To the third question, we *overwhelmingly* heard that:

- we should spread the course out for at least 12 weeks, if not the entire semester;
- the homework should be graded more leniently;
- the class should meet more often so that each lecture is shorter;
- the homework should be shorter or spread out more; and
- we should provide help to people with Windows machines.

So, what conclusions can we draw from these comments that would allow us to improve the course the next time we teach it? Well, the responses to the first question tell us that we should: continue to provide resources and information via the class web site, continue to teach using a myriad of examples, and teach the course at a very introductory level. The responses to the second and third questions indicate that:

- too much was taught in too little time and the course should be spread out over a larger part of the semester;
- classes should be shorter and meet more often (this would also allow us to make each homework assignment shorter); and
- we should provide additional support for those students who are having trouble getting T<sub>E</sub>X to work on either their own computer or a public computer.

On the other hand, it has been our experience, that in all courses that involve computers and programming, students almost *invariably* find them to be

more time-consuming than they would like. Thus, some of the feedback was not unexpected. We do agree, however, that the course could and should be spread out throughout more of the semester. In addition, we will more strongly encourage students to seek out our assistance rather than beating their heads against the wall.

The one problem the students were having that we will have the most difficulty reconciling is the issue of getting T<sub>E</sub>X running on either public computers or personal machines. We hope that we can fix the issue of running T<sub>E</sub>X on public machines by using T<sub>E</sub>XShop along with Wierda's teT<sub>E</sub>X-T<sub>E</sub>XLive distribution. As for getting students up and running on their own machines, we will most likely proceed as we did the first time we taught the course, that is, we will tell the students that we will only support the public machines and if they want help on their personal computers, they will have to seek out help on the web.

### Thoughts for the Future

Based on student feedback, the utility of (L<sup>A</sup>)T<sub>E</sub>X for academic work, particularly at the graduate level, and our experience teaching this course, we are left with the question: Is there a place for a course like this in the university curriculum? There is no question that the majority of students in the course, despite thinking it was too much work, expressed a great deal of enthusiasm for it. In addition, we have found via a recent follow-up survey of students who took our class that more than half the students in the course continue to use what they learned about L<sup>A</sup>T<sub>E</sub>X on a regular basis. We did find, however, some reservations about offering this course on the part of our department. There were people who felt that this was not the kind of course that should be offered at a university for credit. They felt that it should be offered as an "extra-curricular" activity. Given the importance of publishing in academia, at least for graduate students, and the fact that all graduate students (and many undergraduate students) need to write a substantial thesis or dissertation during their tenure as students, we feel that a practically important course such as this one can be an important part of the curriculum.

We welcome the thoughts and experiences of other instructors in academia on these issues.

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