# The LabWrite Project: Experiences reforming lab report writing practice in undergraduate lab courses

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**Abstract**
Laboratory reports have always been a part of the modern science and engineering curricula. However, it has also often been the least liked part of a students' (and instructors') laboratory experience. Despite research demonstrating the importance of lab reports to the undergraduate science and engineering lab experience, instructors are likely to minimize their use. Lab reports have been replaced with fill in the blank labs, reports that are worth only a token number of points towards a final grade, or excluded altogether. The LabWrite project has been developing online support materials to promote and support undergraduate lab report writing. A NSF-CCLI funded project, LabWrite is a web-based tool containing both static pages and an interactive tutor designed to support the lab report writing experience from before the student enters the lab through reviewing the graded lab report. Integral to LabWrite is a set of training materials for lab instructors, both faculty and graduate teaching assistants. Since 2000, LabWrite materials have been piloted in institutions ranging from Research I universities to community colleges. Our experiences and research have demonstrated the importance of lab reports in undergraduate education but have also pointed up the difficulties in successfully integrating lab reports back into courses.

## Introduction

Communicating scientific, engineering, and technical knowledge with clarity and understanding is a critical skill all future engineers need to have. To be able to do so is a literacy benchmark instructors strive to have all undergraduate and graduate engineering students meet. Perhaps the most important means for developing this literacy is the writing of lab reports. However, lab reports are often among the least liked aspects of undergraduate science and engineering labs, by both the student and the instructor.

From the instructor's side comes the common complaint that there is simply not enough time to include a large number of full-length lab reports into their courses. There is not enough time to instruct students on the proper approach to writing lab reports and there is not enough time to grade the lab reports. Not surprisingly, student's feel that they do not receive appropriate instruction on how to write an effective lab report and when they do write one, they do not receive sufficient or appropriate feedback for improving their next attempt. In fact, there is often the feeling on the part of the instructor that even if they did have the time, they don't know how to successfully teach the art of lab report writing. All too often, they feel that teaching writing is

something best left to the English department, not something that Engineering faculty should know how to do.

It was into this gap between what was known to be a critical tool for developing engineering and scientific literacy—lab report writing—and the tool's general disuse and misuse that the LabWrite project was born. Funded initially in 2000 as a NSF-Course, Curriculum, and Lab Improvement pilot project, the LabWrite project created a web site that was used as part of small-scale study at North Carolina State University[1]. This two-semester, iterative study involved the collection of both qualitative and quantitative data that supported the belief that the LabWrite approach could improve both the quality of the lab reports being written, the students' specific knowledge of the topic covered in the laboratory, and their understanding of the process of scientific investigation. Included in this pilot project was a materials engineering laboratory[2]. The second phase of this funded project has taken place over the last couple of years and has led to continued improvements to the students' and instructors' materials along with the addition of an interactive Tutor to provide additional support for students learning to write lab reports. Below is an overview of the current LabWrite instructional materials[3] and results from past and ongoing studies into how best to implement this suite of tools into science and engineering laboratories.

**LabWrite Approach**

LabWrite provides support for all phases of the lab experience. This approach has been taken because having a productive lab session and writing a successful lab report requires: planning prior to coming to lab, careful observation and note taking during lab, a thoughtful and effective write-up of the lab, and making use of feedback from the lab instructor on the next lab. The screen shot of the LabWrite homepage for students (Figure 1) shows the four main phases of the LabWrite process:

- PreLab
- InLab
- PostLab
- LabCheck

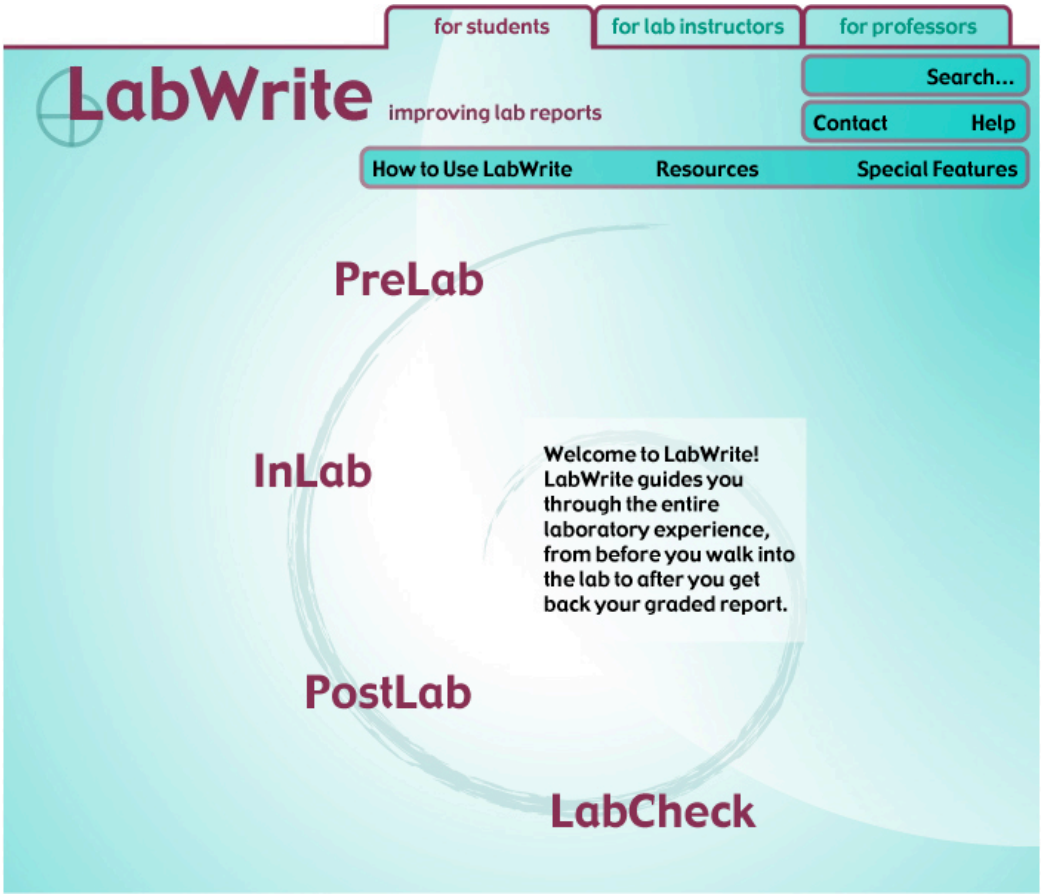


Figure 1. LabWrite homepage.

***PreLab*** is a set of questions for students to answer before doing each lab. Answering these questions prepares students to get the most out the lab by developing their understanding of the scientific concept they are supposed to be learning about by doing the lab and, where appropriate, developing a hypothesis prior the start of the lab.

***InLab*** acts as a lab notebook that takes students through the process of collecting, analyzing, and making sense of the data from the lab. Throughout the process, students are provided resources that help them work effectively with data, such as using Excel, identifying dependent and independent variables, making a table for raw data, understanding the kinds of data they have collected, and creating tables and graphs appropriate to the data.

***PostLab*** is a step-by-step guide for writing the lab report. By using information from their PreLab and InLab responses to write their reports, students build reports section by section, starting with the ones that they already know the most about. PreLab has prepared students to write their Introduction section while InLab has organized much of the information they need for their Methods and Results sections. LabWrite's *"inside-out" approach* provides students a sensible and logical way of writing the lab report (Figure 2). Most students have only used a linear approach to writing—starting with the first paragraph and writing to the conclusion. This beginning-to-end approach, however, does not work with lab reports. For example, it is

impossible to write the Abstract until the remainder of the lab report is done. However, writing up the Methods and Results provides an excellent warm-up to revisiting the reasons for conducting the lab, what the scientific concept was that the lab was centered on, and what hypotheses might have been proposed—all material for Introduction.


Figure 2. The "inside-out" order to writing lab report sections.

***LabCheck*** provides a checklist students can use as a guide for revising their reports before turning them in. Another feature of LabCheck is an evaluation sheet that matches the instructor's grading sheet supplied by LabWrite. When the graded lab report is returned, students can use the links on their online evaluation guide to find specific help they can use to improve the next report they write.

In addition to these core sections of the LabWrite site, there is also a ***Resources*** section. Here is found a collection of guides tailored to meet students' specific needs. For example, if they need help in entering data into an Excel spreadsheet, creating a graph, making sure they have the right format for citations and references, or correcting their grammar, they can find the answers they need in a LabWrite resource. Links to most of the resources are also integrated throughout the remainder of the site.

Not surprisingly, PostLab is considered the core of the LabWrite process, since it is the stage that supports the actual writing of the lab report. Because it is so critical, the site has provided three separate approaches to using the PostLab support materials. First time users of the LabWrite site are encouraged to use the Tutor (Figure 3), an interactive wizard that steps you through the process of writing and assembling the information needed for the lab report. For those students who have more familiarity with the lab report writing process, but still like to have a wizard step them through the process, there is the Brief Tutor, which condenses the core information into fewer steps. Finally, there is the Self-Guide that presents all of the information contained in the Tutor in the form of static web pages.

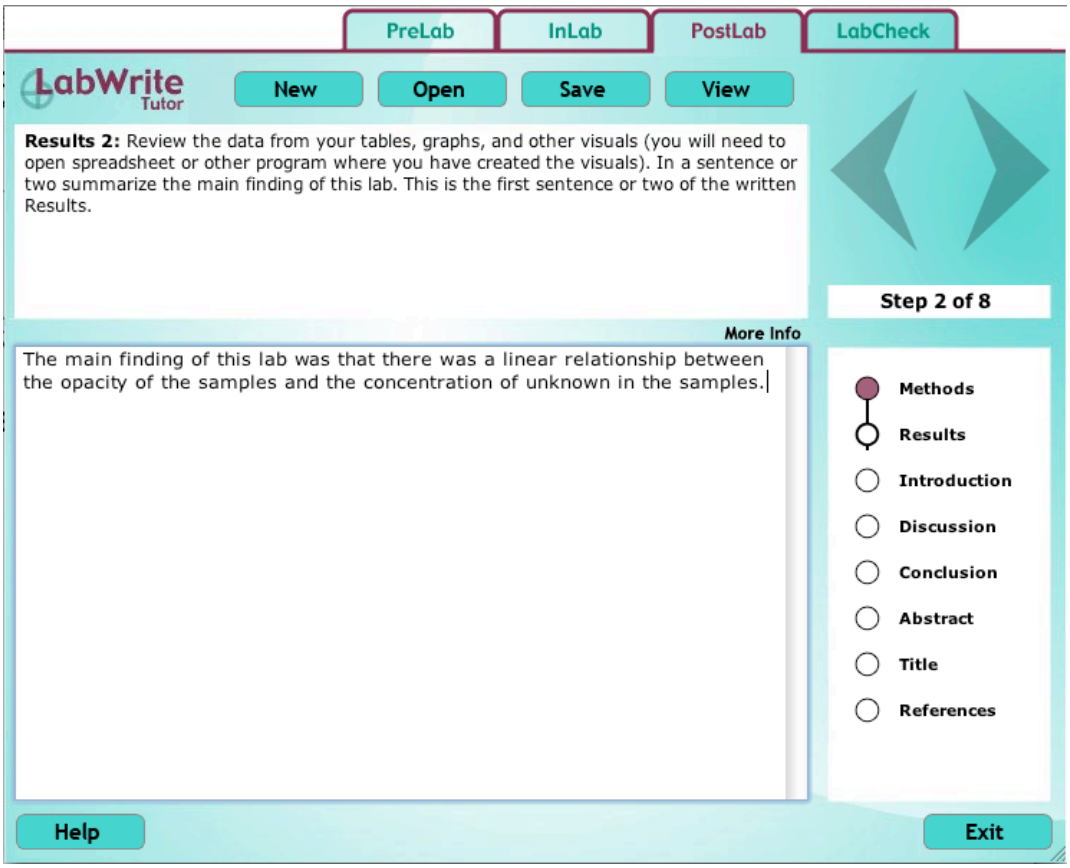


Figure 3. The LabWrite Tutor.

Notice in Figure 1 in the upper right corner that in addition to having a special site for students, there are also tabs for lab instructors and (at larger universities and colleges) for professors supervising multi-section lab courses. These additional portions of the LabWrite site are in recognition that the professors and instructors designing and running the labs are a critical component to a successful laboratory experience for the student. LabWrite is not meant to be a "self-teaching" tool for most students but, instead, a "just-in-time" resource for students to use when needed. For them to make effective use of its resources, lab instructors should provide a meaningful introduction to the sites' features and support its use over the course of the semester.

**LabWrite Research and Evaluation**

Prior and ongoing research and evaluation has provided important insight as to when LabWrite is or is not an effective tool in undergraduate labs. In a post-test only control group study, LabWrite was shown to be effective in improving students' learning of the scientific concepts covered in the lab and in applying scientific reasoning[4, 5]. In this study with an introductory biology course, the lab sections were split between those that supported the lab report writing with the traditional level of support (a one-and-a-half page handout on the sections of a lab report with a brief overview by the lab instructor) and those using LabWrite. In the sections using LabWrite, the lab instructors were given a two-hour introduction to LabWrite by the project team consisting of an overview of the web site and effective lab report writing and instruction. In these experimental sections, the lab instructor had the students complete a pre-lab worksheet using the PreLab section of the LabWrite site, encouraged students to use the PostLab section to write their reports, and used the LabCheck resources to grade the reports. Students were also encouraged to use LabCheck to review their graded reports. Qualitative data collected during this study indicated that students who made use of LabWrite found it an effective and useful set of tools for writing lab reports[4]. These interviews revealed that many students had never received effective instruction in writing lab reports in the past and that LabWrite was a revelation as to how to strategically approach the scientific writing process.

After the control group study, the LabWrite site was revised and the testing expanded to a larger range of undergraduate lab-based courses. These courses included chemistry, physics, and biology and were being taught at a range of institutions, including community colleges, historically minority institutions (HBCUs), small private colleges and large universities. In all of these cases, the initial two-hour training was provided, but instructors were given more latitude as to how they implemented the LabWrite materials. This was a more realistic scenario as to how LabWrite is likely to be implemented on a larger scale. Periodic site visits were made to these institutions to observe labs, interview lab instructors and students, and collect lab report samples.

Arising out of both the initial study—and the later, larger-scale piloting—were recommendations for modifications and variations on the LabWrite materials. For example, LabWrite was initially designed to support empirical laboratory investigations where specific hypotheses were tested. There was difficulty on the part of the instructors and students in adopting LabWrite for use with the relatively common descriptive labs in which students were to perform procedures, make observations, and answer questions concerning what they had observed. The materials science lab course that participated in the early piloting was all descriptive labs. In response, the development team created a parallel set of support materials for students writing up descriptive labs. In addition, many laboratory instructors preferred to have students write up only parts of labs. They might only assign methods and results for one lab and only write up an introduction for another. While the development team did not philosophically support the notion of writing up only a partial lab report, bowing to reality, a set of support materials was also created for labs using partial lab reports. Both engineering and science education has recognized the importance of students engaging in the design of their own experiments. Not surprisingly, the development team was asked to also create a set of support materials for student-designed experiments, which was done.

The wide-scale piloting providing critical insights as to how labs were implemented in a wide variety of institutions and disciplines. As noted above, some of these observations resulted in the creation of new materials for the LabWrite web site. Observations of these pilot sites also revealed how critical the lab instructor is in creating a meaningful laboratory experience for the students, with or without the LabWrite support materials. It was another indication that, no mater how good the curriculum materials, effective implementation and support by the instructor is a necessary component. At the pilot sites it was demonstrated on many occasions that LabWrite, by itself, would not make a widespread impact on the quality of the lab experience and the lab report. The most able, self-sufficient students were able to make use of the LabWrite materials without much support from the instructor. However, those students who would most benefit from LabWrite needed encouragement and support from the instructor to make use of these materials. It meant that the lab instructor had to take time to review the LabWrite site and effectively integrate it into the lab curriculum.

Students are, not surprisingly, goal-oriented. They will assess what expectations the instructors has for them, what each component of the course is weighted relative to the others, and what work will be required to complete each component. If the lab component of the course is discounted relative to the lecture, it will automatically put LabWrite at a disadvantage. Similarly, if the lab instructor discounts lab report writing relative to the procedural aspects of the lab, then LabWrite is not likely to be used by the students. If lab reports are an important part of the lab experience but LabWrite is implemented in such a way as to be seen as an "add-on," creating additional work for the students, then it is likely not to be widely used. Time pressures on many lab instructors means that the LabWrite materials were often not reviewed thoroughly or effectively integrated into the lab portion of the course. While lab reports and the use of LabWrite were required components of the lab, the lack of initial instruction and support would lead to student frustration.

**Conclusions**

LabWrite has been demonstrated to be an effective instructional tool to help students write better lab reports but, more importantly, think more deeply about the scientific and technological concepts being covered in the lab. However, like any set of curriculum materials, proper integration of the materials into courses and support and training of the lab instructors are necessary elements of successful implementation. An ongoing effort has been to devise better ways to providing this logistical support for LabWrite. Clearly, if LabWrite is going to be implemented on a wide scale, then these logistical issues of implementation need to be addressed. While the development team is convinced that the time and effort to learn about and implement LabWrite is not unreasonable, the lab instructor, like the students, is also goal-oriented. The development team will need to both lower the entry point with better training materials and convince potential adopters that the time spent will be well worth it.

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**Biography**

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Dr. Wiebe is an Associate Professor in the Department of Mathematics, Science, and Technology Education at NC State University. During the past nine years, he has worked on the integration of scientific visualization concepts and techniques into both secondary and post-secondary education. Dr. Wiebe has been a member of ASEE since 1989.

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