USE OF COMMUNICATION ACTIVITIES THROUGHOUT THE ENGINEERING CURRICULUM TO PRODUCE WELL-ROUNDED ENGINEERS

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1. INTRODUCTION

The traditional stereotype is that engineers have poor communication skills; however, studies have shown that communication skills are extremely important for engineers. Moreover, the Accreditation Board for Engineering and Technology (ABET) and the industrial advisory board at Indiana University-Purdue University Fort Wayne (IPFW) have identified effective communication skills as being highly desirable characteristics for engineering graduates. Thus, an important question is how to improve the communication skills of engineering students—through additional communication coursework or through additional communication activities within technical courses?

Students in typical engineering programs take an introductory composition course, and possibly a speech or technical writing class. In many engineering programs, a second writing course is not required. In such cases, writing activities embedded within the engineering curriculum are more important.

Different approaches have been devised to integrate communication activities within the curriculum (Williams, 2000). At Georgia Tech, formal programs exist in the various schools of engineering to develop students' communication skills (Bourgeois, *et al*., 2005). These formal programs that are administered at the school level ensure a consistent, focused approach. Innovative strategies to introduce communication activities in first-year engineering courses with large enrollments (Manion and Adams, 2005) and in senior-level required engineering courses (Lui, 2005) have also been reported. One strategy that has been shown to be successful is to link a communication course to an engineering course (Lengsfeld, 2005).

Despite many different approaches presented in the literature, most engineering programs have similar communication activities within the engineering curriculum. Students are usually required to write short design project memos in technical courses and reports in laboratory courses. As part of the senior design course, students typically work as a team to produce a written report and deliver an oral presentation. This typical approach to develop an engineering student's communication skills can be strengthened with additional activities.

This paper presents a range of additional, somewhat unique communication activities used by the author in various courses throughout the engineering curriculum. For example, at the first-year level, students create a CAD drawing as part of a team and then present key aspects of their work to the class. In junior- and senior-level courses, students are often required to report on a new technology or to read and summarize an article in a current magazine or journal. Students in the capstone design course participate in "debates" on situations that involve engineering ethics.

In addition to simply improving the communication skills of the students, the activities described in this paper have additional benefits. ABET requires that engineering programs must demonstrate that their graduates have

a. an ability to apply knowledge of mathematics, science, and engineering
b. an ability to design and conduct experiments, as well as to analyze and interpret data
c. an ability to design a system, component, or process to meet desired needs
d. an ability to function on multi-disciplinary teams
e. an ability to identify, formulate, and solve engineering problems
f. an understanding of professional and ethical responsibility
g. an ability to communicate effectively
h. the broad education necessary to understand the impact of engineering solutions in a global and societal context
i. a recognition of the need for, and an ability to engage in life-long learning
j. a knowledge of contemporary issues
k. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Many opportunities exist throughout the engineering curriculum to develop some of the ABET outcomes, such as (a) and (e)—these outcomes are developed in almost every engineering course. However, few opportunities exist in traditional courses to develop some of the desired ABET outcomes, such as (h), (i), and (j). The communication activities described below are useful to make students aware of important concepts such as teamwork, information literacy, contemporary issues, impact of engineering solutions on society, and engineering ethics.

2. FIRST-YEAR ACTIVITIES

One of the first courses that IPFW engineering students take is ENGR 120-*Graphical Communication and Spatial Analysis.* The main purpose of this course is to introduce the students to a CAD software package and drafting conventions; however, a secondary purpose is to introduce students to important communication activities—the memo and oral presentation. These activities are introduced through two projects.

In the first project, students are required to measure and draw pieces of hardware as shown in Figure 1. Then, the students are required to communicate answers to simple questions in a brief memo.

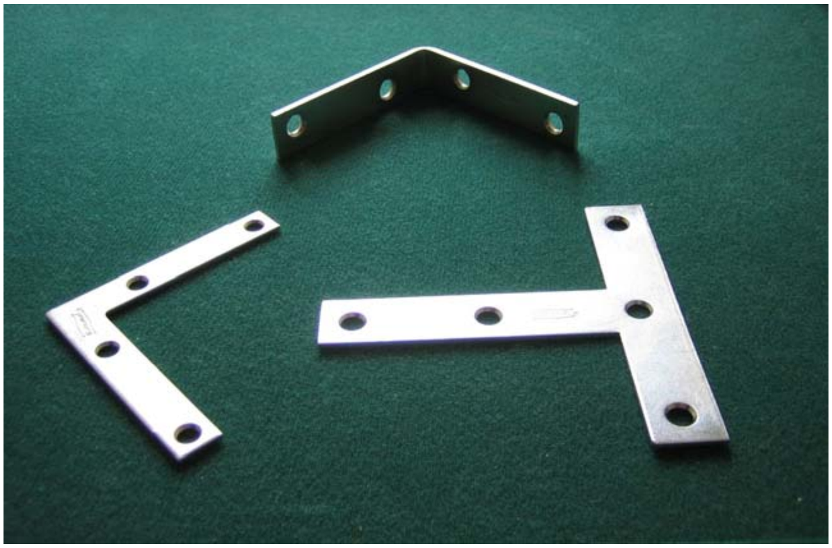

Figure 1. Sample pieces of hardware.

Typical question that the student must answer are:

> How many pieces of the part could you obtain from a 1-ft by 3-ft piece of sheet metal? How would you lay out the parts? How much waste would result? How much does the waste weigh?

Students are given the assignment via memo and instructed to follow a similar format when presenting their results. The focus in this first-year class is on the memo format and the inclusion of a figure in the text. The questions are structured so that there are no unique solutions; students must be creative and specific when describing how they would lay out the parts.

In the second project of the semester, students are required to work with a classmate to draw an object of their choosing. The objects that students select to draw are varied: car wheels, bookcases, tools, inhaler, model rockets, cell phones, etc. In most cases, students create a solid model of the object, as well as dimensioned drawings.

As a team, students are required to give a brief, five-minute presentation to explain some key aspects of their chosen objects or drawings. In the prior class, students are taught the basics of PowerPoint and the structure of an oral presentation. Students are instructed how to prepare a good title slide and a presentation outline slide. Next, students are instructed to make up several additional slides to answer various questions about their part or drawing, e.g. How much does the part cost?, How does the part fail?, How much does the part cost? Each student presentation receives a peer grade and a faculty grade that are averaged.

A survey (see Appendix A) was distributed at the end of the fall-semester 2005 course to assess the second project. Seventy-six student responses were recorded. On average, the drawing for the final project was divided fairly evenly among teammates, i.e., students self-reported (Question 1) that they did 53% of the drawing. However, eight students claimed that they did 100% of the drawing in their projects, and seven students admitted that they did 0%. In general, student response to the project was positive. Students felt that this project would help them in the future when working on teams (Question 5—2.9/4.0) and delivering presentations (Question 7—2.9/4.0).

These first-year activities provide the students with the basic format to follow and the basic tools to use when creating an oral presentation and writing a memo.

3. SECOND AND THIRD YEAR ACTIVITIES

Required courses, such as ME 200—Thermodynamics I, ME 301—Thermodynamics II, and ME 318—Fluid Mechanics, have brief design projects associated with them. Students communicate the results of their projects with a brief memo. The required format of the memo is communicated to the students by the sample memo that I give to them.

In addition to conventional activities, such as these design project memos, I also require students in Thermodynamics II to investigate current issues related to thermodynamics and to report on these issues. An excerpt of the problem statement is provided:

Engineers must be aware that their designs impact society and the world around them. Thus, engineers must have an understanding of professional and ethical responsibility and knowledge of contemporary issues. In order to properly place their work in a larger context, engineers must develop recognition of the need for, and an ability to engage in life-long learning.

In your current design project, you are working with a refrigerant. Refrigerants have received attention recently due, in part, to environmental concerns. You are to think about your design and discuss one of the following two statements:

1. The primary intent of the Montreal Protocols is to reduce and then eliminate the use of compounds believed to deplete the earth's ozone. Discuss some of the main features of the Montreal Protocols, list some of the compounds targeted, and describe the progress made to date.

2. Chlorofluorocarbon (CFC) refrigerants, such as R-12, were introduced, in part, because they are less toxic than ammonia which once was widely used as a refrigerant. But in recent years, CFCs largely have been phased out due to concerns about depletion of the earth's ozone. As a result, there has been a renewed interest in ammonia as a refrigerant, as well as an increased interest in natural refrigerants, such as propane. Discuss the advantages and disadvantages of ammonia and natural refrigerants. Consider safety issues and any special design requirements that these refrigerants impose on refrigeration system components.

As a starting point, you might refer to articles (Gopalnarayanan, 1998; Hwang, 1998) which can be found in the American Society of Mechanical Engineering's webpage.

This assignment gives the students the opportunity to investigate and become aware of additional aspects of their design projects and it gives me the opportunity to discuss the role of professional societies, life-long learning, and the impact of engineering solutions on society.

4. LABORATORY ACTIVITIES

In many ways, ME 322—Heat Transfer Laboratory is similar to many other labs. Students perform six experiments and two numerical experiments. For each experiment students are required to communicate their results in a memo. In the first lecture, students are given the memo format to be used in this course. To facilitate grading, I currently make use of a rubric. A sample of the rubric is provided in Appendix B. Use of this rubric has reduced time spent on grading and helps to insure consistency.

In addition to these traditional laboratory reports, students are required to give two oral presentations to the class. In the first presentation, students are required to research a common heat transfer measurement device, such as a thermocouple, and report various characteristics of the device to the rest of the class. Students are required to utilize at least one piece of reference material that is not on-line. Students are also asked to assess their on-line references for accuracy and objectivity. In the second presentation, student groups report on the results of one of the experiments.

5. TECHNICAL ELECTIVES

In a technical elective, ME 424—Design and Optimization of Thermal Systems, students are required to read an article (Engle, 2004) from an on-line publication such as *Distributed Energy*. (http://www.distributedenergy.com) This article discusses six state-of-the-art trigeneration facilities. Students are asked to summarize the article and compare the relevant features of each of the facilities in a table. This exercise not only gives the students an opportunity to practice their communication skills, but also to learn about recent technological advances. In class, students are asked to assess the information in the article for technical accuracy and objectivity. This discussion presents an opportunity to introduce the concept of information literacy and how engineers assess information. Students are directed to the IPFW library webpage and the *Integrated Information Foraging Environment* for a more detailed discussion of information literacy.

In a technical elective, ME 421—Heating and Air-Conditioning I, students are given an assignment to investigate a current HVAC technology. The assignment requires a ten page paper and a 15-minute presentation to the class. Students are required to use both on-line and print sources to obtain information. Students learn from both their research and the presentations of other students.

7. SENIOR DESIGN

Within the Senior Design course, different faculty lecture over various topics. I am responsible for presenting material on Engineering Ethics in two, one-hour class periods. In the first hour, I lecture over various ethical theories and the codes of ethics of various professional societies.

At the end of class, students are assigned a situation to investigate and make a determination as to whether or not the engineers acted in an ethical manner. Examples of situations that students have been asked to investigate include:

1. On January 28, 1986 the Space Shuttle Challenger was launched. From an ethics point of view were the actions of the engineers leading up to the launch proper?

2. Deregulation of the utility industry has contributed to recent blackouts. Has the unethical behavior of engineers contributed to the problem?

3. One consequence of nuclear energy is the production of long-lasting waste. One plan to dispose of the waste is to store it in the Nevada desert. From an engineering ethics viewpoint is that plan reasonable?

Students are instructed to analyze the assigned situation with regard to the National Society of Professional Engineers Code of Ethics and to map aspects of the situation to specific sections in the code. In the following class, students participate in a "debate"—one group of students explains how the engineers acted ethically, while the other group explains how the engineers did not act ethically. Students are instructed to base their interpretation on the NSPE code.

8. CLOSING REMARKS

Communication skills are extremely important for engineering students. Many opportunities exist to integrate communication activities throughout the engineering curriculum. In addition to helping students develop and sharpen their communication skills, the activities presented in this paper allow for opportunities to students to become aware of the importance of teamwork, life-long learning, engineering solutions in a global context, and information literacy.

Although the activities presented in this paper have the potential to provide a significant impact to a student's education, several notes of caution should be pointed out:

- The communication activities described in the paper take time—time for the students to complete and time for the instructor to grade. Sufficient time must be given for the student to complete the work. Moreover, grading some of these activities can be extremely time-consuming and sometimes appear arbitrary to the students. The use of well-structured rubrics has the potential to eliminate some of the problems with grading.

- Instructor attitude concerning the activities is important. Students can sense if the activity is important to the instructor, and if they sense that the activity is not important, they will not put forth effort—they will simply go through the motions.

- If more time were available, I would not introduce more activities. I would increase the feedback given to the students. One thing that I find very difficult to do is find ways to ensure that students understand and know how to correct their errors.

- The activities described in this paper have not been thoroughly assessed. However, student satisfaction with the activities is high. In my opinion, most of the student's performance on these activities is very good.

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Appendix A

Outcome evaluation: ENGR 120 Semester: Fall 2005

Please list your team number: ________________

In this course there were 9 outcomes. Three of the outcomes were:

- Create a drawing as part of a team.
- Communicate important aspects of a drawing orally and in writing.
- Use modern computer tools for drawings, memos, and presentations.

In relation to Project 2: *Creating a drawing with a partner*, please answer the following:

1. How much of the drawing did you do on the final project?

   0 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

2. How much work did you do on the final project?

   0 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

3. This project helped me to better understand the issues of working with a partner/team.

agree strongly	agree	neutral	disagree	disagree strongly
4	3	2	1	0

4. This project helped me learn how to communicate with a partner/teammate.

agree strongly	agree	neutral	disagree	disagree strongly
4	3	2	1	0

5. This project will help me to work with a partner/team in the future.

agree strongly	agree	neutral	disagree	disagree strongly
4	3	2	1	0

6. I learned how to give better presentations.

agree strongly	agree	neutral	disagree	disagree strongly
4	3	2	1	0

7. This project will help me deliver better presentations in the future.

agree strongly	agree	neutral	disagree	disagree strongly
4	3	2	1	0

Note: This information will not affect your grade in any way.

Appendix B

ME 322 Heat Transfer Lab Grade Sheet—Sample **Name:** ______________________

	Points Possible				Points obtained
	5	**10**	**15**	**20**	
Abstract	Several grammatical errors, missing key information	Relatively complete with one or two grammatical errors	Complete, clear, and concise with no grammatical errors		
Objectives	Complete without grammatical errors				
Procedure	Relatively complete; schematic is xeroxed	Complete and free of grammatical errors; schematic is drawn			
Tables/ Figures	Appropriate tables and figures are present, but they contain errors or flaws	Properly constructed with descriptive captions and referenced in report			
Results	Results incorrect; brief, incomplete discussion with several grammatical errors	Essentially correct; discussion is brief and interpretation is flawed; with possible grammatical errors	Correct and completely described, but interpretation is weak or grammatical error	Completely described and correctly interpreted with no grammatical errors	
Conclusions	Contain a few grammatical errors and are not complete	Complete and free of grammatical errors			
Appendices	References, equipment list, and sample original data; poor sample calculations	References, equipment list, and sample original data; sample calculations are nearly correct	Plus sample calculations are clear, complete, and correct with units		
Question/ Uncertainty	Attempt to answer question and/or perform uncertainty analysis	Question answered completely and convincingly; uncertainty analysis performed correctly			
Format and Appearance	Memo format properly used and report is neat				
				Total	

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