How Issues of Enrollment, Funding, and Resource Allocation Have Shaped Three Engineering Communication Programs at Georgia Tech

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Motivated in part by ABET's emphasis on communication skills, many engineering schools have chosen to integrate explicit communication instruction into their existing technical curricula. Regardless of the motivation for creating them, engineering communication programs are commonly administered at the school level, with each school having the freedom to implement instruction in a way that best fits with its particular sequence of laboratory, design, and capstone courses. As a result, within any one engineering college, a variety of successful writing program models can exist. The choice of paradigm reflects not only the communications norms of the particular disciplines, but also the constraints presented by the number of students enrolled in each school and by limitations on staff and resources.

At Georgia Tech, several models of meeting the technical communications requirement have been developed. Within the College of Engineering (COE), some schools outsource technical communication instruction, requiring students to take a stand-alone course taught by faculty in the School of Literature, Communication, and Culture. Other schools have developed in-house, discipline-specific communications programs in which written, oral, and visual communication instruction is integrated into existing technical courses in the undergraduate program. One program uses the aforementioned undergraduate model but offers in-house, stand-alone courses on the graduate level. All of the schools within the COE at Georgia Tech have met the communications requirement by assessing their individual department's needs and resource allocations in an effort to create a model that works best within their local environment. While institutional context helps to inform how communication instruction is handled at the school level, local/departmental issues of enrollment, funding, and faculty attitudes and perceptions of technical communications ultimately shape the genesis, development, and growth of each school's communication program.

"Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exposition

This paper will describe three in-house engineering communications programs that have been implemented at the Georgia Institute of Technology. This paper will discuss the rational behind the integration methods adopted in the School of Electrical and Computer Engineering, the School of Mechanical Engineering, and in the joint program between the Schools of Civil and Environmental Engineering and Materials Science and Engineering.

It is important to note that there were three common motivating factors that led each School to develop an in-house program. These common factors were the following:

- EAC/ABET's requirement that competence in written and oral communication must be demonstrated by each engineering graduate (Section I.C.3.g.);
- Growing awareness within the Schools of the need for engineers to be able to clearly and directly communicate with their colleagues and clients; and
- Feedback from industry and alumni that explicitly identifies communication skills among the most desirable traits a new hire can possess.

Within this context, we will describe the program model that is used in each School and the resource issues that have made that model appropriate. Additionally, we will emphasize why and how the choice of a technical communications program paradigm is dictated by philosophies of teaching and by issues of enrollment, resources, and funding. The discussion is intended to facilitate other engineering schools in choosing an appropriate model for integrating engineering communications instruction into their existing curriculum.

Undergraduate Professional Communications Program
School of Electrical and Computer Engineering

Background

Since the mid-1990s, the School of Electrical and Computer Engineering (ECE) at Georgia Tech has placed increasing emphasis on teaching electrical engineering (EE) and computer engineering (CmpE) majors communication skills appropriate to their discipline. In 2000, the School began developing its own in-house Undergraduate Professional Communications Program (UPCP) in response to the growing demand to produce graduates who could effectively communicate technical information. External concerns from ABET, alumni, and industry about the ineffective communication skills of ECE students coupled with internal pressure from faculty and administration to find institutional and departmental ways of addressing the problem became the catalyst for a major revamping of ECE's approach to technical communication instruction in early 2000. With close to 1900 undergraduate students, issues of enrollment, resources, and funding were at the forefront of the technical communications dilemma. These issues ultimately informed and influenced the philosophy of teaching oral, written, and visual communications embraced by the School of ECE, as well as the implementation of that philosophy.

Overview and Description of ECE's Undergraduate Professional Communications Program

The School of ECE at Georgia Tech is the largest School within the College of Engineering and is one of the largest programs nation-wide. Enrollment figures over the past few years have escalated to almost 1900 undergraduate students in ECE. Administering a rigorous communications curriculum is a challenging prospect for any engineering program, but figuring out the most effective way to teach technical communications to so many students has proven to be quite an undertaking. In efforts to balance concerns of efficiency and to maintain quality, the Undergraduate Professional Communications Program has gone through several iterations over the past four years (2000-04). In an attempt to find ways to meet the ABET EC 2000 requirement, ECE has utilized the two most prevalent pedagogical models of writing instruction currently available:

- the genre-driven, stand-alone technical writing course offered through the English department, and
- the integrated, discipline-specific approach based on Writing-Across-the-Curriculum (WAC) and Writing-in-the-Disciplines (WID) philosophies.

Early on, ECE students were required to take a two-credit technical writing course intended to give them the requisite skills needed for the types of discourse they will practice in their major courses. This genre-driven, stand-alone course was offered through Georgia Tech's School of Literature, Communication, and Culture (LCC). In spring of 2004, ECE's Undergraduate Curriculum Committee voted to drop the technical writing course as a degree requirement for a variety of reasons. At the core of those reasons was ECE's commitment to its own in-house technical communications program. A further complication was ECE's inability to enforce the LCC course as a pre/co-requisite with the first ECE course with a communications component (not enough sections of the LCC course were offered each semester to accommodate ECE students).

Concurrent with ECE's initial decision to require students to take the LCC technical communications course was ECE's investment in designing an in-house program to meet the goals and objectives for competence in communication as prescribed by the discipline and agreed upon by the School's faculty and administration. The programmatic paradigm that ECE began building in 2000 is based on the principles espoused by both Writing-Across-the-Curriculum (WAC) and Writing-in-the-Disciplines (WID) movements. The basic tenets – "writing-to-learn" and "learning-to-write" – are the foundation for how writing is taught throughout the ECE curriculum. The decision to blend the WAC and WID models was made by School administration early in the communication program's development and has remained the approach used to integrate technical writing and oral communication instruction into the ECE curriculum. The "writing-to-learn" philosophy fits well with the School's content-driven communications program. Consequently, several required ECE courses were purposefully selected as candidates in which to integrate a technical communications component.

Five required courses (beginning at the sophomore level and continuing through the senior design experience) have been designated as communication-intensive: ECE 2031 (Digital Design Laboratory), ECE 3041 (Instrumentation and Circuits Laboratory), ECE 3042 (Microelectronics Laboratory), ECE 4000 (Project Engineering and Professional Practice), and ECE 4006 (Major Design Project). These courses work well for three important reasons:

- The courses are required.
- The courses are taken sequentially.
- The technical content for each course is varied, and the content can be easily used in various types of writing assignments.

The five-course sequence allows communication skills to be taught throughout the curriculum, giving students multiple opportunities to engage in writing and speaking situations applicable to both academic and professional settings. All of the writing assignments required in the communication-intensive ECE courses are derived from content covered within the course so that writing becomes a mode of learning – a way of reinforcing engineering content.

Collaboration between writing faculty and engineering faculty is a key component of this model of technical communication integration. Collaboration has resulted in the creation of several innovative, discipline- and course-specific writing assignments and in the improvement of assessment instruments and evaluation rubrics. Much attention has been placed on creating a learning environment that fosters the development of critical thinking through the use of both traditional academic assignments (such as lab reports and summaries) and applied workplace-oriented assignments (such as user's manuals and application notes). Thus, applied communications and transferability of skills are important learning objectives of the UPCP.

Program Administration and Staffing

The UPCP is staffed by two full-time, 12 month, non-tenure track, technical writing faculty who are supported by the ECE budget. Both faculty members spend approximately 60% of their time teaching and working with students and 40% of their time carrying out administrative and programmatic duties. Since technical communications instruction takes place within several required ECE courses, the two UPCP faculty are listed as co-instructors of record for four of these courses. The UPCP coordinator teaches the oral and written communications component in the sophomore- and senior-level courses (ECE 2031 Digital Design Lab and ECE 4000 Project Engineering and Professional Practice), while the assistant coordinator teaches in the two junior-/senior-level Instrumentation and Circuits and Microelectronics labs (ECE 3041 and 3042).

ECE 2031: Sophomore Digital Design Lab

Students enrolled in ECE 2031 (approximately 150 students per semester—fall and spring; 75 students in the summer; 18 students per lab section) attend a one-hour-a-week lecture and a three-hour lab. Technical communications instruction is delivered during lecture by UPCP faculty. One-third of the lectures are dedicated to writing and oral communication instruction. Table 1 describes the types of technical communications assignments required in the sophomore

course. Typically, students prepare 2-3 individual writing assignments, two group reports, and one group PowerPoint presentation. All writing assignments are graded by graduate students who are trained and supervised by UPCP faculty, while the oral presentations are evaluated by UPCP faculty. Thirty-five percent of the final course grade is derived from the communications component.

ECE 3041 and 3042: Junior/Senior Instrumentation and Circuits and Microelectronics Labs

Students enrolled in these two labs attend a one-hour-a-week lecture and a three-hour lab. Enrollment in each of the courses exceeds 350 students annually (~700 students total in both classes). Approximately 150 students take each course in the fall and spring, and 50-75 enroll during the summer. Lab sections consist of 18-36 students, depending on the number of work stations available in each lab. Technical communications instruction is delivered in the lab to small groups of 18 students by UPCP faculty. All writing assignments are graded by graduate students who are trained and supervised by UPCP faculty. Close to 15% of lab time is spent teaching technical writing. Two writing assignments are required in each of these labs (Table 1), which comprise 20% of the final grade in these two courses.

ECE 4000: Project Engineering and Professional Practice

Approximately 300 students are enrolled in this course annually (100 per semester). Students attend a one-hour-per-week lecture and a 1.5 hour a week recitation. Lectures are co-taught by engineering faculty and communications faculty, while recitations are taught entirely by engineering faculty. Roughly 20% of the weekly lectures are dedicated to technical communication instruction delivered by UPCP faculty. Students spend the bulk of the semester preparing a research paper, which is accompanied by a "conference-style" oral presentation. Table 1 shows the various communications assignments required in this course. Unlike the three other communication-intensive ECE courses in the sequence, engineering faculty (recitation instructors) grade and evaluate all written and oral assignments. UPCP faculty work closely with engineering faculty to develop appropriate grading rubrics and evaluation criteria, which are used by the recitation instructors.

ECE 4006: Major Design Project

The culminating experience within the major, senior design is taught exclusively by engineering faculty, with UPCP faculty playing only a supporting role in the delivery of technical communication instruction. Engineering faculty teach and grade all written assignments and oral presentations in this course. Students are encouraged to work with UPCP staff, especially on their project proposals and design reports, but the UPCP serves mainly as a resource for senior design students and the faculty teaching the course.

Table 1. Description of Communication Requirements/Assignments per ECE Course

Communication-Intensive Courses	Communication Requirements and Types of Assignments Completed
ECE 2031: Digital Design Laboratory (2^{nd} semester sophomore)	– Informal lab summaries (1½-2 pages) – Formal lab reports (10 pages + appendices) – E-mail reports – Proposal – Oral presentation of group design project – Group design report – Mandatory 30-minute consultation with GTA writing consultant
ECE 3041: Instrumentation & Circuits Lab (1^{st} semester junior)	– Formal lab report (10 pages + appendices) – Industry-style writing assignment (e.g. user's manual) – Mandatory 30-minute consultation with GTA writing consultant
ECE 3042: Microelectronics Circuits Lab (2^{nd} semester junior)	– Formal lab report (10 pages + appendices) – Industry-style writing assignment (e.g. recommendation report)
ECE 4000: Project Engineering & Professional Practice (1^{st} semester senior)	– Research paper, based on topic of student's intended area of specialization – Annotated bibliography – Critique of a design project – Career plan and resume – Impromptu speech – Status presentation on research paper (w/transparencies) – Formal final presentation of research paper (w/PowerPoint graphics)
ECE 40XX: Senior Design (2^{nd} semester senior)	– Project proposal – Formal project report – Oral presentation of design project

In addition to participating in the teaching of the ECE communication-intensive courses, the Program's coordinator and assistant coordinator co-teach ECE 8901 (Writing Consultant Practicum), a one-credit hour course designed to address problems in teaching writing to undergraduate engineering students. All graduate teaching assistants who work with the UPCP are required to take the practicum course (which begins in fall and continues through spring semester). GTAs are exposed to the theoretical and pedagogical approaches to working with discipline-specific assignments, and they are taught grading and evaluation techniques. GTAs also learn strategies for working one-on-one with students so that they can effectively tutor in the ECE Writing Lab.

Graduate teaching assistants play an integral part in the Program's success. GTAs from the School of Electrical and Computer Engineering are trained as writing consultants who act in a dual capacity as both evaluator and tutor. GTAs (also referred to as writing consultants) are responsible for evaluating student writing and for providing meaningful feedback on writing assignments. Additionally, they spend at least four hours per week working face-to-face with students in small group sessions or in individual writing conferences. All writing consultants are centrally located in the ECE Writing Lab. GTA writing consultants are trained to analyze the discourse practices within the field of electrical and computer engineering. Understanding the rhetorical characteristics, communication patterns, and the language of the discipline enables the consultants to work effectively with undergraduate students who are themselves in the process of initiation into the larger engineering discourse community.

GTAs who work with ECE 2031 (sophomore level digital design lab) independently teach 1-2 lab sections, depending on their assistantship stipend. These GTAs are responsible for all aspects of the lab, including teaching the content, grading quizzes, and evaluating all written assignments. All GTAs assigned to ECE 2031 have an undergraduate degree in electrical or computer engineering and are degree candidates in ECE working toward an M.S. or Ph.D.

GTAs who work with ECE 3041, 3042 (junior/senior level labs), or ECE 4000 (Project Engineering and Professional Practice) only work as writing consultants. They do not independently teach any lab sections or recitations. Their primary responsibilities include grading writing assignments and working one-on-one with students in these classes to help them improve their communication skills. All of the GTAs assigned to these three courses are ECE graduate students pursuing M.S. or Ph.D. degrees.

Program Resources and Funding

The UPCP operates on an annual budget of approximately $230,000.00, all of which comes out of the general ECE budget. The School of ECE is committed and clearly invested in supporting the in-house technical communications program. The 4 ½ year old UPC Program is not currently endowed, but an endowment is the next step in the Program's development. External funding is generated through grants and gifts (primarily from alumni). The $230K is used to support a variety of resources, including two full-time faculty members, 11 ECE graduate students employed during fall and spring semesters (6 GTAs employed during summer term), the ECE Writing Lab, and the On-line Writing Lab (OWL). A brief description of the Writing Lab and the OWL is included below:

- The ECE Writing Lab is open 40 hours per week and operates under the philosophy, "better writers, not better papers." In other words, the emphasis is on long-term improvement of writing skills, not on quick fixes. Students can sign-up or drop-in for 30-minute, individualized writing instruction and tutorial. The lab directed by the UPCP coordinator and assistant coordinator and is staffed by GTAs who work for the UPCP. The lab is also equipped with a library of handbooks and handouts, several PCs with Internet access, and a network printer.

- Another resource offered to students is the On-line Writing Lab (OWL), a virtual extension of the physical space (http://upcp.ece.gatech.edu). The site contains a variety of discipline-specific and course-specific materials to assist engineering students who are working on and completing writing assignments throughout the curriculum.

Discussion

May 2005 will mark the five year anniversary of the UPCP. This milestone is significant because within a relatively short period of time, the Program has proven to be highly successful according to assessment results and anecdotal evidence. Nevertheless, the Program continues to grapple with overwhelming enrollment numbers (1900 undergraduate students) and issues of quality control. Administering a technical communications program within a large department is challenging, particularly when it comes to training and supervising the graduate teaching assistants who work with the UPCP. Maintaining consistency in grading among so many GTAs (10-12 per semester) and across so many sections (upwards of 12 per lab course) is difficult and time consuming, though not impossible. However, training engineering graduate students to work as technical writing consultants and graders does have its rewards. Today's ECE graduate students are tomorrow's tenure-track engineering faculty and professional engineers. It is exciting to be a part of this changing culture of engineering, a culture that is slowly beginning to embrace the importance of technical communication instruction. The future of engineering education looks promising since it is a future in which engineering faculty are more comfortable teaching and evaluating student writing.

Frank K. Webb Program in Professional Communication
Woodruff School of Mechanical Engineering

Background

Georgia Tech's Woodruff School of Mechanical Engineering is home to roughly 1300 undergraduate and 700 graduate students. In the most recent year for which data is available, the School granted 276 undergraduate degrees and 200 graduate degrees. The Woodruff School first moved to develop a writing program in 1990, when a composition professional was hired to address the needs of graduate students and their advisors through a combination of seminars and individual instruction. An alumnus contacted the School with an offer to fund this program after reading a description of it in the School's Newsletter. The program was named for him—the Frank K. Webb Program in Professional Communication. The Program is now funded largely from this endowment.

Overview and Description of ME's Professional Communication Program

While the Program was originally developed to address the specific problems of graduate theses, the program's scope expanded quickly as faculty grew familiar with the instructional materials that were used and as they became comfortable with the results that were obtained with graduate students. Instructors in the School's undergraduate design sequence began to seek

communication instruction, beginning with lectures and guides and regular meetings with student teams. During a curriculum revision in the late 1990s, the communication program was given responsibility for communication instruction in the whole of the undergraduate experimental and design sequences in addition to its responsibilities for the graduate program. The Program now provides materials, lectures and feedback for five required undergraduate courses and one graduate course.

Design 1

This is a required sophomore course introducing students to the issues of system design including design and evaluation, construction, and project documentation. In addition to traditional lectures, students attend a small weekly studio session where they are supervised by both a tenure-track faculty member and a teaching assistant; in their studio sections, students work in teams to complete numerous design-and-build projects. Student teams present their project results in eight written and oral reports each term.

For this course, the Webb Program coordinator delivers four lectures on the basics of technical description, prepares written feedback for each of the written reports that is submitted for grading, and attends studio sessions to observe and give oral feedback on each of the oral presentations that is delivered. Because enrollment in this class can reach 160 students, distributed across eight studio sections, this course can require upwards of 30 hours a week for preparation, actual studio time, and subsequent grading.

Experimental Methods

This required junior-level class introduces students to the practical issues of measurement equipment, measurement methods, and data analysis. Students attend a lecture and a laboratory session each week, usually completing ten laboratory projects over the course of a semester. Working in teams of two, students prepare written reports to document each project, and these reports are evaluated by teaching assistants.

For this course, the Webb Program coordinator delivers one lecture each term, describing the appropriate editor settings for page design and display format, and meets periodically with teaching assistants to outline practical matters of reviewing and commenting on written work. Upon request, the Webb Program coordinator also reviews reports before submission and hears complaints about grading. Because the communication program's responsibilities involve supervision more than direct instruction, this course generally demands only a few hours each week

Experimental Engineering

This required senior-level course concentrates on planning experiments in representative domains and on analysis of experimental data. Students attend a lecture and a laboratory session each week, and they typically complete six projects over the course of a semester. Working in teams of two and three, students present the results of their work in oral reports.

For this course, the Webb Program coordinator delivers two lectures each term. The coordinator is also expected to review and grade oral presentations for six different lab sections; these tasks generally amount to a time commitment of one hour a week over the course of a term.

Senior Design

In this required capstone course, students work in teams to address a substantial project, such as the redesign of an automotive component or the design of a new capability for an existing machine. Projects are commonly proposed by industry/corporate sponsors, although instructors are also open to substantive projects proposed by the students themselves. For this course, only two formal oral and written reports are submitted, with one set of reports presented at midterm and a second set presented at the end of the term.

The Webb Program coordinator reviews the midterm talks and reports, and delivers to the student teams written comments about both the document and the written report. This review typically requires about fifteen hours of time, concentrated in a single week around midterm.

Graduate Support and Program Assessment

Each term, the Webb Program coordinator teaches a non-credit graduate seminar that meets for an hour a week, and reviews proposals, papers, and funding proposals as they are prepared. The summer term each year is dominated by program assessment, which is a comprehensive review of graded reports submitted in the required design and experimentation courses. This review is performed to characterize strengths and weaknesses in the program and to locate potential problems in each of the required courses.

Discussion

The program described here is weighted heavily to undergraduate education, as is appropriate given the size of the school and the primary role of the advisor in graduate instruction. However, because this program was originally conceived to support a small population of doctoral students, staffing remains a significant challenge. The communication Program's endowment cannot support two full-time professionals, yet the size of the undergraduate courses makes it difficult for the Program's coordinator to oversee writing tasks across the School's undergraduate sequence. Engineering teaching assistants are asked to evaluate and comment on large volumes of undergraduate documents, yet these teaching assistants are not hired by the communication program coordinator, they do not answer to the communication program, and training sessions have been poorly attended. In a given term, as many as two dozen teaching assistants may be involved in grading undergraduate reports; working without coordination, they periodically give contradictory instructions to the undergraduate students.
The communication program in ME has grown by evolution rather than by planning, and this evolution speaks to both acceptance by the engineering faculty and to freedom granted by the School's administration. However, evolutionary growth is at once invisible and inflexible.

Course commitments—particularly grading activities—never get smaller, yet the slow pace of change makes it difficult to argue for significant increases in staff.

Charles E. Gearing Program in Technical Communications
Schools of Civil and Environmental Engineering and Materials Science Engineering

Background

The School of Civil and Environmental Program in Engineering Communications was started in 1998 through an endowment to the School by Joseph Mundy and his family. Officially called the Charles E. Gearing Program in Technical Communications, in honor of one of Joe Mundy's most influential professors, the origins of the donation are significant. Joe Mundy was a graduate of the School of CEE—an engineer and businessman himself—yet chose to support the School's effort to create an in-house communications program. He supported the in-house model because he understood that in order for the communications instruction to be meaningful, it had to be taught within the context of the discipline. His endowment demonstrates to students that a practicing (and highly successful) engineer understands the value of communication skills. While students expect the director of the program to defend the importance of such skills, it sends a very powerful message to them to learn that an engineer valued these skills enough to endow an entire program.

Note: The program coordinator also administers the Engineering Communications Program in the School of Materials Science and Engineering at Georgia Tech, but for the sake of simplicity has chosen to only describe the program in Civil and Environmental Engineering.

Overview and Description of CEE's Communication Program

The goal of the CEE Engineering Communications Program is to teach engineers the written, visual, and oral communications skills they will need in order to compete and succeed in the workplace. From its beginning, the engineering communications program was designed to be comprehensive. Comprehensive in this case means two things: it means that the program exists on both the undergraduate and graduate level and it also means that the program addresses issues in the three aforementioned forms of engineering communication. Like the other programs described in this paper, the CEE program was designed to meet the general needs identified earlier in the paper while still working within constraints specific to the School. These specific constraints include a one-person program and no stand-alone communications courses on the undergraduate level. The one-person constraint was dictated by the size of the endowment: while generous, it could still only support one person. The prohibition against a stand-alone course on the undergraduate level was dictated by the fact that the undergraduate degree program could not accommodate another required course, nor could one person handle teaching a required course to a School with 600 undergraduates. The School also teaches undergraduate distance learning classes at two campuses in south Georgia, which increases enrollment size to varying degrees each semester.

Therefore, a dual program was designed, and it should be noted here that the communications specialist was given *carte blanche* on how to design the program. At the undergraduate level, the program directly links communication skills with course content by meaningfully integrating communications instruction into the School's existing courses. On the graduate level, which has approximately 300 students, the program directly links communication skills with the course content by incorporating a stand-alone course called "Engineering Communication" in which students use content from their own course of study –there is no textbook—to improve their skills in written, visual, and oral communication. The graduate level course within the School is optional, although many professors informally require their graduate students to enroll.

What follows is a brief overview of the topics covered within the Engineering Communications Program:

Written Communication
Basic principles of good writing (clarity); editing and revision skills; conventional engineering documents such as laboratory and design reports, proposals, SOQs (Statement of Qualifications), abstracts, executive summaries, business documents such as letters and memos, skills relating to audience analysis and communicating with a non-technical audience.

Visual Communication
How to choose the appropriate graphic for a given purpose; how to design effective figures and tables; standard practices and standards of excellence in graphical design; how to effectively integrate these visuals into reports and presentations; how to effectively describe visuals; document design, including page lay-out and color theory; graphical integrity; basic principles of slide design for electronic presentations.

Oral Communication
How to create and deliver effective technical presentations; organizational strategies for different kinds of presentations; delivery issues for both individuals and groups; how to effectively talk an audience through a visual; strategies for beginning and ending presentations, including how to handle the Q&A session; incorporation of videotaping for purposes of self-evaluation.

Undergraduate Program Description

There are no independent undergraduate communication courses; rather, instruction in communications is meaningfully incorporated into the existing curriculum in a variety of ways.

The Program Coordinator in CEE

- Co-teaches two required courses, CEE 3000--Engineering Systems and CEE 4090--Capstone Design;
- Guest lectures, as requested, in many other CEE courses;
- Provides the faculty with teaching materials for courses;
- Works one-on-one with individual students or student teams in any CEE course;

- Periodically runs communications workshops on such topics as resume and letter writing or fellowship application essays;
- Helps students through the thesis and dissertation process; and
- Assists colleagues on papers, proposals, and reports.

The most significant characteristic of the Program is that the undergraduate training exists within an established sequence of courses. No one course will give the students all the training they need; however, over the course of the degree program, the students will gain the knowledge that they need to be competent in all forms of engineering communication. What follows are selected undergraduate classes in this required sequence and a description of what engineering communications issues are raised in each class.

CEE 3000—Engineering Systems

This undergraduate engineering course incorporates a series of lectures on written, visual, and oral communication. After each lecture, homework that reflects the instruction on a particular topic is assigned. For example, after a lecture on basic principles of engineering reports, the students are required to write a short report on a civil engineering system. Recent report topics have included the Venice Tide Barrier Project and the Yangtze River Diversion Project. After a lecture on visual communication, students are required to find a visual that does not meet the profession's standard of excellence and revise it, explaining the changes that were made and the justification for making them. A lecture on oral communication prepares the students for their final technical presentation. The course concludes with written reports and final group presentations that analyze a given civil engineering system. Each group receives substantial guidance by the communications specialist so that the students can produce a technical report that adheres to the highest professional standards in terms of content, style, and format, and a presentation that adheres to the highest professional standards in terms of organization, delivery, design, and management of electronic equipment.

CEE 4090—Capstone Design

Students enroll in the Capstone Design course with a firm foundation in basic principles of engineering communication. This foundation is essential because the course matches students with external engineering firms or local government sponsors in order to work on real engineering design projects. All three forms of engineering communication are covered in this course, but with real-world applications. For example, students are required to prepare SOQs before they submit their design proposals, and they are required to submit preliminary and final design reports. The technical presentations are no mere academic exercise in this course: the students have to present their projects to their project sponsors, who can include local government officials, members of regional agencies, or engineers in local high-profile firms. Consequently, the communications instruction in this course is far more advanced than in CEE 3000. For example, students are instructed on how to create SOQs—hybrid documents that require technical content along with marketing savvy. They are also instructed on how to write design reports in which the visual argument for a design is as essential as the written argument.

Finally, they are instructed on how to deliver technical presentations in which audience members might pose difficult or adversarial questions to them or even quarrel among themselves.

General Graduate Program Description

The graduate program in engineering communications is not a required part of the graduate students' degree program. It exists to the extent that there is one rigorous course in Engineering Communication that is offered each semester. While not required, the course is always highly enrolled and receives excellent student evaluations. The course covers written, visual, and oral communication, and the material that students write and talk about is taken from their own studies. The course is conducted as a workshop: equal time is devoted to lectures, in-class individual and group work, and evaluation and critique sessions. First, the course covers basic principles of clarity. Students then apply these principles as they learn how to create well-written and effectively designed technical documents. Emphasis is placed on the editing and revision process. Second, students learn not only how to create visually effective figures, graphs, and charts, but also how to write and talk effectively about them. Third, students learn how to create and deliver professional-quality technical presentations. These presentations are delivered exclusively through electronic media, and equal emphasis is placed on achieving excellence in content, delivery, and slide design. All presentations are recorded so that students can evaluate their individual efforts and assess their overall progress.

Discussion

The Engineering Communications Program in CEE is considered successful by the Institute's and the School's administration, the School's alumni, the School's faculty and perhaps most importantly by the School's graduates. That being said, the limitations of the program are the limitations of any one-person program: there will be no growth without more human resources. If the endowment is not increased or if the School does not find alternate ways to supplement the endowment, the Program will not grow beyond its original vision.

Conclusions and Recommendations

While the details of these three in-house programs may vary, the commitment to providing high-quality engineering communications instruction does not. Therefore, we would like to recommend the following practices to any school that is considering establishing an in-house communications program:

Define the scope of the desired program: Will it be an undergraduate program, graduate program, or both? Will there be stand-alone courses, integrated instruction, or both? How will the program be funded? Will there be enough money to fund the type of program envisioned?

Consider issues in implementation: These programs take time to show their effects. Give the program time (1-3 years) to develop. It takes time and patience to change the culture of the School. Give the program administrator time to build relationships and develop trust among his

or her colleagues. Finally, give the program administrator the authority to design, develop, and implement a program that meets the School's individual needs.

Incorporate assessment activities: Assessment helps legitimize any educational program. It also helps people evaluate the quality of the program and shows them where changes or improvements need to be made. Assessment tools for in-house engineering communications programs include grading, surveys, focus groups, and creating student portfolios that document student improvement over time.

The importance of fitting technical communication instruction to the local needs and resources of any given department, School, or program cannot be emphasized enough. Long term success of an in-house technical communications program hinges on understanding the local environment, the attitudes and perceptions faculty and administration have about the role technical communication education should play in the curriculum, and the availability of funding. Getting a program started is relatively easy compared to the effort it takes to sustain and develop it over time.