AC 2011-419: IMPROVING ENGINEERING STUDENTS' TECHNICAL COMMUNICATION SKILLS

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Improving Engineering Students' Perception of Technical Communication Skills

Abstract

The ABET 2000 Criterion 3g states that engineering programs must educate students with "an ability to communicate effectively.[1]" Surveys of engineering graduates and current students at West Texas A&M University (WTAMU) indicate that there is a desire on behalf of the students to experience more technical communication opportunities within engineering coursework.

Traditionally, written and oral communication instruction has been conducted in a formal setting within the required three course sequence of ENGL 1301 (Introduction to Academic Writing and Argumentation), ENGL 2311 (Introduction to Professional and Technical Communication), and COMM 1315 (Basic Speech Communication) as part of the university's core educational requirements. The State of Texas has legislated a 120 semester credit hour restriction on degree requirements with the exception being a need for additional hours to receive accreditation. The Department of Engineering currently holds one of these exceptions but it is felt that it cannot be extended to cover a course specific to engineering communication.

The authors, working in conjunction with the Communication and the Engineering and Computer Science Departments, respectively, have identified methodologies to improve and reinforce technical communication skills in the existing engineering curricula. Communication instruction has always been an important part of the university education process but this current initiative strives to focus on the study and improvement of technical communication skills throughout engineering coursework requirements. This reflects the need of employers for engineers with strong communication skills and the desire of our students to improve these skills. Three engineering courses have been targeted for the initiative: ENGR 1201 (Fundamentals of Engineering), ET 2371 (Metals and Ceramics), and ENGR 1171 (Engineering Ethics). The first two courses have a laboratory component with written laboratory reports and oral presentations while the third is a course created in direct response to ABET Criterion 3f (an understanding of professional and ethical responsibility) and requires extensive written communications in the form of written and oral assignments. These three courses also support the civil, mechanical, and engineering technology programs in the Engineering and Computer Science Department at WTAMU. Additionally, a section of COMM 1315 has also been targeted to participate in a common assignment with the ENGR 1201 course.

This paper will examine student self-assessment before and after completion of the targeted engineering courses as well as for the common written technical communication assignment shared between the selected COMM 1315 and ENGR 1201 classes. Additionally, several exercises have been identified and incorporated into these courses to test their effectiveness and possible integration into other engineering courses. Preliminary results of this multiyear initiative indicate measureable improvement in students' application of technical communication skills in the targeted engineering courses. Preliminary results of this multiyear initiative indicate improved perception in students' application of technical communication skills in the targeted engineering courses.

Introduction

Senior exit interviews as well the technical advisory committee for the Engineering and Computer Science (ECS) Department has indicated a desire to strengthen technical communication skills (written, oral, and presentation) for its graduates. Practicing engineers realize the importance of technical communication skills, as evidenced by a study conducted in 2010[2]. That study indicated a need for an "awareness of the big picture" and a "willingness to engage" in regard to communication skills in the workplace. The Body of Knowledge document prepared by the American Society of Civil Engineers (ASCE) further emphasizes the need for technological communication skills along with business management competence and lifelong professional development in order to compete in the global marketplace[3]. Communication and business management skills can be fuzzy concepts for people primarily trained in applied math and science, yet these skills are recognized when they are or are not present in individuals, especially when it comes to job performance and the ability to advance in one's career path.

While computer science and engineering technology have been well established at WTAMU, the mechanical (2003) and civil (2010) engineering programs are relatively new. Curricula for the newer engineering degree programs are similar to other ABET-accredited programs which are constrained in the number of credits that can be allotted to specific English and technical communication courses.

The ECS Department at WTAMU recognizes the importance of strong technical communication skills for its students and alumni. In addition to instructional strength in civil and mechanical engineering, engineering technology, and computer science, the departmental outreach coordinator and Communications Department instructor, Rhonda Diffurth, holds a master's degree in communications from WTAMU. Civil Engineering professor Dr. Kenneth Leitch holds an MBA with an emphasis in Corporate Training which incorporates graduate-level education and business principles. In this context, the authors bring a fresh and relevant perspective to the ECS Department in regard to the need for engineering graduates to hone their technical communication skills throughout the engineering curriculum on their way to work in the globally competitive workplace of the 21st century.

Many universities have successfully dealt with the constraint of a limited number of credit hours specifically devoted to technical communication by implementing improvement to curricula, with a few examples described in the following Review section. These examples fall into two broad approaches: 1) a multi-departmental approach involving engineering programs with technical communication experts or 2) as an engineering program or engineering college only approach.

Review

Multi-Departmental Approach

The multi-departmental approach is an involved process that brings together experts from very different disciplines in order to improve technical communication skills. While more involved, the process appears to be very effective. The University of Texas at Tyler has implemented a four-year Engineering Writing Initiative (EWI) between the English and Engineering Departments to improve engineering students' technical communication competency and appreciation [4]. An interesting finding was that while students recognized the importance of technical writing skills, they frequently overrated their skills in self-assessments when their work was reviewed by experts. Qualitative and quantitative surveys allowed the researchers to adjust and improve curriculum to emphasize better technical writing skills.

The State University of New York (SUNY) at Oswego incorporated technical communications skills across the curriculum of a new electrical and computer engineering (ECE) program[5]. Experts in communications, English, arts, and information science were consulted to implement efficient and innovative ways of instruction in technical communications across the new ECE program curriculum.

Even more modest approaches to improved technical writing skills of engineering students have been utilized with measurable improvements. The United States Coast Guard Academy (USCGA) developed an engineering technical style writing guide in conjunction with the university writing center[6]. Similarly, Embry-Riddle Aeronautical University developed a style guide in conjunction with humanities and communications faculty[7]. The University of Maine has developed a partnership between the Civil Engineering Department and the English Department to improve the technical laboratory writing skills of freshmen students[8]. The University of Houston[9] has developed a partnership between its writing center and a multidisciplinary engineering capstone course in order to improve oral, writing, and presentation skills.

Engineering-Only Approach

Examination of technical communication skills has also been explored on a strictly engineering departmental or college standpoint. A consortium of five well-known engineering schools[10] (Vanderbilt, Northwestern, University of Texas at Austin, Harvard, and MIT) has examined technical communication skills in multiple engineering disciplines through the VaNTH Engineering Research Center (www.vanth.org)[11], which also offers teaching modules for use by other instructors. This consortium found a gap between not only individual engineering programs but also between faculty and students in expectations and need for technical communications.

Other schools address technical communication skills in freshmen introductory and senior capstone engineering courses. For example, Marquette University[12] reports that the Mechanical Engineering department targets freshmen for improving technical communication skills. Terry et al.[9] (2004) reports that various large engineering departments such as at Virginia Tech, Georgia Tech, and the University of Texas at Austin have in-department experts on technical communications.

Scope of Current Study

Three engineering courses at WTAMU were been selected for study: ENGR 1201 (Fundamentals of Engineering), ET 2371 (Metals and Ceramics), and ENGR 1171 (Engineering Ethics). The ENGR 1201 and ET 2371 courses have a lecture and laboratory component while the ENGR 1171 course is a lecture only course. The three courses were selected due to significant written and oral communication requirements. These courses are core engineering courses for the civil, mechanical, and engineering technology programs in the Engineering and Computer Science Department (ECS) at WTAMU. An additional factor to the choice of these courses is that there is no pre-requisites for these subjects and the majority of students enrolled are freshman level.

In Fall 2010, Dr. Leitch instructed the sole sections of ENGR 1171, ET 2371, and one section of ENGR 1201 (four sections of ENGR 1201 in total, with four separate faculty members). All sections of these courses were surveyed at the beginning and end of the semester for students to self-assess their technical written and oral presentation skills. Samples of course assignments were copied for evaluation purposes. Survey findings are summarized in the Results section.

Technical communication assignments were given for all three courses. The ENGR 1171 course had twelve weekly memo assignments, nine group written homework assignments, and weekly ethical discussions in a group and class setting as a part of lecture. The ET 2371 course had four written group laboratory reports and one final group oral and written technical presentation. The ENGR 1201 course was taught with a common in-house developed lecture and laboratory manual[13]; each section had approximately ten group laboratory assignments (including a thorough final design project) requiring written reports or memos.

In addition to the assignments described above, one of the laboratory activities in the ENGR 1201 was a two-part exercise and report on the creation of a paper airplane design. This laboratory involved the documentation of the steps to create a paper airplane design in a group setting in a memo format and then sharing that design with another group. Three ENGR 1201 sections had lab groups swap the designs and attempt to construct the paper airplanes from those instructions. One ENGR 1201 section swapped its instructions with a COMM 1315 section, with each section commenting to the original group on the ease of following the instructions to build the paper airplane. The findings of this exercise are described in the Results section.

The COMM 1315 selected section was instructed by Rhonda Dittfurth. At the beginning of the semester there were thirty students enrolled in this section. Although enrollment was open to all students, seventeen of those enrolled were declared nursing majors and five were pre-engineering majors. The students followed the basic COMM 1315 curriculum and syllabus with the exception of the common airplane assignment. Although the initial assignment was begun during the class period, student groups were required to complete work outside of class. The class was surveyed at the beginning and end of the exercise for students to self-assess their technical written and oral presentation skills and group work. Emphasis was given to the students that a vital part of good communication is the skill of writing directions and/or instructions.

The airplane exercise was chosen during this initial trail period for several reasons, first and foremost being that no engineering skills are required to assemble a paper airplane or to write out instructions to assemble a specific plane. All three engineering courses selected have no engineering course pre-requisites with the majority of those enrolled being freshman engineering students. Additionally the communication class has no pre-requisites that include any technical writing requirements, so it was felt this would be a simple but constructive method way to highlight the need for these skills. For the purpose of this study the COMM 1315 section stood as a control group among the engineering sections.

Results and Discussion

Technical Communication Skills Survey

Students were surveyed in regard to their self-assessment of their technical communication skills at the beginning and end of the ENGR 1201 (Fundamentals of Engineering), ET 2371 (Metals and Ceramics), and ENGR 1171 (Engineering Ethics) courses during the Fall 2010 semester. The survey questions were essentially the same for all of the courses; a sample is given at the end of this report.

Thirteen questions were used. The first five are demographic-related characteristics of gender, age at time of survey, grade classification based on credit hours earned, course number, and degree major. The remaining eight questions addressed technical communication concepts and the students' agreement with these statements, as listed in Table 1. Five responses were possible (Strongly Agree, Agree, No Opinion, Disagree, and Strongly Disagree) which were assigned integer values from five (Strongly Agree) down to one (Strong Disagree) using a Likert scale. Students were assigned a unique code to identify individual results while preserving subject anonymity. Use of a Likert scale results in a weighted average (values between one and five) which indicate the degree to which students agree or disagree with a survey question.

Question Number	Survey Question
1	I understand which technical communication skills are needed and how they are used in a STEM (science, technology, engineering, or mathematics) career field.
2	I can compose a standard business letter.
3	I can compose a standard interoffice memorandum (memo).
4	I can create a data spreadsheet and related graph(s) for the data using a typical spreadsheet program such as Microsoft Excel ®.
5	I can compose a complete technical report including title page, cover letter, table of contents, and body of the report.
6	I understand what skills are necessary for a team to function effectively to accomplish a project or assignment.
7	I can create and give a technical presentation using notes, a whiteboard/blackboard, visual displays, and/or presentation program such as Microsoft PowerPoint ®.
8	I plan to pursue a career in a STEM (science, technology, engineering, or mathematics) field when I complete my university education.

Table 1: Technical Communication Quantitative Survey Questions

The ENGR 1201, ENGR 1171, and ET 2371 courses were all surveyed at the start and end of the Fall 2010 semester instruction period. Figures 1 and 2 show the results for the combined three courses and for ENGR 1201 by itself, respectively. The three courses together cover a wide range of students from freshman through senior standing while the ENGR 1201 course is primarily populated by incoming freshmen and transfer students. It was theorized that the ENGR 1201 students would have less exposure to technical communication instruction.

Based on the survey data when considered together, the three courses showed an improvement in student self-assessment of technical communication skills in Figure 1. Improvement was observed by the study authors throughout the semester in the student assignment submittals. In particular, the students in ENGR 1201 showed marked improvement in their confidence in using technical communication skills in Figure 2 except for questions #7 and #8. In particular in regard to question #1, understanding of the connection of technical communication skills to STEM fields increased 35% from 3.03 to 4.11. Many students were unaware of the importance of memoranda and executive summaries as shown in question #3; this value nearly doubled (+89%) from 2.31 to 4.34. Of prime importance to engineering students and graduates, the process of developing a complete, coherent engineering report

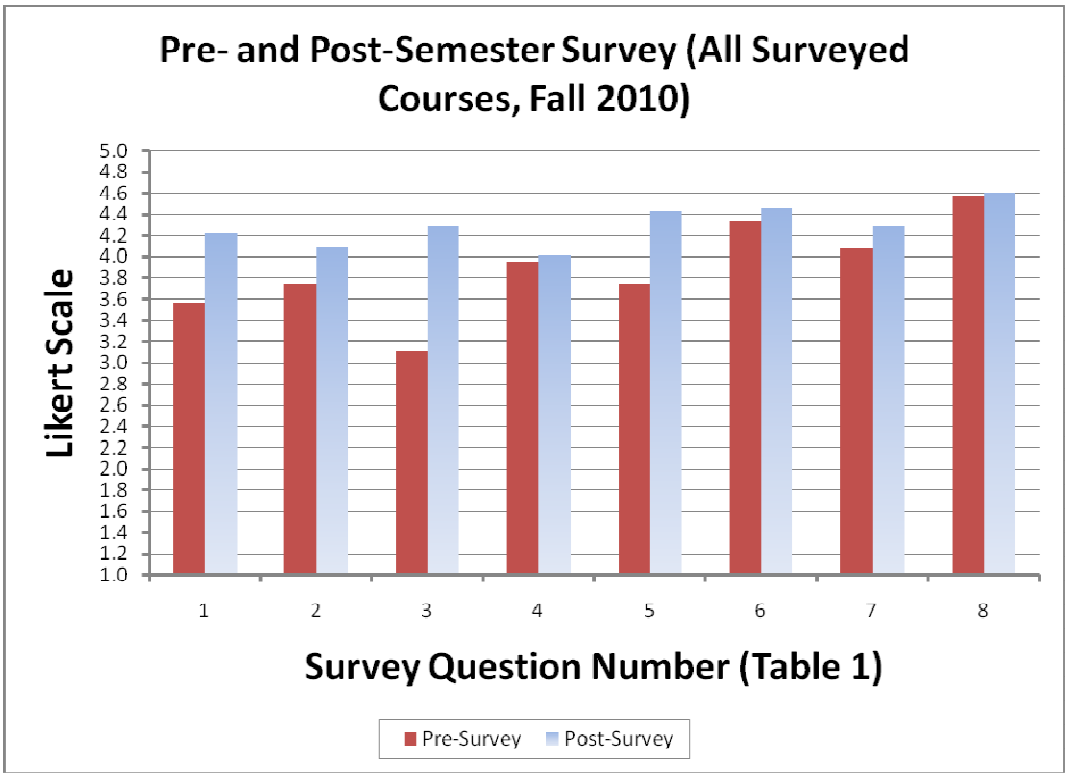

Figure 1: Pre- and Post-Semester Technical Communication Skills Surveys (ENGR 1201, ENGR 1171, and ET 2371 Courses)

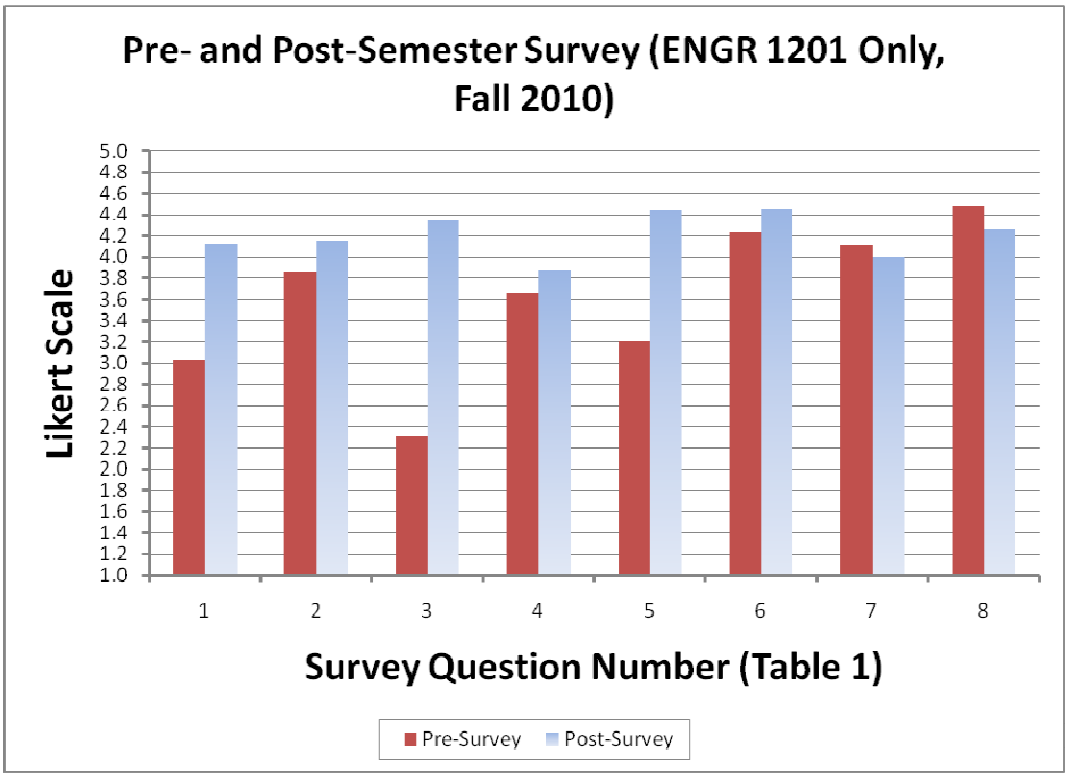

Figure 2: Pre- and Post-Semester Technical Communication Skills Surveys (ENGR 1201Course Only)

(question #5) increased by 39% from 3.21 to 4.45. Student confidence was decreased in oral presentations as evidenced by question 7, a skill that will be addressed when this cohort of students enrolls in the COMM 1315 course. Question #8 showed a decrease in the number of students that thought they would continue study in STEM fields. Since the ENGR 1201 course is designed as an overview course of engineering study, it is logical that some students would determine at the end of the semester that they may wish to pursue studies in non-STEM fields as a part of the self-discovery process that happens to many students during their first year of study in college.

Example Technical Communication Assignment: Airplane Instruction Laboratory Exercise

As part of the ENGR 1201 course (all four class sections) and for one COMM 1315 section, students were asked to document the steps to create a paper airplane design of their choice from a single standard sheet of paper so that another group could successfully construct that design *without* assistance. What started as a fun exercise for students became a realization that writing instructions is actually quite difficult. Students were encouraged to keep the documentation as brief and yet as descriptive as possible. Students worked as part of teams of three to four students which emphasized the team nature of STEM professionals to solve problems.

One section of ENGR 1201 (31 students survey respondents) and one section of COMM 1315 (28 students survey respondents) were selected to swap paper airplane designs. Students were surveyed before the start of the activity using questions #1 through #6. The post-survey used the same questions plus two additional questions relating to group dynamics. The survey questions are given in Table 2. The results were compiled in Figure 3, with results for ENGR 1201 and COMM 1315 kept separate for comparison purposes.

Question Number	Survey Question
1	I am able to follow written instructions, such as those included for the assembly or use of a product.
2	I am able to create a written detailed set of instructions that another person or group of people can successfully follow *without my guidance*.
3	I am able to collaborate with a group of people to complete a project or assignment.
4	In a group setting I usually am the leader of the group.
5	I take the initiative to perform the task(s) that I am assigned within the group.
6	I am able to communicate my thoughts (written, graphically, and/or verbally) within the group in order to complete a project or assignment.
7	My group was able to follow the instructions written by another group in order to successfully recreate that group's paper airplane design.
8	My group worked well as a unit, able to delegate tasks and communicate well.

Table 2: Airplane Instruction Laboratory Exercise Quantitative Survey Questions

For question #1, both the ENGR 1201 and COMM 1315 students note a decrease in their confidence in following written instructions in regard to the activity. Of note in the results is that the questions #2 and #7 both fall below 4.0. Question #2 discusses the ability of the group to create its set of instructions with #7 relates to the group's ability to follow another group's set of instructions. Many students remarked that while creating a paper airplane is very easy, it is difficult to document this for another group to follow. Likewise, many groups were frustrated by the instructions furnished by another group, with several unable to complete the design as intended. Students were shown prototypes of the design at the conclusion of the exercise, with many groups surprised the design looked different from what they constructed. Several students remarked that they had been frustrated by instructions at some point in their own lives, but now had a profound appreciation for the instructions that are written by someone that they may never meet in order to assemble a product.

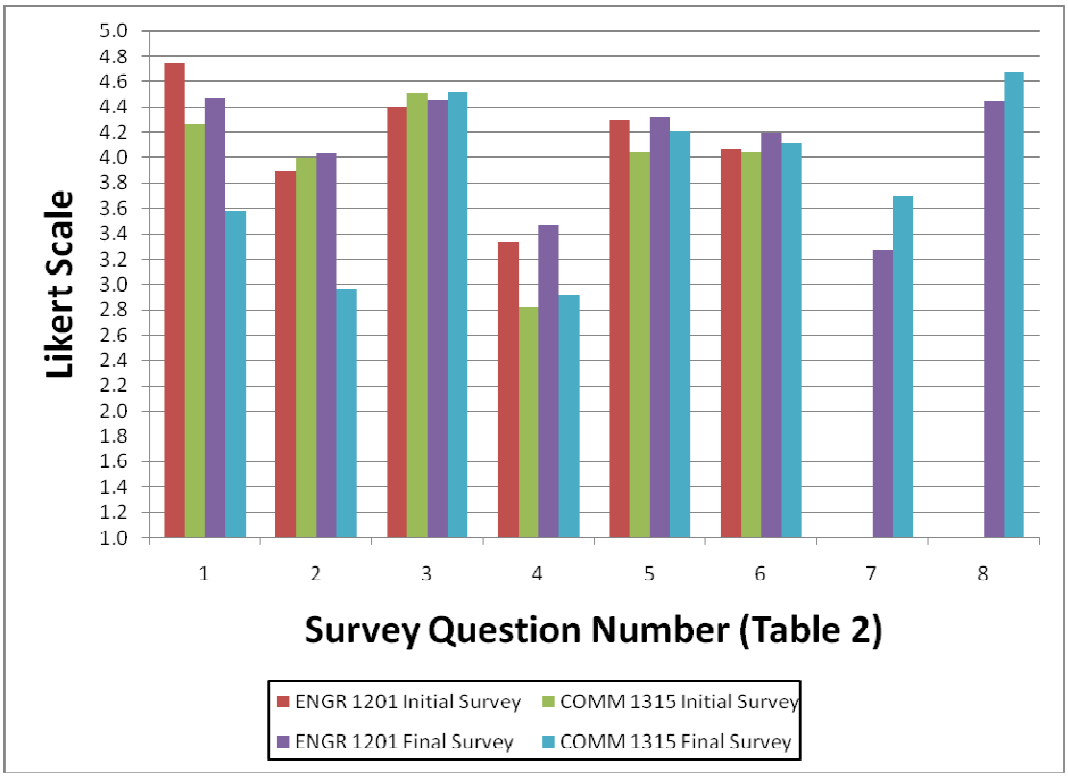

Figure 3: Airplane Instruction Laboratory Exercise Quantitative Survey Results

Conclusions

Student and alumni surveys as well as feedback from corporate and government entities indicate a need for improvement of technical communication skills to meet the challenges of an ever-changing global marketplace. In this context, the Engineering and Computer Science (ECS) Department at West Texas University working in conjunction with the Communications Department are implementing incremental changes to curriculum that improve technical communication skills without resorting to major disruption to coursework and credit hours required to complete a bachelor's degree. The scope of the current study indicates the incorporation of technical communication skills into engineering curriculum can be done within current coursework, beginning at the freshman introductory level. Student self-assessment shows are greater awareness of technical communication skills that are required in STEM fields and that practice within engineering assignments is vital for their understanding of effective communication as students and in the workplace.

The use of the airplane project served as a very productive learning tool for the students self assessment of their technical writing skills. It also provided the added benefit of group work experience for the students. The scope of the current study indicates the incorporation of technical communication skills into engineering curriculum can be done within current coursework, beginning at the freshman introductory level. Student self-assessment shows are greater awareness of technical communication skills that are required in STEM fields and that practice within engineering assignments is vital for their understanding of effective communication as students and in the workplace.

The department plans to track this cohort of students through their undergraduate education as well as to survey new students in the future. The authors plan to assist other ECS faculty to implement improvements in technical communication skills in department course offerings by means of improving the departmental writing style guide, standardizing technical communication assessment, adding more oral presentations, and documenting student work in a portfolio for program assessment as well as for job-seeking purposes.

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