

AC 2008-2528: LAB REPORT WRITING (AND TEACHING!) MADE EASY

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Dr. Cynthia Furse is a Professor of Electrical and Computer Engineering at the University of Utah and the Associate Chair for Undergraduate Studies. She is the PI of an NSF DLR project – Integrated System Level Design -- and an NSF STEP program -- Utah's Engineers: A Statewide Initiative for Growth. Dr. Furse received her B.S. in electrical engineering with a mathematics minor in 1985, M.S. degree in electrical engineering in 1988, and her Ph.D. in electrical engineering from the University of Utah in 1994. Dr. Furse has taught electromagnetics, wireless communication, computational electromagnetics, microwave engineering, antenna design, and introductory electrical engineering. Dr. Furse works to interest young students, particularly women and minorities in engineering and routinely volunteers in Utah's K-12 schools as an engineering mentor, science educator, and engineering career guidance counselor and is active with the Society of Women Engineers, Junior Engineering State, Expanding your Horizons, School-to-Careers, MESA, Girl Scouts and Boy Scouts. Dr. Furse was the Professor of the Year in the College of Engineering at Utah State University for the year 2000. She is the Director of the Center of Excellence for Smart Sensors, an active, funded research program including electromagnetics for biology and remote sensing. The Center focuses on imbedded antennas and sensors in complex environments, including sensors for location of faults on aging aircraft wiring and telemetry systems in the human body. Dr. Furse has directed the Utah "Smart Wiring" program, sponsored by NAVAIR and USAF, since 1998. She is Chief Scientist for LiveWire Test Labs, Inc., a spin off company commercializing devices to locate intermittent faults on live wires. Dr. Furse is a Fellow of the IEEE.

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Abstract

This paper reports on a project to improve students' ability to write better lab reports and assist teaching assistants (TAs) in grading reports in a consistent manner. A lab report teaching system was developed that includes lab report templates, teaching assistant instructions, grading rubrics, examples, peer review materials and instructions, and recommendations for quickly providing student feedback (grading). These materials were developed for project-based labs across the electrical engineering curriculum and utilize methods to write weekly lab updates that are combined into a final lab report, mimicking methods commonly used in industry. The technical writing information was adapted to all levels of complexity to help students from freshman through senior years. The system begins with instruction on writing very basic reports, and builds each year on previous knowledge and practices, to prepare students to later write complex reports. This system is designed to improve students' understanding of labs (by 'writing to learn') in addition to preparing them for the communication intensive workplace. The amount of time spent grading such reports is often a primary concern, as this is commonly given as a reason for not requiring advanced writing assignments in engineering classes. Detailed guidelines and grading rubrics are included in this manual to instruct TAs on better and more consistent grading techniques. Guidelines for checking both lab books and formal lab reports help improve TA training and grading consistency, reducing student complaints. Although this system was designed for an electrical engineering program, it can also be adapted to other technical fields and used for various scientific lab reports.

Improving Teaching and Learning

This paper describes a project focused on the departmental goal to improve students' ability to write excellent lab reports and assist teaching assistants (TAs) in grading reports in a consistent manner. It was developed to help train new TAs to continue the success of a new curriculum shift towards project-based learning¹. This new curriculum includes more writing to help students process what they are learning and includes project-based labs to help students understand the relation between individual and system-level concepts.

New Teaching System

In order to train TAs, a lab report teaching system was developed and made available through a website⁵. This system includes TA instructions, resources for conducting a lab overview, lab report templates, grading rubrics, examples, peer review materials and instructions, and recommendations for quickly, but effectively, providing students with constructive feedback. This section describes each of these resources in more detail.

TA instructions are essential to having successful TAs. Answers to commonly asked questions have been compiled and included on the website to provide TAs with all the information necessary to prepare for and conduct lab sessions. Some of the instructions may be department

or university specific, but like the rest of the material in this system, these can be adapted to the procedures of various departments.

Material was provided on the website to help the instructor and TAs conduct a Lab 0 introductory lab, where an overview of the lab project and expectations for the Weekly and Final Report were explained. The students were assigned to read a technical article that showed the importance of the project. The TA then explained an overview of how the project was broken down into individual labs to help students understand how each lab they would complete throughout the semester related to the project as a whole. The TA familiarized students with the lab instructions and rubrics, showing students where to find lab report checklists and templates. In the end of the session, the students wrote the introduction for their Final Report and conducted a peer review of these introductions. While this might seem a bit backwards (write the ending before you have even started!), the introduction to a system-level report normally describes the system, motivation for the system, and how all of the individual parts fit into the system. This classic example of 'write to learn' required the students to conceptualize and then write about the system project for that semester. Later, when the students were completing their final reports, they were asked to go back and adjust their introductions as needed, but most found their initial introductions were close to their final form. Additionally, the instructor found students asking excellent questions in class as they made connections between the concepts in class and the material they would need for the lab².

Lab report templates were provided for both independent labs and project-based labs. Each section of the templates includes descriptions of what content should be included as well as step-by-step instructions on how to format the reports, as seen in Figure 1 and Figure 2 . These were found to be an excellent resource to help students understand the format and content that are expected for lab reports, and also provide a consistent format to make grading easier for TAs. We observed that when students are given a template, they immediately download the template, and begin using it. This was not necessarily true of instructions! By combining the instructions into the template, the students had to delete the instructions (hopefully reading them in the process) before typing their own work. This practice is being used for many professional templates, including those for this ASEE conference!

1.0 INTRODUCTION

(A few Paragraphs) The introduction should include the purpose (what was tested), problem (why was the experiment conducted), and scope (what was analyzed) of the report. In addition, introductions can sometimes include justification of the experiment's importance. It can also refer to relevant theory and important previous studies. The goal is to supply sufficient background for readers to understand and evaluate the experiment and its results without having to read previous publications.

Figure 1: Sample Introduction¹

Here is how to handle tables. Be sure to talk about Table 1-1 in the text before it appears on the page. To insert the reference to Table 1-1 above, Insert – Reference – Cross reference – table.

Table 1-1 Insert caption here (Table captions go above tables)
 (Toolbar menu: Insert – Reference – Caption, Option Label: table)
 To make a table: Table – Insert Table

Table text	Table text

Figure 2: Sample Table Formatting¹

Sample grading rubrics were provided for weekly lab books and reports, as well as the final report required for project-based labs. These provide TAs with better and more consistent grading techniques. The amount of time spent grading is often a primary concern for engineering writing assignments, and this is commonly given as a reason for not requiring advanced writing assignments in engineering classes. The rubrics are broken into sections, which then list essential components and how many points each component is worth, as seen in Figure 3.

Formal Report	Pts	Grd
<i>Abstract Includes</i>		
Summary of the purpose of the lab project	4	
Summary of the methods used	4	
Summary of key findings	4	
Summary of significant conclusions	4	
<i>Executive Summary Includes</i>		
Detailed summary of complete report	5	
Conclusions and recommendations	5	
<i>Intro Includes</i>		
Overview of the project	10	
Description of problem of interest	10	
How this relates to the bigger picture (qualitative)	10	
Overview of each lab	12	

Figure 3: Sample Sections from Final Report Grading Rubric

The students were given the grading rubrics along with the lab handouts. The content listed in the rubric is also listed in the report templates, ensuring that students include the complete content in their report. Previous lab reports (prior to use of the templates and rubrics) had major problems with content. Most often students left out major sections of important engineering content and received poor grades as a result. Specifically telling students what content is required through the use of templates and rubrics ensured better content in later reports, as

expected. We are not yet certain if students are actually learning to judge what content they should include in their reports, or not. However, we do know that many students have chosen to continue using the templates outside of the classes where they were originally required. Other resources to help teachers and their assistants in creating rubrics were also included on the website, such as a generalized rubric and instructional rubric websites.

Examples of excellent student lab books and reports were collected with permission and scanned in to provide TAs and students with a baseline of what was considered good work. These were not available for the previous year and are a recent addition that we are hoping will help students reach a higher level of report writing.

<p>1.0 INTRODUCTION:</p> <p>Six lab experiments were conducted in order to design, construct, and test a communication system for the implementation of wireless communications with an implantable cardiac pacemaker. The first experiment involved the measurement of dielectric properties of different materials and how it related to the attenuation of electromagnetic (EM) signal propagation. The second experiment involved the evaluation of signal loss in transmission lines (TL) due to multiple wave reflections caused by impedance mismatches in the TLs. The third experiment involved construction of a single-stub matching network. Matching the load impedance of the antenna to the line maximizes power transfer to the receiver. The fourth experiment involved application of numerical analysis, particularly finite-difference-time-domain (FDTD) methods, to achieve close approximation calculations of magnitudes of EM signals and evaluate the present and future behaviour of EM signals propagating in various mediums. The fifth experiment again involved the application of numerical analysis use of a matrix library (MATLAB) computer program to understand how an EM wave attenuates with distance from an electrical source (e.g., current distribution). Finally, a frequency shift keying (FSK) system was designed, tested, and implemented to operate according to a power link budget, such that a transmitter would transmit enough power to a receiver with minimal loss. Sufficient power is needed so that transmitted information can be available at the receiver for access by an end-user.</p> <p>The dielectric constant of a material impacts the attenuation of power transmission. Several types of materials were examined, and their dielectric constants were measured using a network analyzer. These materials were beef, oil, a 5% saline solution, and a mixture consisting of instant pudding mix and water. Each material relates to tissues in the human body. When transmitting a signal from within the human body to communicate with something at the surface, the attenuation of biological tissues is the dominant source of power loss. The power loss for 2/3 muscle mass and brain tissue was calculated and plotted to gain a visual understanding of the attenuation occurring in the human body, and it impacted the communication range of the system and the safety of the patient.</p> <p>The purpose of this experiment was to apply transmission line and electromagnetic concepts in the design of a communications system that would be beneficial to the medical industry. Particularly, what is needed is a system that can wirelessly communicate with an implantable pacemaker inside of a human body. Ideally, the pacemaker can be employed to transmit real-time medical information to a receiver external to the body such that a user may continuously monitor the health of patient(s) from a PC and provide the appropriate medical attention and treatment to them in case of any health issues.</p>

Figure 4: Sample Student Final Report Introduction³

We found that constructive feedback involved more than just letting students know whether they were right or wrong, but required details on what to work on, giving them scaffolding for improvement. This was accomplished through a few avenues. At the end of the report rubrics, a

writing feedback form was provided so the TA could give individualized feedback without the student losing points, as shown in Table 1. This allows the TA to point out general problems, without having to grade the writing meticulously. Peer reviews were also found to be very beneficial to students and helped them think about what they were writing. Additional instructions on how to conduct peer review sessions were also provided on the TA website. Giving guided feedback was found to be a major aspect of importance in peer reviews (again through the use of a rubric) so that students knew what they were looking for. For instance, if students were asked to include information on how the individual lab related to the overall project, the peers were asked to circle or number the sentence(s) that included that information. Students were often surprised when their peers could not find information they thought they had included, which meant their writing was not as clear as they thought it was. The process of reviewing someone else’s paper also caused students to question how clearly they had explained the content in their own paper. Many made changes for better clarity after the peer review.

Table 1: Writing Feedback Form for Final Lab Reports¹

Writing Feedback	Needs Work
Writing flow	
Spelling	
Grammar	
Past tense	
Passive voice	
Equation formatting	
Clarity of ideas	

Constructive feedback from students was also helpful to the TAs to improve their explanations in lab. This was accomplished by having students in freshman and sophomore labs research and give short presentations on “muddy points,” or points they had not understood in the previous week’s lab⁴. This was also beneficial as a way for students to have a short experience speaking in front of the lab group.

Results

All materials included in this system were first tested in the lab setting and approved by an individual faculty. The website was given to all faculty members the first week of the semester so they could become familiar with the site and share it with their TAs. The materials were adopted by multiple faculty, or adapted as needed for individual classes. These materials were developed for project-based labs across the electrical engineering curriculum and utilize methods to write weekly lab updates that are combined into a final lab report, mimicking methods commonly used in industry. The system begins with a lab overview, which not only helps the students in the lab, but also helps improve their understanding of concepts in class. Students are able to relate what they are learning in class to what they need to accomplish in lab². The technical writing information is adapted to all levels of complexity to help students from freshman through senior years. It includes instruction on writing very simple basic reports, building each year on previous knowledge and practices, to prepare students to later write complex reports. This system improves students’ understanding of labs (‘writing to learn’) in

addition to preparing students for the communication intensive workplace. Detailed guidelines and grading rubrics have also been included in this web-based manual to instruct TAs on better and more consistent grading techniques. Methods for reducing the time required to grade the written labs were also provided. Guidelines for checking both lab books and formal lab reports have helped improve TA training and grading consistency, reducing student complaints. Although this system was designed for an electrical engineering program, it can also be adapted to other technical fields and used for various scientific lab reports.

Future Adaptations

This writing method is now being integrated into most/all of the electrical engineering laboratory classes. We hope to see significant improvements in writing as students progress through multiple years of this program. At present, significant improvements in individual students' writing have been observed over a single semester, but we have not been able to follow students through multiple years. We have also implemented our own department-wide writing class and will be developing templates for a number of other types of writing. Finally, we will be experimenting with better ways to have TAs provide electronic feedback to the students, and tracking the changes they make to their writing as a result of these comments.

Acknowledgements:

The design of these laboratories was supported by the National Science Foundation under Grant 0431958.

Bibliography

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3. Daryl Wasden, Brian Wynn, Paul Beard. Personal Communication. January 2008.
4. <http://www.ece.utah.edu/~cfurse/CLEAR/>
5. This TA training website will be integrated into the department writing website found by clicking on the "WRITING website" link found at <http://www.ece.utah.edu/facilities/ugradlabs.html> and will be posted by April 1, 2008.