

Writing for Engineering: Benchmarks in the BS in Engineering Program at East Carolina University

*Rita Reaves, Visiting Associate Professor, College of Technology and Computer Science,
Greenville, North Carolina 27858 reavesr@ecu.edu*

Abstract –The BS in Engineering program at East Carolina University is designed as an integrated collaborative engineering environment (ICEE) in which students use and communicate knowledge to solve engineering problems throughout their undergraduate program. Within this integrated engineering environment and with strong endorsement and input from our Engineering Advisory Board, faculty have designed a sequence of writing benchmarks including lab reports, memo reports, summary reports, research reports, proposals, and collaborative project reports required for success in engineering. This paper presents the rationale for this sequence of writing benchmarks for engineering students, the advantages of this integrated approach to developing writing skills, the need to train students to see “writing as a public activity,” and strategies for making it work.

Keywords: Writing, curriculum design

RATIONALE

The 2006-2007 Criteria for Accrediting Engineering Programs calls for engineering programs to demonstrate that their students attain eleven program outcomes (3a-k) that describe what their students are expected to know and be able to do by the time of graduation. Although professional writing skills are most directly related to program outcome 3g, “an ability to communicate effectively,” clear and effective writing in engineering is also directly linked to other program outcomes as well including the following:

- a) An ability to apply knowledge of mathematics, science, and engineering
- b) An ability to identify, formulate, and solve engineering problems
- j) A knowledge of contemporary issues

In support of these program outcomes, faculty in the BS in Engineering program at East Carolina University have designed a curriculum strongly committed to the importance of building communication skills. The engineering program is designed as an integrated collaborative engineering environment (ICEE), giving students frequent opportunities throughout their four-year undergraduate program to communicate knowledge to solve engineering problems. Within this integrated engineering environment, and with strong endorsement and input from our Engineering Advisory Board, students progress through a sequence of writing benchmarks including lab reports, memo reports (engineering analysis), summary reports, research reports, proposals, and collaborative project reports required for success in engineering.

Our goal is that employers seek out our engineering graduates in part because of their demonstrated ability to write and speak effectively to communicate solutions to engineering problems, to conduct sound research on contemporary issues, and to work collaboratively in engineering teams.

Faculty designed the sequence of benchmarks through which students develop skills in writing for engineering. While students have opportunities to develop written and oral communication skills in many courses, including those at the freshman level, major focus is given to developing skills in writing for engineering in six courses required for all graduates of the BS in Engineering at East Carolina University:

Table 1: Writing Benchmarks for Engineering Students

Course number	Course title	Benchmark
ICEE 3024	Mechanics of Materials	Lab reports
ICEE 3100	Internship	Summary reports
ICEE 3300	Project Management	Memo reports
ICEE 3400	Engineering Economics	Research reports
ICEE 4010	Senior Design Capstone I	Proposals
ICEE 4020	Senior Design Capstone II	Collaborative reports

Integration of Writing-Intensive Courses

Each engineering course listed in Table 1 is designated as “writing-intensive” in the engineering curriculum. East Carolina University has a strong Writing Across the Curriculum Program with a graduation requirement that all students complete a minimum of twelve semester hours of writing-intensive courses, including six hours of freshman composition and a minimum of three semester hours of writing-intensive coursework in the major field of study. Graduates of the engineering program at East Carolina will far exceed the university requirement, with fifteen semester hours of writing-intensive coursework in engineering alone. The Writing Program at East Carolina University also provides a writing consultant for the College of Technology and Computer Science with an office located in the main classroom building for engineering students. This dedicated resource further emphasizes to our students the importance of clear writing in engineering.

Integration of Problem-Based Learning Approaches

Much of the curriculum for the integrated collaborative engineering environment reflects problem-based learning, an instructional method through which students work together to find solutions to real-world problems. A key advantage of this approach is that students develop writing skills for different but realistic rhetorical contexts, all related to engineering problems. Felder and Brent state that “development of communication skills occurs automatically in problem-based learning as long as written and oral reporting is part of the implementation, especially if students work on the problem in structured teams” [1]. Our senior capstone courses illustrate the use of problem-based approaches, with some problems provided by area industry. Two such examples follow:

Example 1: Assessment of Existing Energy System

As our infrastructure ages, Company X will be faced with a major rebuild or replacement. Engineering students would provide an assessment of our equipment, its energy efficiency, and in some cases, maintenance cost and history. Then they would research the current technology, its energy efficiency, capital cost and maintenance needs and provide a cost/benefits analysis for repairing older equipment versus replacing it with newer technology. This documentation would be used to determine the path forward for maintenance and capital spending on energy system equipment. Students would work closely with the engineer for the area and the maintenance department in order to understand the costs and performance data associated with existing equipment. They would also interact with vendors to obtain price quotes and performance data for replacement equipment. The end result of this semester

assignment would be a report that includes the equipment assessed, current efficiency and costs, and replacement technology with its efficiency and costs.

Example 2: Assessment of Waste Streams at the Solid Waste Incinerator

By documenting and observing the natural gas required to burn specific wastes, students would be expected to provide a “recipe” of waste mixtures that would allow for the minimization of the auxiliary natural gas. Ideally, hot and cold wastes would be identified and targeted for mixture to minimize or avoid gas consumption that would normally occur with burning only cold waste. By working closely with the incinerator operators, students would be expected to identify, document, and quantify the impact of different wastes on the combustion requirements for the incinerator. This experience would provide an excellent opportunity to work with front line operations and to realize the potential to immediately impact the manufacturing costs at the site. The end result of this semester assignment would be a report, documenting the types of waste that the incinerator receives, the natural gas required to burn that waste, and the results of experiments where different wastes were mixed and the corresponding impact on natural gas consumption. Ideally, the report would provide recommendations for waste mixing to minimize gas consumption.

WRITING AS A PUBLIC ACTIVITY

To write as engineers, students must first develop an understanding of writing as a public activity. Throughout their first twelve or fourteen years of education, their writing has primarily been a private communication between a teacher who assigns a paper and a student who responds individually to the assignment, folds the written response in half to avoid even the random gaze of another, and gives it to the teacher who reads it privately and returns comments to them, still folded and shielded from others’ comments and interpretations. Engineering faculty members realize that we have a responsibility to help students to begin to see that writing at work is far different; it is a more often than not a public activity, with many people both contributing to and reviewing drafts and all needing clarity to aid in comprehending complex information.

In Writing Like an Engineer: A Rhetorical Education, Dorothy Winsor points out that writing in a university setting and writing in a corporate one require completely different understandings of audience and context [5]. She stresses the importance of helping engineering students transcend the assumption that “writing like an engineer” means writing only for other engineers or that it means writing only objectively. In fact, as engineers report information, they are often placed in persuasive rhetorical situations; that is, they must be equipped to translate and interpret the significance of the information they present to multiple audiences at varying levels of technical expertise.

To help students begin to see writing as a public activity, they should be led gradually into sharing their work with others. One approach is to assign each student a “writing partner,” one person in the class who reviews everything the student writes, helps identify areas of weakness, and offers help in revision. In addition to the writing partner, each student is also part of a “helping circle,” a group of 5-7 students who review drafts and discuss ways to improve them. For reluctant students, it is helpful to have a draft first reviewed by the writing partner before taking it on to the helping circle. The University of Minnesota’s Center for Writing provides excellent guidelines for “Peer Response Workshops” involving pairs of students or groups and peer collaboration strategies to use in class, outside class, or online [7].

Extremely useful strategies for teaching students how to write collaboratively are found in Green and Duerden’s “Collaboration, English Composition & the Engineering Student: Constructing Knowledge in the Integrated Engineering Program” [3]. The authors point out that “although our students will be expected to write collaboratively in their professional lives, they are nevertheless unprepared to do so without training” [3]. Their NSF-sponsored research includes strategies for group invention, problem-solving, distribution of work, and final editing that are most effective and easy to implement in any course.

Felder and Brent discuss cooperative learning methods to address ABET outcomes 3a-3k. In particular for program outcome 3g, they suggest having pairs of student teams critique each other’s first drafts of written reports or rehearsals of oral presentations. Each member of the team completes a copy of the actual scoring rubric; the teams then meet and discuss their ratings and offer suggestions for improvement.

Online, the wealth of guidelines, strategies, assignments and rubrics for writing in engineering is tremendous. Two of the richest sites are at Virginia Tech and Rensselaer Polytechnic Institute. The Writing Center at Rensselaer provides a broad array of handouts, assignments, and rubrics for professional reports including the senior project proposal and final report [6]. Virginia Tech provides the host site for “Writing Guidelines for Engineering and Science Students” with Penn State, the University of Illinois, the University of Texas, and Georgia Tech serving as contributors. Contents include writing exercises and guidelines for memos, letters, laboratory reports, design reports, progress reports, proposals, instructions, and theses and dissertations [7].

Writing Benchmarks in the BS in Engineering

The following paragraphs summarize the goals for the writing experience and the writing assignments in each of the six writing-intensive courses in the BS in Engineering at East Carolina University:

Writing Lab reports: ICEE 3024 Mechanics of Materials

The writing experience in this course has two key goals:

1. To prepare students to write professional lab reports in subsequent courses in the BS in Engineering degree program.
2. To prepare students to write professional lab reports upon entering the workforce.

Written assignments require students to synthesize course content from two previous courses, ICEE 2022 Statics and ICEE 2070 Materials and Processes. A primary course objective is that students will be able to conduct experiments involving load, deflection, and/or strain measurements, analyze experimental data, and write concise laboratory reports. The assignments are as follows:

1. Two lab reports, each 8-10 pages and written in three drafts
2. Six additional concise reports (1-2 pages each) in response to lab activities

Students are provided a standard format for lab reports. The student’s original draft is reviewed by the student’s lab team, based on a rubric provided by the course instructors. Students revise the drafts based on peer review and submit the revised draft to the course instructor for suggestions for further revision. Based on instructor input, students revise the lab reports and submit the third draft for final evaluation.

In addition, students write a series of brief reports on lab activities which are evaluated to improve students’ ability to analyze experimental data and present findings in concise, clear reports.

Writing Summary Reports: ICEE 3100 Internship

Writing experiences in this course prepare students to maintain an engineering log, to communicate effectively in short technical reports, and to gain proficiency in self-assessment reporting. Assignments include the following:

1. Engineering log: Students maintain a reflective log (50-60 pages) during their internship experience which includes descriptions of the internship, the internship sponsor, work or project assignment, performance metrics, and organizational policies.
2. Analytical assignments: In a series of short reports, students explore and analyze specific areas of the organizational operation. Each report requires multiple drafts and consultation with the assigned university writing consultant.
3. Summary report: The final internship report includes the work log, samples of engineering work performed, analytical assignments, and evaluation by the supervisor.

Writing Memo Reports: ICEE 3300 Project Management

In this course, students write memo reports evaluating progress in learning the project management process and conduct of service-learning engineering projects.

Students write ten or twelve memos (1-3 pages each) in multiple drafts, summarizing, critiquing and synthesizing course materials. Peers review each draft, following an analysis guide/rubric provided by the instructor.

Students document methods, procedures, systems used in defining, planning, scheduling, controlling, and organizing project activities and present a project closure report of a service-learning project. Student learning/writing activities include the following:

1. Research and analyze needs of the organization sponsoring the service-learning project and write a project charter.
2. Provide schedules and reports describing the progression of the project
3. Develop final notebook of project materials
4. Present project closure report and a reflective journal evaluation of service-learning project and the course content.

Evaluation of writing assignments is a significant portion of the final course grade.

Writing Research Reports: ICEE 3400 Engineering Economics

This course provides engineering students with experience in writing research reports leading to the development of lifelong learning skills. The research reports focus on equivalent worth, benefit/cost, and rate of return, including impact of depreciation, taxes, and statistical risk. Students are assessed on thoroughness of analysis and clarity of expression. Peers review each draft, following an analysis guide/rubric provided by the instructor.

The research report (10-15 pages) is written in multiple drafts, with each draft reviewed by peers. In addition, students write two short preparatory reports in multiple drafts. All drafts are peer reviewed with substantive questions addressed in class.

Writing Proposals: ICEE 4010 Senior Capstone Design I

The capstone engineering course is also the culmination of students' writing experience in the BS in Engineering at East Carolina University. In their capstone courses, students demonstrate skills in academic and professional writing through a year-long senior design project. There are three goals for the writing experience in this course:

1. Students will be able to apply technical content by solving a complex problem in a manner equivalent to expectations in the workplace.
2. Students will perform project management, planning, and economic analysis to develop a reasonable scope and related project plan.
3. Students will demonstrate written communication skills by developing and submitting a project proposal that meets industry standards.

These goals are accomplished through the following sequence of written assignments

1. Weekly team memo (twelve 1-2 page memos)
2. Monthly progress reports (four 1-2 page reports)
3. Midterm report (3-4 pages)
4. Written proposal (8-10 pages)

Multiple drafts are used to prepare students to write for external audiences. The midterm report and the final written proposal are reviewed by peer groups and the course instructor prior to presentation to the client and final evaluation.

Writing Collaborative Reports: ICEE 4020 Senior Capstone Design II

In their final semester, students perform project management, planning, and economic analysis required to complete their design project. Students develop and submit a project report that meets industry standards and present the report orally to industry clients.

The course focuses on managing engineering projects, collaborative engineering, working with clients, and elements of the final report. The sequence of weekly team reports and monthly progress reports is designed to give students practice in keeping clients informed of their progress and to contribute to the success of the final report:

1. Weekly team memo (twelve 1-2 page memos)
2. Monthly progress reports (four 1-2 page reports)
3. Mid-project report (3-4 pages)
4. Written final report (15-20 pages)
5. Team member evaluations (1 page each)

WRITING FOR ENGINEERING

A senior research engineer who serves on our Engineering Advisory Board noted that the government agency for which he works recently rededicated itself to the importance of technical writing, in large part as a response to the recognition that “engineering by PowerPoint” or primarily through any string of bulleted lists does not work. Engineers must communicate in a rhetorical context and in a variety of formats through which they translate and interpret technical communication. We believe that the writing benchmarks in the BS in Engineering program at East Carolina University prepare our graduates to begin their careers well equipped to write as engineers, clearly and effectively communicating solutions to engineering problems.

REFERENCES

- [1] Felder, Richard and Rebecca Brent, “Designing and Teaching Courses to Satisfy the ABET Engineering Criteria,” *Journal of Engineering Education*, January 2003, 7-25.
- [2] Flash, Pamela, “Creating Effective Peer Response Workshops,” University of Minnesota, Center for Writing, http://writing.umn.edu/tww/responding_grading/peer_workshop.htm
- [3] Green, Meredith and Sarah Duerden, “Collaboration, English Composition, & the Engineering Student: Constructing Knowledge in the Integrated Engineering Program,” *FIE 1996 Proceedings*, pp. 3-6.
- [4] Shwom, Barbara and Penny Hirsch, “Re-envisioning the Writing Requirement: An Interdisciplinary Approach,” *Business Communication Quarterly*, 62(1), 104-108.
- [5] Winsor, Dorothy, *Writing Like an Engineer: A Rhetorical Education*, Lawrence Erlbaum Associates, 1996, 114.
- [6] The Writing Center at Rensselaer Institute, <http://www.rpi.edu/dept/11c/web>
- [7] Writing Guidelines for Engineering and Science Students, <http://www.writing.eng.vt.edu>

Rita Reaves

Rita Reaves is a Visiting Associate Professor in the Department of Engineering and Associate Professor Emeritus, East Carolina University. She has taught courses in technical communication, technical presentations, and research. She is a former associate editor of *Technical Communication*, where she served as editor of "Recent and Relevant." She served as Director of the Writing Across the Curriculum Program and as Associate Vice Chancellor for Academic Programs at East Carolina University. Her research interests include effective teaching and writing as a tool for learning.