Instruction for Communicating in the Information Age

Cecelia M. Wigal[1]

Abstract

Engineers seek solutions for simple to very complex problems. They must communicate these solutions to their peers, their management, various internal and external customers, and even the general public by corresponding, instructing, analyzing, researching, and presenting. Visuals and document design features as well as state-of-the-art hardware and software enhance an engineer's ability to effectively communicate. However, effective use of these tools requires knowledge of (1) what tools are available, (2) how best to integrate these tools, and, most importantly, (3) how the reader and listener best grasp written and orally communicated information.

This paper presents the process being used by the engineering program at the University of Tennessee at Chattanooga that introduces technical communication in the freshmen year and develops competency as the students' programs advance through their senior year. Descriptions of the process and process objectives and specific course objectives for the initial course as well as assignment and objective assessment practices are provided. How students use technology, specifically, computer-based systems, to enhance the information gathering and sharing processes that support the communication of individual and team-based information is also discussed. Assessment tools for evaluating specific course objectives and overall process objectives are also presented.

Introduction

Practicing engineers, industry representatives, and ABET recognize the need for technical communication instruction in the engineering curricula. Studies estimate that engineers spend a minimum of fifty percent of their time on some form of written or verbal communication [5]. However, many students see written and oral communication as largely unrelated to their future jobs and/or career goals [6]. Engineering students believe that engineering is understanding and building something and does not include explaining and transferring knowledge, and thus, does not require rhetorical skills [7].

Many engineering courses require students to compose documents (such as laboratory reports, activity reports, and project reports) and to verbally present project findings or laboratory results. However, Walvoord expresses that engineering faculty, although they know that writing is important, are often reluctant to "teach" writing to their students. The faculty worry that their knowledge of technical writing and verbal communication and their ability to constructively respond to student work is limited and their ability to constructively provide feedback to the students is inadequate [6]. In addition, many schools and programs do not recognize the difference between what is being taught in introductory composition courses and industry's needs. Ramey believes that to adequately prepare students for communicating in specific disciplines, students need additional instruction in genre-based writing and verbal communication [8]. Thus, engineering students need instruction in writing and communicating per industry accepted processes and documents.

Some engineering programs address this issue by requiring their students take an additional course in technical, scientific, or research writing. This requirement, however, adds additional hours to the already busy engineering

[1] The University of Tennessee at Chattanooga. College of Engineering & Computer Science, Dept. 2402, 615 McCallie Avenue, Chattanooga, TN 37403. Cecelia-Wigal@utc.edu.

curriculum. Some institutions have created University-wide Writing Centers to provide tutoring and workshop instruction to supplement required composition courses. Ramey states that advising engineers on technical communications requires a variety of techniques and approaches that differ from traditional writing center theory. Specifically, due to the emphasis on design and application, students need to be more directly guided and the instruction has to be product-oriented [8].

The UTC Integrated Technical Communications Process

UTC chose to take Ramey's advice and prepare students for the needs of the workplace and further education by providing genre-based instruction. This instruction is provided through a process we call "Integrated Technical Communication" or ITC. Operationally, UTC's ITC process is the integration of the UTC university graduation requirements of oral communication and intensive writing with the engineering curriculum. The driver of this integration is the goal to better prepare UTC engineering students for technical communication tasks and expectations of the workplace. The objectives of the ITC process are

- To graduate engineers who effectively use writing to communicate ideas and concepts.
- To graduate engineers who effectively use verbal skills and tools to communicate ideas and concepts.

ITC Process Structure

Fundamentally, the UTC ITC process structure involves a number of courses across the four-year curriculum. Specifically, the structure of three interdisciplinary design courses—Introduction to Engineering Design (ENGR 185), Junior Interdisciplinary Design (ENGR 385), and Senior Interdisciplinary Design (ENGR 485)—and four discipline–specific laboratories—Mechanics of Materials Laboratory (ENGR 247), Control Systems Laboratory (ENGR 329), Soil Mechanics (ENCE 361), and Advanced Electronics Laboratory (ENEE 378)—were revised to integrate technical communication instruction. Figure 1.0 illustrates the step structure of the ITC program traversing the four-year curriculum and figure 2.0 defines the prerequisite path.

As illustrated in Figure 1.0, the ITC process structure includes four levels or steps that involve the students during their freshman, sophomore, junior, and senior years. The freshman course (ENGR 185) emphasizes the introduction of technical writing and oral communication and using the Internet as a communication and writing tool. This course is the foundation for all other courses in the ITC program. The sophomore course (ENGR 247) emphasizes communicating ideas in figures, tables, equations, and graphs as well as their correct application in a technical paper. In the junior level laboratory courses (ENGR 329, ENCE 361, and ENEE 378), the students learn of and practice using the specific format and content requirements of a laboratory report. Students are held responsible for ensuring they utilize those techniques and practices introduced in ENGR 185 and ENGR 247. The senior level course (ENGR 385 and ENGR 485) takes what was learned in the previous courses and applies it to the context of communicating with the industrial customer with respect to a real-life application. All engineering students are introduced to the writing of project-based reports such as proposals, memorandums and letters, and process descriptions. They also practice collaborative writing, team-based presentations, individual impromptu reporting, and e-mail correspondence.

All UTC engineering students complete the ITC process. A typical student ITC process path is to take (1) ENGR 185, (2) ENGR 247, (3) one of the laboratory courses—ENGR 329, ENCE 361, ENEE 378—depending on his/her specialty area, and (4) the interdisciplinary design sequence—ENGR 385 and ENGR 485. Since ENGR 485 is a continuation of the ENGR 385 course (students must take them consecutively), the path essentially requires the student to take three courses to complete the ITC program. The ITC process takes freshmen with little to no technical communication experience and produces graduates prepared for the communication responsibilities of the workplace.

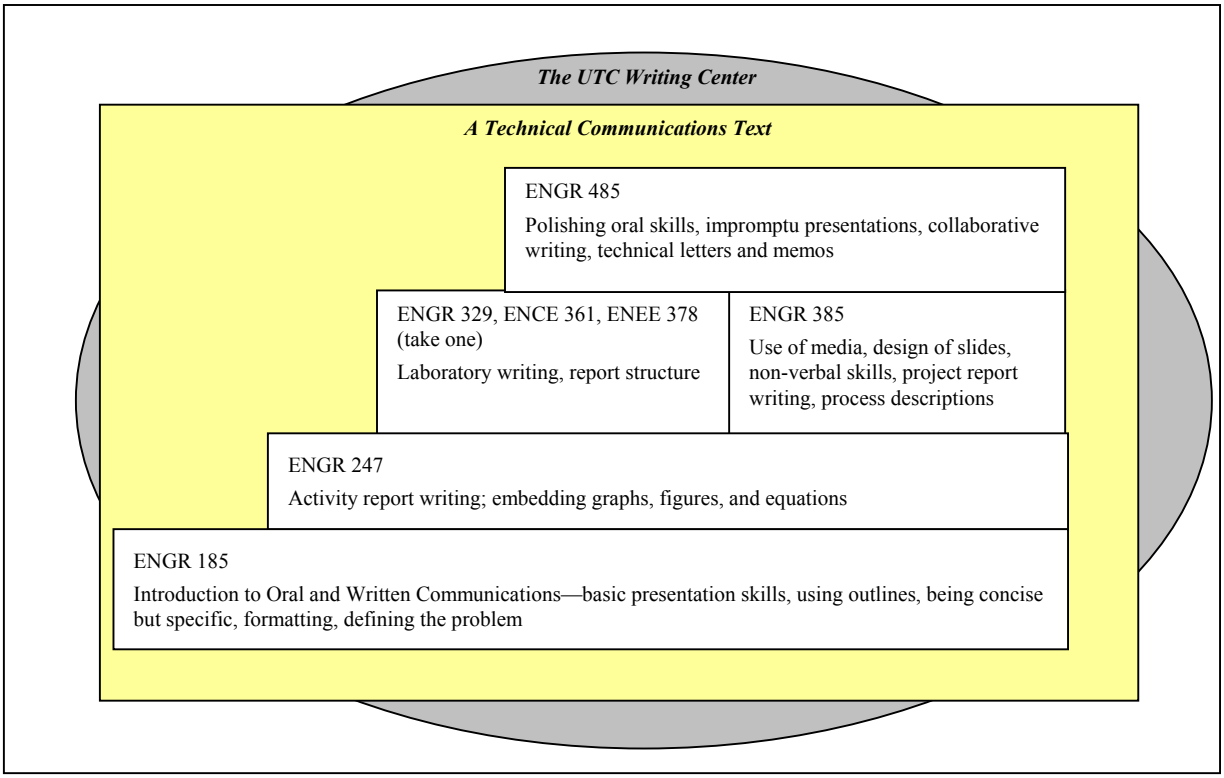

Figure 1.0: The Engineering ITC Process Structure

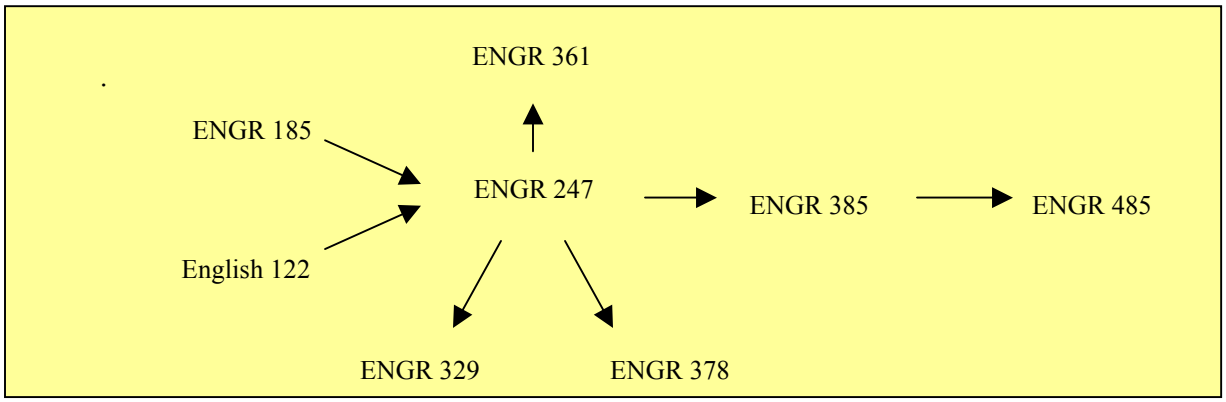

Figure 2.0: The ITC Process Flow (Prerequisites)

For each of the ITC courses, it is the instructors' responsibility to review the reports and oral presentations and provide constructive comments about format, technical content, use of figures and/or slides, precision, and readability. In addition, if students are having difficulty understanding or constructing the particular report or presentation with respect to format or content requirements, the instructors address these needs. However, if students are having difficulty with grammar and/or sentence structure, they are directed to obtain assistance from the Writing Center.

A single technical communications text is used throughout the UTC process to guide consistency with regards to instruction and student production. Presently the program is using

Finkelstein, Jr., Leo. *Pocket Book of Technical Writing for Engineers and Scientists*, The McGraw-Hill Companies, Inc., 2000.

This handbook succinctly and sometimes humorously describes the concepts of technical writing. And, although the title of this text mentions only technical writing, the content also addresses oral communication with respect to presentations and technical briefings. In addition, each instructor provides supplemental material and direction specific to his/her course objectives.

ENGR 185 – Example of ITC Course Activity

The ITC courses use assignments, lectures, examples, handouts, feedback, and course websites to facilitate the instruction of technical communication. Each course has specific technical communication course objectives

ENGR 185 is the Introduction to Engineering Design course. This course provides an introduction to the design process in engineering and computer aided design. Design exercises culminate in a prototyped group design project. Reports are written to communicate knowledge of the progress of the device definition as well as to communicate its final design. The objectives of this course specific to written and oral communication are:

- Know and be able to use principles of good technical writing (emphasizing minimizing wordiness and improving formatting and use of headings) to effectively communicate major ideas
- Know, understand, and be able to use the principles of good oral communications to effectively communicate major ideas
- Understand and be able to use Microsoft PowerPoint software to aid oral presentations
- Be able to document team meetings
- Be able to participate as a team member

Technical Writing

It is expected that by the end of the ENGR 185 the students are writing technically complete, concise (minimized wordiness), scannable, and credible documents. A number of practices help us meet this objective.

First, students are provided documentation (electronic handouts) describing good technical writing practices as well as the specific technical writing principles the students are responsible for practicing in ENGR 185. We emphasize eliminating sexist language, vagueness, shoptalk, jargon, redundancies, and roundabout phrases. We also emphasize the use of parallel structure, white space, headers, type sizes and fonts, indentations, and lists (bullets and numbers) to improve readability.

Second, we devote one class period to a lecture on technical writing. This is a participative lecture and covers those handouts described above. The students have had some practice writing a technical document prior to this lecture.

Third, we try to practice good technical writing in all of our written communications with the students. All homework assignments, lecture notes, and supporting documents are presented with bolded headers, bullets to emphasize steps and lists of activities, white space to aid readability, and correctly cited references.

Fourth, and maybe most important, we continually provide timely feedback to the students on their technical writing progress. All homework assignments (four individual assignments and one team assignment) are evaluated not only on their ability to adequately address the assignment but also on their readability, neatness, grammar usage, spelling, and reference notation. We provide written comments to each assignment emphasizing both what the student does well and where the student needs additional work. Specific examples on how to improve the readability of the documents are provided. We ask students to pick up their assignments prior to the next class period so they can review comments, discuss them with the instructor, and use the feedback to improve their next homework assignment. If many students are experiencing the same problems, we address this issue in class. If a student has specific problems with grammar, we refer the student to the Writing Center. The writing component of the assignment is 20% to 30% of the total grade.

Fifth, and maybe the most important to the students, we provide opportunities for the students to revise and improve their assignments. The students write their first technical documents prior to the technical writing lecture. They are provided the technical writing text and handouts as reference for this assignment. After the technical writing lecture they are provided an opportunity to revise their assignments to replace their original grades. This emphasizes that they are participating in a learning process and the first revision is a gage of their present abilities. The revision evaluation indicates how they are doing in the learning process.

The Report Grading Requirements and Guidelines: The content and writing of the reports are graded separately. The writing component is evaluated based on (1) grammar and spelling (40%), and (2) presentation (60%). Presentation includes (1) adherence to technical writing principles (use of bullets, lack of jargon and gobbly-gook, ensuring scannability, etc.), (2) adherence to the given report format, and (3) neatness. The writing grade is assigned based on the following 5-point scale. Table 1.0 defines how the scale is applied to evaluating the report writing (not the technical content).

- 5 points superior performance (exceeds expectations in most areas)
- 4 points commendable performance
- 3 points adequate performance
- 2 points marginal performance (below university standards)
- 1 point far below expectations
- 0 points unqualified failure

Table 1.0: Report Writing Grading Rubric

Score	Explanation
5	♦ The report structure is essentially correct. ♦ The writing is clear, concise, and highly informative. ♦ The report uses technical writing principles in an effective way. ♦ Grammar and sentence structure are almost flawless. ♦ There are no major spelling errors.
4	♦ The structure is essentially correct. ♦ The writing exhibits minor shortcomings. ♦ The report most often applies technical writing principles successfully. ♦ Grammar and sentence structure are solid, but small flaws that do not detract significantly from the impact of the overall report may be present. ♦ There are no spelling errors that would have been detected by an electronic spell-checker.
3	♦ The format is mostly correct. ♦ The writing exhibits noticeable shortcomings. ♦ The report takes a good try at applying technical writing principles ♦ Grammar and sentence structure contain flaws that detract somewhat from the impact of the report, but the overall quality is adequate. ♦ There are a minimal number of spelling errors that would have been detected by an electronic spell-checker.
2	♦ The format is lacking. Some try at meeting the requirements ♦ The writing exhibits severe shortcomings. ♦ The report minimally incorporates technical writing principles. ♦ Grammar and sentence structure contain flaws that detract much from the impact of the report. ♦ There are a few spelling errors that would have been detected by an electronic spell-checker.
1	♦ The format for the report was not followed at all. ♦ The writing exhibits severe shortcomings. ♦ The report does not incorporate technical writing principles. ♦ Grammar and sentence structure contain a significant number of flaws that detract greatly from the impact of the report. ♦ There are a significant number of spelling errors that would have been detected by an electronic spell-checker.
0	♦ The writing, structure, and format are so poor that the report is unintelligible.

Oral Communication

It is expected that by the end of ENGR 185 students are able to create oral presentations using Microsoft PowerPoint software that contain relevant material, present material in a structured and developed manner, and use slides effectively (are viewable and readable, contain graphics, and supplement the presentation). In addition, the students will have practiced delivery skills such as minimizing gestures, maximizing eye contact, varying pitch, intensity, volume, and rate, and being expressive. Two presentation activities have been initiated to help us meet this objective.

Individual presentations: Each student is required to develop and present a 5 to 7 minute technical presentation on the features, functions, and operation of a small appliance or tool they are reviewing for improvement. Prior to this assignment, the instructor instructs the class, using a Microsoft PowerPoint presentation, on accepted practices of good technical oral presentations. This lecture emphasizes planning and organizing, creating and using slides, and delivery. Of specific interest when using slides is emphasizing bullet points and phrases, slide layout and color, and font type and size. Some subsequent lectures on design topics are also presented using Microsoft PowerPoint and other instructional technology.

Group presentations: Each student must also develop and present a 15 to 20 minute presentation as part of a design team describing their team project and demonstrating the device prototype. Each student must orally participate in the presentation. It is also expected that they contribute to the development of the presentation. Each individual has received feedback on their individual presentation performance prior to the team presentation (assessment is discussed below) and thus the use of the presentation media and the presentation delivery are expected to be at a more advanced level than that for the individual presentations.

Presentation Evaluation: Both the individual and the team presentations are evaluated by the course instructor, the students, and any class visitors the day of the presentation. Students are evaluated in seven categories:

1. Organization
2. Language
3. Material
4. Delivery
5. Voice
6. Visual Aids
7. Length

Each of the categories is evaluated on a 5-point scale (1 to 5). The instructor, visitors, and students using the same recording sheet and guidelines to evaluate the presentations, are asked to score each of the categories and provide comments to support these scores. The instructor's and visitor's scores are averaged and are weighted as 90% of the student's grade. The student scores are averaged and are weighted as the remaining 10% of the student's grade. The evaluation sheet for the individual oral presentation is shown in Figure 3.0. The team evaluation sheet is similar. Each student receives as feedback to their presentation the weighted average grade—total and for each category—as well as a summary of the comments provided.

As shown in Figure 3.0, the Organization and Material categories have the heaviest weight for the individual presentations. For the team presentations, this is also true, except we also put additional weight on Visual Aids and combine the Language and Voice categories. Of course, the weights can change depending on what categories are being emphasized for a specific presentation.

Other Technical Communication

In addition to oral and written communication skills, ENGR 185 introduces students to team communication skills including participation in meetings, recording useable meeting minutes, and using Web-based software to enhance team communication.

Categories	Comments	Score	Weight
Organization: Purpose clear? Clear arrangement of ideas? Introduction, body, conclusion? Pattern of development clear?			.25
Language: Clear, accurate, varied, vivid? Appropriate standard of usage? Conversational mode? Helped the presentation?			.1
Material: Specific, valid, relevant, sufficient, interesting? Properly distributed? Adaptive to audience? Credibility (personal/source)? Use of evidence? Key points?			.25
Delivery: Poised, at ease, communicative, direct? Eye contact? Do gestures match voice and language? Do breaks aid presentation?			.1
Voice: Pleasing, adequate, not distracting? Varied in pitch, intensity, volume, rate, quality? Expressive?			.1
Visual Aids: Contain right amount of information? Easy to read/see? Enhance effectiveness of presentation? Bullets logical*?*			.1
Length: Within time limits (5 to 7 minutes)? (in limits get 5; 0<>2 out get 3; 2< out get 1)			.1

Scale:	***5***	***4***	***3***	***2***	***1***
	Superior	Good	Adequate	Inadequate	Poor
	(All Criteria)	*(Most Criteria)*	*(Some Criteria)*	*(Few Criteria)*	*(Very Few Criteria)*

Figure 3.0: ENGR 185 – Individual Student Oral Presentation Evaluation Form

During the second half of the semester when the students are working in teams, they are required to hold team meetings to work on the team assignments (there are four team assignments). For each of these team meetings they must record minutes and post these minutes on the team's course website so all team members, including the course instructor, have access to them. These minutes must state who attended the meeting (and who was absent), a summary of the outcomes from the meeting, a statement of assigned action items including due dates, and an announcement of the next meeting time and location. The students are also required to post the outcomes of their meetings (completion of the assignments) on the team's course website. These postings can be in-progress work and completed work. The objective is that work progress is available for all team members to review and use, including the instructor. The instructor provides feedback to the student teams as replies to these postings.

The compilations of the team assignments are the final team report, device prototype, and presentation. The students use the team's course website to share the individual work being done toward completing the report and presentation. Some of the team meetings can also be held electronically if necessary (many of our students have limited "free" time due to work schedules).

Assessment of ITC Process Objectives

The ITC assessment process provides a means to evaluate student oral and written communication competence and course exercise, preparation, and tool use effectiveness. Presently oral communications skills are evaluated at the freshman, junior, and senior levels and written communications skills at all four levels. Assessment tools—check sheets for recording the level of proficiency for each skill addressed at each level—have been developed for each course (examples have been provided for ENGR 185). In addition, for written communications, the assessment tools have been integrated, considering the interrelationships of instruction and learning, to provide sufficient indication of progress and effectiveness of the instruction, activities, and tools over the four levels. Examples of one of these assessment tools are shown in Figures 4.0 and 5.0. To complete these tools, "average" student work and course syllabi and supporting material, are reviewed for each ITC course. Each objective (in this case written

communication objectives) is assessed for each ITC level. Three reviewers participate in this exercise. The reviews are averaged and comments are summarized.

The assessment tools were first used following the Spring 2003 semester. Since the ITC process is still in its infancy, we did not expect to have many controversial findings. We did find, however, areas where we were not providing material or supporting student work as originally proposed in the ITC process plan.

Listed below is engineering *program outcome #5* that is associated with the written communication pathway. Under the outcome, one or more individual *pathway objectives* that support that program outcome are shown. Evaluate whether the performance of the students reflects an expected level of achievement (2), a higher than expected level of achievement (3), or a lower than expected level of achievement (1). Check the appropriate number for student learning objective, as it is associated with each pathway course.

Outcome # 5: Demonstrated the ability to work in interdisciplinary teams and to communicate effectively.

Written Communication Pathway Student Learning Objectives for Outcome 5							
	Level of Achievement (< (1), = (2), > (3))						**Average Score per Objective**
Student is able to:	**ENGR 247**	**ENGR 329**	**ENCE 361**	**ENEE 378**	**ENGR 385**	**ENGR 485**	
1. Include the appropriate and sufficient amount of technical information in the document—including appropriate technical language.							
2. Have a minimum amount of grammatical and spelling mistakes in documents							
3. Present information in an easy to read format – including headers, bullets, and figures where necessary							
4. Create documents using acceptable technical structure—including references, citations, and tables and figures with appropriate titles.							
5. Present information in an organized way—including Title pages, table of contents, abstracts/summaries, and appendices as needed							
Average score per course:							

Reviewer Comments on Assessment Results

Figure 4.0: Assessment of UTC Learning Objectives for Written Communication

Assessment of Engineering Program Outcome 5 – Assessment of Pathway

Listed below are objectives for the written communications pathway created to ensure written communication instruction and support is embedded across the engineering curriculum. Evaluate whether each of the pathway courses are sufficiently supporting the engineering written communication program using (1) for indicating the course does not sufficiently support positive student written communication outcomes and (3) for indicating the course does sufficiently support positive written communication outcomes.

Written Communication Pathway Assessment for Outcome 5							
	Level of Support (1-not sufficient, 3-sufficient)						**Average Score per Objective**
The course provides students:	**ENGR 247**	**ENGR 329**	**ENCE 361**	**ENEE 378**	**ENGR 385**	**ENGR 485**	
1. Time to write and get feedback on report drafts							
2. Sufficient number of assignments to practice writing							
3. Instruction/guidelines on technical writing							
4. Verbal and/or written feedback on assignments regarding technical writing good practices							
Average score per course:							

Figure 5.0: Assessment of ITC Pathway for Written Communication

Concluding Thoughts

UTC's ITC process has existed now for two years. This is not enough time to assess the outcome of the process with respect to its main objectives. However, we have seen some intermediate results that indicate the process and emphasis are having some affect. The ENGR 185 instructor has received comments from students (after they have completed the course!) that they appreciate the emphasis on technical communication. They feel more confident in expressing their ideas both orally and in writing. The instructor of the ENGR 247 course has begun to see some improvements in the written work and how ideas are represented.

It is anticipated that the spring 2004 ENGR 385 class will include a significant number of students who have completed both ENGR 185 and ENGR 247. The ITC process will be assessed again following the spring 2004 semester and the reviewers are eager to see whether the spring 2004 ENGR 385 students produce more readable and useable documents than those of previous semesters.

References

1. Panitz, Beth (1997) "Training Technology's Maestros," *ASEE PRISM*, Nov. pp. 18-24.

2. Buede, Dennis M. (1999) "Functional Analysis" *Handbook of Systems Engineering and Management*, A. P. Sage and W. B. Rouse (Eds.) John Wiley & Sons, Inc., New York, pp. 997 – 1035.

3. Levis, Alexander H. (1999) "System Architectures" *Handbook of Systems Engineering and Management*, Andrew P. Sage and William B. Rouse (Eds.), John Wiley & Sons, Inc., New York, pp. 427 – 453.

4. Oliver, David W., Timothy P. Kelliher, and James G. Keegan, Jr. (1997) *Engineering Complex Systems*, The McGraw-Hill Companies, Inc. USA.

5. *Baren, Robert. (January 1993)* "Teaching Writing in Required Undergraduate Engineering Courses: A Materials Course Example." *Journal of Engineering Education,* pp. 59 – 61.

6. *Walvoord, Barbara E. (1997)* "From Conduit to Customer: The Role of WAC Faculty in WAC Assessment." *Assessing Writing across the Curriculum*. Ed. Kathleen Blake Yancey and Brian Huot. Greenwich, CT: Ablex, pp.15-36.

7. *Windsor, D. A.. (1996) Writing Like an Engineer: A Rhetorical Education*. Mahwah, NJ: Lawrence Erlbum.

8. *Ramey, Deanna Elizabeth. (January 2000)* "Assessing Writing Instruction in a Sophomore Engineering Course: Iterations of Integrating Writing from 1995-1999." *Monographs in Engineering Education Excellence*. *Gateway Engineering Education Coalition/University of South Carolina. Number 1.*

9. Finkelstein, Jr., Leo (2000) *Pocket Book of Technical Writing for Engineers and Scientists*, The McGraw-Hill Companies, Inc. USA.

Cecelia M. Wigal

Dr. Wigal is an UC Foundation Associate professor of Engineering at the University of Tennessee at Chattanooga (UTC). She received her B.S. degree (electrical engineering) from Ohio Northern University (1985), her M.S. degree (electrical engineering) from Illinois Institute of Technology (1991), and her Ph.D. degree (industrial engineering and management science) from Northwestern University (1998). Before coming to UTC in 1999 and before undertaking her Ph.D. work in 1993, she worked in industry for over 8 years as a Project Engineer and Senior Project Engineer in the Aerospace Electrical Systems Division of Sundstrand Corporation (now Hamilton-

Sundstrand). Dr. Wigal's primary areas of interest and expertise include complex process and system analysis (ensuring representativeness while minimizing bias and data overload), quality process analysis with respect to fast-paced growth, and information system analysis with respect to usability and effectivity. She is also much involved with curriculum development, emphasizing the holistic component.