More than just lab work: A summer intern program teaches undergraduates how to communicate their research

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Abstract

A number of North American universities offer summer programs which enable undergraduates from their home institutions and others to explore the world of engineering research. The Summer Undergraduate Research Intern program at Purdue University, a two-year-old program funded by NASA and NSF, was established to interest students in pursuing graduate work by simulating the professional activities of a research scientist. What distinguishes the SURI program from its counterparts elsewhere is systematic instruction in technical communication. The SURI developers embraced the complementary and necessary relationship between laboratory research and written and spoken communication skills by offering a weekly seminar in technical communication as part of the program. This professional seminar is conducted by an engineering communication specialist with help from an engineering librarian. This paper discusses the skills in library research, writing, and speaking needed by students to produce a review of the literature and to give a mock conference presentation based on their summer research. The paper also explores the challenges the seminar instructors faced in effectively delivering those skills to a linguistically and academically diverse group of engineering students.

Introduction

Over the past couple of decades, research experiences for undergraduates (REUs) have become an increasingly popular and effective way for engineering students to explore the world of research. These programs come in an array of choices of topic, location, program goals, enrollment, and duration.[1] Most of the papers published about REUs tend to discuss either research approaches, "how-to" run a program, or assessment.[2]

Some programs assess their success based on future graduate school matriculation of their former students, or on the number of publications or conference papers for which these students are listed as co-authors.[3-6] That a publication record is considered a measure of success of REUs is external validation for the importance of communication skills for engineers. Nearly 50 years ago, the founder of the IEEE Professional Communication Society called clear speech and writing "…prime and necessary characteristics of the successful engineer."[7] More recently, ABET 2000's Criterion 3 (g) stated that "Engineering programs must demonstrate that their graduates have:…an ability to communicate effectively."[8]

Unlike the wide-angle view of many of the papers on REUs, in which communications and library activities often are mentioned in passing, this paper focuses in on how one relatively new REU program reinforces the message that the ability to communicate one's research orally and in writing goes hand-in-hand with the research itself.

Program Background

The NASA Institute for Nanoelectronics and Computing at Purdue University established its Summer Undergraduate Research Internship (SURI) Program in the summer of 2003. The 18 students, representing nine different colleges and universities (including various departments at Purdue), joined ongoing interdisciplinary research teams consisting of professors and graduate students. The following summer, 23 students from 13 schools participated in the eight-week SURI program. The 2003 students represented five different majors; in 2004, there were eight majors. Information on the projects in which the students participated is on the SURI website [9].

Similar to many other REUs, the goals of the SURI program are to expose undergraduates to the professional lives of graduate students and research scientists. During their time on campus, the SURIs spend more than 40 hours per week attending professional development and research seminars; short courses and workshops; and working on their research projects.

Technical Communication Seminar

Recognizing the importance of communication skills for engineers, the SURI organizers decided to devote a weekly two-hour seminar to issues in technical communication, and asked me, the communications specialist for the School of Electrical and Computer Engineering at Purdue University, to lead it. In deciding what aspects of technical communication to teach, I let the program goals be my guide. While many REU students write technical or lab reports or prepare posters [10-13], only a couple of programs assign a literature review [14, 15]. It seemed to me that the literature review and conference abstract are appropriate and authentic documents for students trying out the role of researcher because an academic's professional reputation primarily rests on his or her success in publishing journal articles and presenting conference papers. [16] Furthermore, since undergraduate and graduate engineering students rarely receive instruction in writing either document, I felt confident that I would be exposing the SURI students to something novel and useful. In addition, as is the case with many of these REU programs, these students are expected to make an oral presentation on their summer's research during a conference on the final days of the program.

There are several other valid reasons to teach undergraduates how to write a literature review. The first is their lack of familiarity with the history, context, and issues of the research field in which they are assigned to work. This is hardly surprising since few undergraduate engineering programs as yet offer majors in nanotechnology, and the technical courses that exist are generally aimed at upperclass and graduate students. [17] In addition, because of logistical issues concerning matching SURI participants to research groups, the students often do not learn their assignment until they arrive on campus, so they have no chance to investigate the field in advance. This lack of knowledge is substantiated by the students' response to a first-day, in-class informal writing on their research goals in the technical communication seminar--many students write that they are unclear about the specific nature of the research they are about to undertake.

Doing the research for a literature review (more on the library research in a later section) sharpens critical reading skills, helping students make the transition from the summarizing and paraphrasing of undergraduate school to the higher-level skills (on Benjamin Bloom's well known taxonomy of educational objectives) required in graduate school and beyond. [18] In

addition, assembling the paper requires the ability to logically organize information from different perspectives.[19]

The technical communication seminar focused intensely on the literature review for the first four weeks of the summer of 2004. This was a logistical change from the first year, when the document was due at the end of the summer. Several students commented in the 2003 program evaluations that they would have preferred having the literature review due midway through the summer so that they could concentrate on their research and preparations for the final conference during the second four weeks. Apparently this was a better arrangement since no students complained about the timing of the literature review in 2004.

To keep the literature review from being overwhelming to the students, the task was broken into several steps. At the first seminar meeting, the students were given an information sheet to discuss with their advisors when they met them for the first time. The advisors were asked to stipulate the number, genres, and age of sources which would be acceptable in the literature review, and to identify the leading journals and conferences in their research field so the students would quickly recognize some credible sources. These sheets are kept on file to make certain the students' work would conform to the advisors' expectations; any changes need to be approved by the advisor and me.

I teach the content and organization of the literature review by means of handouts and in-class activities. An example of such an activity involves the students collaborating in small groups to suggest possible organizational strategies for a number of abstracts I provide. The students are surprised to compare their strategies and realize that there is no one way in which the same information can be organized.

One early class session is devoted to a discussion of research and publication ethics, covering such topics as misrepresenting data and plagiarism. Related to plagiarism is the need for scrupulous documentation and citation practices. Students are instructed to write down complete reference information for any sources they consult. At the third class, they are required to submit a draft of their reference list for the literature review. Many students have had little or no prior experience with documentation of sources, or if they have, they only may have been exposed to the Modern Language Association (MLA) style in an English course. Because many of the journal articles and conference proceedings the students consult are IEEE-affiliated, we use IEEE style in-text citations and reference list.[20] However, I caution the students that in future writing they will need to determine the appropriate style by consulting the requirements of the publication or conference to which they are submitting a paper.

Writing process pedagogy is used as a way of encouraging the students to write multiple drafts of their papers in the seminar. Showing students that writing is as much a process as lab research is a means of eradicating the typical "bingeing" behavior of writing papers the night before they are due.[18] To this end, a rough draft of the literature review is due in class a week before the final due date. The rough draft is exchanged with a peer reviewer (preferably, someone from the same research team). Students are provided with a list of guidelines related to literature review content and organization which they complete while reading their classmate's paper; afterwards, the students discuss their comments with their partner. When the final draft is turned in the

following week, I use the same guidelines for making comments on it, and I meet individually with each student to discuss my comments. Finally, the literature review is sent to the advisor for substantive comments.

Similar to the process involved in researching and writing the literature review itself, this in-class peer review work strengthens critical reading and thinking skills, and it gives students another opportunity to engage in teamwork. Reviewing a colleague's written work is another example of a common activity most faculty members frequently undertake as journal article or conference paper manuscript reviewers.

Library Workshop
The library workshop is taught in a library computer lab, so students have the opportunity to begin the resource discovery process while learning about it. The content is based around known habits of undergraduate students when they are looking for information[21, 22], and has several goals, including teaching the tools for discovery of information in a new field, logistics on performing the searches and the use of subject headings for developing additional search terms, and thereby building a bridge to move from new researcher to subject expert.

The first part of the class is a lecture and discussion format with occasional use of the computer. A quick overview of the library system at Purdue is provided and then discussion rapidly moves on to finding content for the literature reviews. Many of the students have been asked to restrict their literature review materials to journal articles and conference papers. I (Amy) spend some time talking with the students about why this may be the case, in particular that information about new research areas will not be in books yet, and based on currency of publications, conference papers and then journal articles will publish the most recent research and findings. A discussion of several library databases specific to engineering topics (Compendex and INSPEC) and what areas they cover is included because database selection is often the most difficult part of library use for researchers new to a field.[22]

Information discovery techniques of non-experts revolve around keyword searching in subject databases.[22, 23] One of the primary goals is to teach students that library research is never a "once-and-done" process, and what they find and read will influence the focus of their research and reveal new questions about which to find literature.[21,23] Some "button pushing" is taught for advanced features of the databases, primarily with the goal of narrowing the results to a manageable size, limiting by years (since the students are given age requirements for the documents they use) and how truncation and auto-stemming could help or hurt their ability to find more information.

Students do not search using the same techniques as their professors or other experts in a field.[21] Just as the REU is an introduction to research, the library session works to introduce students to the literature, how researchers communicate, and to develop the advantages the experts use in their own searching. Several techniques are used to help the students find credible resources. By using the databases introduced earlier, many of the credibility issues have been answered for them. Assistance also comes from the information sheets filled in with their advisors, where they get the names of several journals and/or conferences that are prominent in the field. By tapping into the domain expertise of the faculty, students can ramp up to more sophisticated searching

quickly. The technique of "footnote chasing," or using the references at the end of an article to find more articles on the same topic, is also discussed as a valid research technique, and one used by many domain experts.[21] By using this method, researchers are communicating with each other and the result is that much of the literature indexes itself.[24]

The second part of the session is devoted to actually working in the databases and finding materials. Additional questions about how to retrieve sources come up at this time and can be answered for the whole class. Immediately applying the discussed process helps the students learn the process better and remember it for future use, when they realize a new need or refine their topic further.

Oral Presentations
The second part of the technical communications seminar focuses on preparations for the final conference. After concentrating on learning and writing about their research fields in general, the students now switch to writing and speaking about the research in which they are engaged. First, one class session emphasizes the content and organization of a conference abstract. In the process of doing research for their literature reviews, the students have spent much time reading abstracts, so they are quite familiar with their purpose and format. The following session the students bring in rough drafts of their abstracts and exchange them with a peer for review, again with an instructor-supplied list of questions to guide their critiques. The finished abstracts are submitted to the instructor the following week, evaluated, and returned to the students for final changes before being assembled into a hard copy to be available at the final conference and at the SURI website.[9]

An important component of the preparation for the conference is a discussion about oral presentation design and delivery. By this point in the summer, through attendance at the research seminars, short courses, and workshops, the SURI students have been exposed to a variety of engineering professors and other professionals speaking and have opinions about how effectively the latter presented their material. In preparation for their oral presentations, I give the students a checklist covering talk content, delivery, and visuals as a guide. PowerPoint handouts are due at the time of the dry-runs of the presentations, early in the final week of the program. During the dry-runs, the students practice their presentations, individually or in research groups, while I simultaneously videotape them and make written comments on the checklist and the slide handouts. Immediately after the dry-runs, I discuss my comments and suggestions with the students and give them the videotape to watch on their own time.

To simulate a real conference as much as possible, the actual SURI conference is held in a formal conference room on campus with the students' advisors, graduate mentors, and, if possible, professors from their home institutions, in attendance. The conference sessions also are videotaped.

Challenges
Both years of the SURI program, one of the greatest challenges of the technical communication seminar has been dealing with the varied backgrounds of the students. The information sheets the students receive on the first day also elicit information on the students' personal writing and library research experience. About one-third of the students over the two summers indicated that

they had not written any type of research paper as an undergraduate (the majority of students were between their junior and senior years of college during the SURI program).

Complicating this issue, responses to another question on the information sheet about the students' first language reveals that of the total participants for the first two years of the program, 41 percent have been nonnative speakers of English. Within this number there was an incredible variety of first languages spoken (from Polish to Swahili in 2003 and Tagalog to French in 2004) and in the length of residency in the United States. Some of the students were permanent residents who had completed their entire education here, while others had come much more recently to attend a university. The students' time in the United States had a major impact on the students' ability to speak and write in English. The English of the permanent residents spreads across a linguistic continuum from native-speaker-like to decent oral fluency with poor writing skills.[25] With some of the students, adequate listening comprehension skills also were an issue which affected not only the technical communication seminar but interaction with research team members. For some of these ESL students, feedback on grammar, vocabulary, and pronunciation has to be given along with the feedback on higher-level language issues the native speakers received. In addition to instructor input, pairing students with greater difficulty in English with native speakers during in-class paper review times also helps the former improve. Anecdotally, I am aware that these non-native speakers often seek out the same peers outside of class for additional feedback on their writing.

Just as language background affects the students' performance in the technical communication seminar, so does their past experience in conducting library research. Some engineering undergraduates are fortunate to receive limited training specifically meant to help them write a humanities research paper in a first-year composition class; many others place out of their English requirement and never receive systematic instruction in doing library research.

Conclusion
After the few comments on the 2003 evaluations, there were no changes suggested on the 2004 student evaluations. The quantitative results of the responses to the question, "The technical writing/presentation course was very useful," were 3.93 and 3.67 (where 5.0 indicated strong agreement) in 2003 and 2004, respectively. Since this is the only item on the SURI evaluation about the technical communication seminar, in 2005 I will create my own detailed student evaluation form to elicit more meaningful responses about specific aspects of the seminar and the library workshop.

If REU success is often related to graduate school enrollment, then the results of the 2003 SURI alumni are impressive. Of the 13 students who received bachelors' degrees in 2004, nine entered graduate programs later that year. Happily, four of these students enrolled at Purdue: three in the School of Electrical and Computer Engineering, and the fourth in the School of Mechanical Engineering.

The Purdue SURI program is still too recently established to have its alumni listed as co-authors or co-presenters on the research they did here, but we hope to use this as another one of our success metrics before too long.

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