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An Integrated Approach to Developing Technical Communication Skills in Engineering Students

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An Integrated Approach to Developing Technical Communication Skills in Engineering Students

Abstract

The Project to Integrate Technical Communication Habits (PITCH) is being implemented across seven engineering and computer science undergraduate programs. The overarching goal of PITCH is to develop written, oral and visual communication skills and professional habits in engineering students. PITCH activities begin in the very first semester and are reinforced and extended through all four years of each program. Senior design becomes the culminating experience in which students demonstrate the skills and habits acquired through PITCH courses.

Student outcomes for the project were established based on an extensive survey of employers, alumni and faculty. Communication instruments include technical memoranda, poster presentations, oral presentations, laboratory reports, proposals, and senior design reports. In addition to text elements, the use of tables and graphics also are addressed. Advice tables, annotated sample assignments and grading rubrics are being developed for each instrument to assist students in their work and facilitate consistency in instruction and assessment across multiple instructors teaching different course sections.

Within each of the seven programs, specific courses within all four years are targeted for implementation and assessment of technical communication skills. Roadmaps showing the target courses, and the instruments deployed and outcomes to be learned in each course are made available to students in each program. The different communication products are distributed across courses as appropriate, and the skills are developed at deeper and deeper levels as students progress through the years.

Two critical and distinctive features of the project are that technical communication skills are fully integrated into the content of regular engineering courses and are taught by regular engineering faculty. These features will make PITCH sustainable over the longer term. In the first year of the project, 16 engineering and computer science faculty were trained by an external consultant through summer workshops to deliver and assess the technical communication instruments in their courses. All PITCH assignments submitted by students are being archived and will be used in a longitudinal assessment of the effectiveness of the project as the first cohort of students who started in fall 2012 near graduation.

PITCH is funded by the Davis Educational Foundation and is designed to be self-sustaining after the three-year period of grant support.

This paper describes the approach used, lists the PITCH student outcomes, and provides examples of the PITCH roadmaps, as well as the resources provided to students and faculty.

Introduction

To be competitive in today’s economy, engineers need to have strong technical communication skills. However, many colleges are struggling to provide this extra training effectively and still meet the ever-growing demands of an engineering curriculum. At the University of New Haven an $185,500, three-year grant from the Davis Educational Foundation is funding a new program to provide students with strong technical communication skills.

Through the grant the university is establishing a PITCH (Project to Integrate Technical Communication Habits) initiative that began in fall 2012 and follows students through all four years of college in seven ABET accredited engineering and computer science programs.

The goal of this project is to emphasize professional communication skills and professional habits across engineering disciplines. At many engineering colleges, a common approach to teaching technical communication skills has been to require students to take separate courses in that area. That approach has proven expensive and not especially effective since it is divorced from engineering content and is too often a one-time experience.[3, 7] Based on earlier models developed at Michigan State University and The University of Maine, the communication skills training at the University of New Haven (UNH) is being woven into regular engineering courses. PITCH contains a number of features that refine and extend that model:[1-4]

- PITCH faculty developed a comprehensive set of learning outcomes based on surveys of both UNH engineering faculty and engineering alumni and employers.
- Communication assignments are based on engineering content and designed to have students achieve stated outcomes in a developmental progression throughout their programs.
- PITCH leverages technology to provide students and faculty with supporting resources.

Engineering faculty engaged with PITCH have participated in ongoing training to develop and evaluate effective technical communication assignments. That step, along with using a consultant, avoids the need to hire instructors from outside engineering and will help make PITCH sustainable and cost-effective.

To help faculty incorporate teaching these skills into their classes, the consultant has trained 16 engineering professors and a staff member at intensive three-day workshops during the summers of 2012 and 2013. Students are learning the new skills in both core and advanced classes. Each student will have evidence of achievement in communication in his or her four-year portfolio. A random sample of those portfolios will be reviewed annually to ensure that the skills were actually learned and to identify areas needing further improvement.

Establishing Need and Learning Outcomes

In order to determine the need for technical communication skills in engineering graduates and to establish the learning outcomes a survey was administered to alumni, faculty and employers who often hire UNH engineering and computer science graduates. The survey was

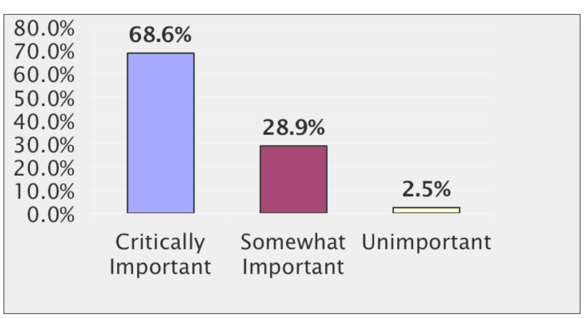

Figure 1: Response to question: “Within my organization, to what degree are technical communications skills considered in hiring and promotion decisions?” $N = 121$.

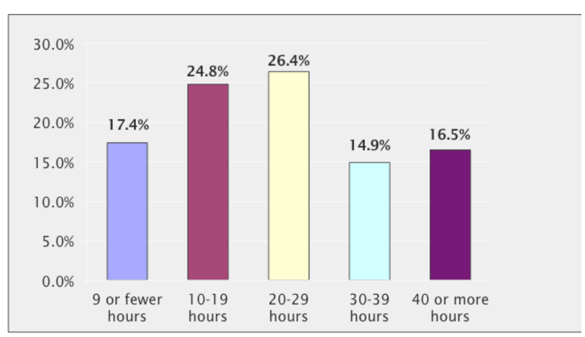

Figure 2: Response to question: “In a typical work week, I spend about the following number of hours performing technical communication tasks (writing, reading, speaking or listening).” $N = 121$.

designed to determine which technical communication attributes, products and professional behaviors are essential. We received 124 responses from alumni and employers and 32 responses from faculty. The results of the survey (available at http://www.newhaven.edu/482669.pdf) reinforced the notion that alumni and employers really do desire technical communication skills from engineering graduates. They desire such skills both in terms of the ability to produce communication products and to exhibit professional communication habits. Responses to two particular questions are shown in Figures 1 and 2. More than 68% of those surveyed indicated that skill in technical communication played a "critical" role in hiring and promotion decisions, while another 29% marked those skills as "some- what important." Furthermore, over 80% of those responding indicated that in their jobs they spend between 11 and 40 hours a week or more on the communication tasks: writing, reading, speaking and listening. The results of the survey indicated that alumni and employers consider technical communication skills to be critical attributes in engineering graduates. These survey results mirror those from similar surveys conducted at Michigan State University and The University of Maine.[1-3]

During the 2012-2013 academic year the faculty considered the results of the survey to develop the PITCH outcomes that students should demonstrate at the time of graduation. Note that these outcomes (listed in Table 1 below) focus on both products and habits.

Table 1. PITCH Outcomes.

1. Technical Communication Products	*2. Technical Communication Habits*
a) Plan, design and produce letters, technical memoranda, short reports, formal e-mails, reports documenting experimental or simulation methods and results, and formal reports (proposals, analyses, progress reports, senior design documents). b) Plan, prepare and deliver oral presentations and poster displays.	a) Use appropriate format and content; b) Exhibit clear, precise and logical expression; c) Demonstrate appropriate organization, level of detail, style and tone for a given audience, situation and purpose; d) Demonstrate appropriate syntax and correct usage of grammar and spelling; e) Highlight or identify critical information; f) Present, discuss, and summarize data accurately and persuasively; g) Write thoughtful and persuasive conclusions and recommendations; h) Work effectively to produce multi-author communications.

PITCH Roadmaps

A critical feature of PITCH was the yearlong effort by faculty to develop a "roadmap" for integrating appropriate PITCH outcomes at both course and program levels throughout the college. In order to ensure that the PITCH outcomes would be met, technical communication products (i.e., letters, technical memoranda, short reports, formal e-mails, reports documenting experimental or simulation methods and results, and formal reports) and specific technical communication habits were distributed amongst several courses in each of the seven ABET-accredited engineering programs. These distributions were planned to introduce skills and habits in introductory courses. Those skills and habits would then be reinforced and extended to new levels as students moved into more advanced courses in their programs and encountered deeper engineering content and more complex communication situations.

The Tagliatela College of Engineering offers a core interdisciplinary curriculum in the first year-and-a-half that is taken by most engineering students. These courses provide an ideal structure for consistent introduction of the PITCH outcomes in assignments. Technical communication products such as letters, technical memoranda, short reports, and formal e-mails were implemented in four courses that are a part of this curriculum. Reports documenting experimental or simulation methods and results were implemented in second or third year disciplinary courses and formal reports (proposals, analyses, progress reports, and design documents) were implemented in senior design courses. So a path emerged for tracing the development of PITCH outcomes from first year through graduation. Each program developed its own path, or roadmap. These roadmaps were exhaustively reviewed and refined until faculty agreed on courses, outcomes and assignments that would be included at each level in ways that made sense for each program's curriculum. The published roadmaps may be viewed at http://www.newhaven.edu/8/PITCH/roadmaps/. Students receive the roadmaps at the beginning of their first semester so that they can see how they will experience PITCH throughout their program.

Faculty Participation and Training

Most engineering faculty delivering PITCH courses were not previously trained to deliver instruction related to the development of technical communication skills in students or to effectively assess and provide feedback on technical communication products. The external consultant conducted three-day workshops during the summers of 2012 and 2013 to train faculty to accomplish these tasks. Items covered in these workshops included inclusion of PITCH outcomes in course syllabi, developing effective technical communication assignments, and development of rubrics to facilitate consistent evaluation of technical communication products.

In addition to the summer workshops, the external consultant visited the university three to five times each year to work with individual faculty and conduct additional short workshops. The short workshops focused on clarity, organization, precision and economy in technical communication.[5] He also interacted with individual faculty remotely to provide continuous assistance in refining assignments and developing course resources such as rubrics, advice tables and models.

To incentivize faculty participation in PITCH they were offered modest stipends to participate in the summer workshops and compensated for developing and evaluating PITCH assignments. By the end of the second year 16 engineering and computer science faculty have been trained to deliver PITCH courses. This number represents 53% of all engineering and computer science faculty. In addition, the third faculty training workshop will be directed by one of the engineering faculty members from the first training cohort. The sequence will develop a core of faculty experienced in PITCH activities who can continue to provide training and sustain PITCH leadership after the initial external funding disappears.

Assignments and Resources in PITCH Courses

While communication assignments existed in the Tagliatela College of Engineering courses prior to PITCH, there has been a substantial effort to revise these assignments to simulate the types of situations that engineers would encounter in professional settings. The fact that a number of faculty associated with PITCH have extensive industry experience has facilitated these revisions. In addition, incorporating a defined set of learning outcomes for assignments has brought consistency and appropriate sequencing across courses. PITCH resources for the courses described below are available at http://www.newhaven.edu/8/PITCH/482611/.

Introduction to Engineering

The Introduction to Engineering course taken by all engineering and computer science students during the first semester of the freshman year deploys technical memoranda. General guidelines on writing technical memos are posted on BlackBoard® and discussed in class prior to each writing assignment. Although only the final two project memos are graded as PITCH assignments, students are given other opportunities earlier in the semester to begin developing their technical writing skills through feedback provided by the instructors. The Lifeboat Exercise is an individual assignment and the Structural Systems Project requires that results are reported using a memo written by each team. Both of these assignments are written in the technical memo format so that students begin to understand the difference between the direct and context driven writing style required when addressing the reader's questions/concerns in a technical memo compared with a research paper. The PITCH outcomes (see Table 1) addressed in this course are 1a, 2b, 2c and 2d.

Feedback from the initial two non-graded PITCH assignments in fall 2013 was used to develop a general advice table, outlining common mistakes made by students. Examples are provided to illustrate these mistakes and how to correct them. The usefulness of the advice table is limited if it does not reflect the mistakes made by the students taking the course. Thus, it is expected that the table will change and expand with subsequent offerings of the course. Some faculty voiced concern that students may not read a multipage table. Thus, in addition, a one-page advice table/grading rubric was developed for each of the graded PITCH assignments. Details of each dimension of the memo are outlined in this table and assigned weights for each dimension are given. The purpose of the advice tables[6] is to provide guidelines as to the structure and content of the specific memo in a concise format.

A typical assignment sheet from before and after PITCH, and advice table and rubric developed as part of PITCH are provided in the appendix.

Introduction to Modeling of Engineering Systems

All engineering students typically take the Introduction to Modeling of Engineering Systems course in the first semester of the sophomore year. This course has two PITCH assignments emphasizing data presentation. Students are required submit a memo discussing their work which includes tables and plots of their results. The PITCH outcomes (see Table 1) addressed in this course are 1a, 2a and 2f.

The first assignment required students to develop a model to predict voltage for a fuel cell as a function of current draw. The data provided showed a highly non-linear character to the V-I relationship. However, a linear model was needed. Students are asked to partition the data into three regions and provide a linear model for each region. In their memo they must discuss how they chose the cut-off points for the regions as well as the possible error in using the model. Data displays are required to augment the text discussion. In addition to the memo, they are asked to append pages from their spreadsheet, which is also evaluated on the basis of organization and communication effectiveness. The audience for the memo is a technical reader.

The second project requires students to specify a pump and pipe system for transferring water from a reservoir to an elevated storage tank. An optimization is required to determine the pipe diameter that would yield a certain incremental return on investment. Again, a technical memo is required to report results and justify choices made. The memo is to include plots and data tables. The audience for the memo is a person with a business background.

Materials provided to the students include a memo about writing memos, a guideline for plots, and a guideline for data tables.

Applied Engineering Statistics

Many engineering and computer science students take the Applied Engineering Statistics course in their third year, which is required in some programs and a popular elective in others. Of the many assignments in this course, two that focus on presenting, discussing and summarizing data accurately, and persuasively are designated as PITCH assignments. The assignments require planning, designing and producing technical memos. Each assignment consists of an assignment sheet and an accompanying rubric. The assignment sheets capture: (1) the goals of the assignment, (2) assignment tasks, and (3) a checklist for completing these tasks. This course deepens the PITCH outcomes (see Table 1) 1a, 2a and 2f addressed in the Methods of Engineering Analysis course.

The first assignment is cast in the form of a technical memo to provide students a reinforced example the memo format. The second assignment did not include a sample memo. However, the design of tasks in the second assignment required students to initiate a memo. The objective for using a slightly different structure in the second assignment was to assess students' retained knowledge of writing technical memos.

Both assignments include a grading rubric. Each category in the rubric has grade percentage allocation and requirements specifications. These rubrics were developed to guide students in producing a well-written memo, one that has necessary information in an organized and effective manner.

Both grading of student papers and the feedback provided are based on the rubrics. Each comment is linked to a grading criterion in the rubric to show students the areas in which they are strong and those that they need to improve. Summary comments to capture the overall performance of the assignment are also included. Furthermore, a sample memo for each assignment is provided as a learning resource.

Disciplinary Courses

Reports documenting experimental or simulation methods and results in disciplinary courses will be enhanced to include PITCH outcomes in spring 2014. Guidelines for such reports, advice tables, rubrics and annotated sample reports are under development and will be posted on the PITCH website in summer 2014.

One specific disciplinary course in which some PITCH assignments were implemented in spring 2013 was the System Engineering Design Process course. The four writing assignments relate to creating important communications documents and design diagrams during an engineering design process: a Statement of Work (SOW), a Requirements Definition Document (RDD), System Engineering Design Diagrams, and a System Description Document (SDD). The System Engineering Design Diagram assignment was fully implemented during the spring of 2013 and teaching materials and an assignment statement for creating a Statement of Work were also developed. The remaining assignments will be added during the next course offering in spring 2014. The PITCH outcomes addressed in the four assignments are as follows:

- Statement of Work: 1a, 2a, 2b, 2c and 2d
- Requirements Definition Document: 1a, 2a, 2b, 2c, 2d and 2e
- System Engineering Design Diagram: 1a, 2a, 2b, 2c, 2d and 2e
- System Description Document: 1a, 2a, 2b, 2c, 2d, 2e, 2f, 2g, 2h

Some of the work involved in creating these new PITCH assignments included developing new assignment statements that clearly define PITCH and technical content requirements. Other work included developing fair and effective ways to assess each outcome, developing new teaching materials, and developing new advice tables. For the System Engineering Design Diagram assignment, a new assignment statement, grading rubric, and advice tables were created for students. Teaching materials were also updated. For the Statement of Work assignment, new teaching materials and a new assignment statement were created.

Results from student feedback indicate that students appreciate more clearly written and developed assignment statements that include clear requirements for writing outcomes and technical content. Students also liked the advice tables and examples provided that indicated both good and poor communication habits.

Senior Design Courses

PITCH activities in the Tagliatela College of Engineering culminate with the senior design experience. The series of technical communication activities in senior design courses follows the general pattern described here with some variation between the various disciplines. These PITCH activities are being or have been developed with input from the six engineering programs and the Computer Science program offered by the college. Since the design activities within the college vary from system design to the design of an electrical or mechanical device to the development of software, the PITCH activities need to allow for flexibility in their preparation. All of the PITCH outcomes (see Table 1) are addressed in all senior design courses.

The first PITCH activity involves the preparation of an engineering proposal for the design project. Each student team gains experience in the preparation of a proposal by providing such a document to the project sponsor (the “client”). Guidelines for the preparation of the design proposal have been developed with input from all of the programs in the Tagliatela College of Engineering and are available on the PITCH website. Since this is a learning experience for the students, the student teams have already received their project assignment before preparing the proposal. The proposal is typically prepared near the end of the first semester of the design sequence and submitted to the course instructor. The course instructor, with input from the sponsor, may request that the project team revise their proposal before proceeding with their project. A grading rubric and advice table are currently being developed for the design proposal.

The second PITCH activity associated with the senior design experience is a poster presentation of the project. The poster is presented at the end of the second semester as part of the Senior Design Expo conducted by the college. While this poster presentation has been a part of the design activities for several years, the guidelines for such posters have been lax. Formal guidelines for the preparation of the design posters with an accompanying grading rubric and advice table are currently being developed.

The third PITCH activity associated with the senior design experience is the final design report. The final design report provides a complete record of the design effort along with a description of the design and recommendations. In the past, the relatively lax guidelines provided for the final design report have varied greatly from program to program resulting in wide variability in the reports. Formal guidelines for the preparation of the final design reports are being prepared with input from all engineering programs and the Computer Science program. These guidelines will allow greater consistency in the final work product. A grading rubric and advice table will be developed to accompany the guidelines and assist students in preparing the final design report. In addition, PITCH sponsors cash awards for the outstanding senior design reports as nominated by faculty and judged by members of the Tagliatela College of Engineering Professional Advisory Board.

Assessment of PITCH

All graded PITCH assignments for all students starting with the freshman class of fall 2012 are being electronically archived so that a longitudinal assessment of the effectiveness of PITCH can be assessed when the freshman 2012 class graduates in 2016. This assessment will evaluate how effective PITCH is in developing technical communication skills in engineering and computer science students. Prior to 2016, partial assessments will be made on the effectiveness of PITCH in the first few years of each program. In addition to annual reviews of student portfolios, each faculty member teaching a PITCH course completes a self-assessment of their experience in the prior year. These self-assessments identify areas of strength and weakness and include plans for improvements in subsequent course offerings. Once the initial cohort has graduated, the initial survey of faculty, alumni and employers of Tagliatela College of Engineering graduates will be repeated. Since the college is only in the third year of developing and implementing PITCH, it is difficult to make any comprehensive assessment at this time.

Some instructors have made preliminary and somewhat subjective evaluations of improvement in student performance within a single course from one PITCH assignment to another. The general consensus is that the more systematic approaches used in PITCH, including the availability of advice tables, rubrics and sample assignments increases student performance in technical communication from one PITCH assignment to another within a single course. Annotated sample assignments will be developed over the next year for all PITCH courses, and these are expected to further improve student performance.

Conclusions

A Project to Integrate Technical Communication Habits (PITCH) in engineering and computer science undergraduate students at the Tagliatela College of Engineering at the University of New Haven is described. This four-year program, coordinated across seven engineering and computer science programs, is believed to be one of the most comprehensive engineering technical communication programs in the country. Rather than offer special courses in technical communication taught by non-engineering faculty, or focusing on one or two courses taught within a program, PITCH trains engineering faculty to develop technical communication skills in students by implementing technical communication products into existing engineering courses in a systematic and structured manner throughout the program. The technical communication products used and the PITCH outcomes were based on the results of an extensive survey of alumni, employers of students, and faculty. Development and implementation of PITCH began in fall 2012. While it is too early to assess fully the effectiveness of PITCH, it is expected that PITCH will significantly improve the technical communication skills of engineering and computer science students in the Tagliatela College of Engineering. Preliminary reactions from PITCH faculty confirm that this is so.

Lessons Learned

At this writing, PITCH has begun its fourth semester of development, and those involved can reflect on a number of lessons from its development so far.

- An effort such as PITCH requires a core of faculty members who are committed to the effort to improve students' technical communication skills. Such a core is easier to assemble and sustain at an institution where teaching is at least as important as research.
- Engineering college administrators, especially deans, must act in full leadership and support of such programs. Faculty efforts must be valued and recognized. For an implementation that spans several engineering programs, it is important for faculty members from different disciplines to collaborate and be flexible so as to arrive at common resource tools that can serve all disciplines (e.g., laboratory reports, and senior design proposals, posters and reports). Within each multi-disciplinary team that develops these common resources, it is essential to have a strong team leader who is able to assemble essential requirements into common resources.At least in the developmental stages, it is essential to have the guidance of an individual (or individuals) experienced in the design and implementation of such efforts.
- A common curriculum at the lower levels makes it easier to provide consistent early instruction followed by variations in outcomes and assignments within engineering disciplines and senior design courses.
- The task of defining and sequencing the full set of PITCH outcomes across seven programs and all four years required more time than initially planned. Instead of a semester, this essential task took a full academic year.
- A trio of critical and linked tasks make a significant difference in improving students' communications skills: refining assignments to reflect PITCH outcomes; developing resources to assist students; designing thoughtful grading rubrics.
- Assessment regimes must be reasonable and sustainable and provide information that can be used for improvement.

Acknowledgement

The Davis Educational Foundation (http://www.davisfoundations.org/site/educational.asp) funded the development and implementation of PITCH at the University of New Haven.

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Appendix: Typical Assignment Sheets, Rubric and Advice Table

EASC 1107: Introduction to Engineering
First Assignment Sheet for Remote Pumping Station System Project

Overview

As our use of energy continues to grow and conventional fuel sources are becoming limited, hydrogen technology is emerging as a viable alternative to conventional fuel sources. The objective of this project is for students to explore the use of solar energy and hydrogen technology using fuel cells to build a simple system model to represent the remote pumping station using this technology.

Major Concepts

Introduction to fuel cells (PEM), electrolysers, energy conversion, efficiency, electrical power, energy, voltage and current, loading (fuel cell and solar cell), oxidation reactions, sustainability, and systems engineering concepts.

Technical Skills

- Determination of solar cell output and variation caused by a changing solar position and a stationary panel position
- Generate x-y graphs for collected data
- Create a simple system(s) model in EXCEL
- Create Hierarchical System diagram, system context diagram, and a functional flow block diagram

Analytical Skills

- Computing voltage, current, resistance, power and energy for basic resistive circuits
- Ability to size solar cell components in an energy generation system
- Creation of a simple system(s) model

Second Assignment Sheet for Remote Pumping Station System Project after PITCH

DATE: October 1, 2013
TO: EASC1107 Students
FROM: Representative for McKim & Creed, Inc.
RE: Design for Renewable Energy System

McKim & Creed, Inc. has hired you to assess the feasibility of using a renewable energy system to deliver water to a remote town in Nepal. One of the alternatives to be considered is a pumping station powered using a renewable energy system that includes a solar cell array, an electrolyser, and fuel cells (see figure on following page). Water at the pumping station is stored in a supply tank that is supported by a base elevated 40 ft from the ground. Design requirements are listed below.

- Supply water for a town in Nepal with a population of 15,000 people;
- Assume per capita consumption rate of 50 liters of water per day per person;
- Store water in a reservoir tank with enough capacity for a three-day supply of water;
- Design a self-sufficient pumping station;
- Supply no external power to pump the water to the reservoir tank.

Because the company has limited experience with this type of system, McKim & Creed has instructed you to conduct experiments using different components of the system. Based on experimental results, determine the following:

- Current generated by solar cell;
- Hydrogen production using the solar cell & electrolyser unit;
- Hydrogen consumption by the fuel cell.

The company (instructor) will provide you with details of the experiments used to characterize the behavior of the fuel cells, electrolysers and solar cells.

Draft a memo to McKim & Creed that addresses the following:

- Renewable energy system specifications including dimensions of the reservoir tank, hydrogen and power requirements;
- Recommendation as to the feasibility of the renewable energy system;
- Discussion of design calculations including assumptions;
- Brief explanation of how the fuel cell works and the potential of using hydrogen as energy source.
- Future work to be done or alternative to the design.

Since other engineers in the company will review all designs submitted, include the following supporting documentation as attachments to the memo:

- Systems Diagrams (hierarchical, context and functional flow diagrams)
- Experimental data tables
- Spreadsheet of your design calculations.

Second Assignment Sheet for Remote Pumping Station System Project before PITCH

Project Description

You have been assigned to design a pumping station in a remote area to deliver water to a nearby town. The pumping station is to be powered using a renewable energy system including solar panels, an electrolyzer, and fuel cells. Water at the pumping station is stored in a supply tank that is supported by a base 40 ft in elevation from the ground. The use of solar energy to power a pumping station is currently being developed and used in Nepal. The pumping station will be designed to supply water for a town in Nepal with a population of 15,000 people. A conservative per capita consumption rate will be assumed for design purposes; namely 50 liters of water per day per person. Water will be stored in a reservoir tank with enough capacity for a three-day supply of water. The pumping station must be self-sufficient and it must require no external power to pump the water to the reservoir tank. See figure on next page.

To assist you in the design of your remote pumping station system, each group will conduct experiments using different components of the system. Experiments include the following:

- Determination of the current generated by solar cells
- Determination of hydrogen production using the solar panel & electrolyzer unit
- Determination of hydrogen consumption by the fuel cell

Details of the experiments used to characterize the behavior of the fuel cells, electrolyzers and solar cells will be provided.

*Technical Memo Requirements (**Minimum of 3 pages)***

Technical Memo Content:

- Introduction
  - Brief discussion of hydrogen as renewable energy source, including applications.
  - Motivation for the project with sufficient information to orient the reader as to the overall scope. Describe some of the content to follow. Do not assume that the reader is familiar with the subject area. Be sure to clearly state the problem.
- Main Body of the Paper (use appropriate headings and sub-headings)
  - Explanation of how fuel cells work
  - Describe interactions of system with internal components and environment. Verbally describe the attached system diagrams (hierarchical, context and function flow block diagrams) Attach diagrams in appendix.
  - Explanation of experiments conducted, data collected and summary of results for each experiment.
  - Calculate solution of system. Show step-by-step calculations. Discuss any assumptions made and their validity. Explain how the results from the experiments are used in the design.
- Conclusion
- Citations-references-websites
- Appendix
  - Raw Data Collected in Experiments
  - (3) Diagrams
  - Calculation spreadsheet

EASC 1107: Introduction to Engineering
Grading Rubric for Remote Pumping Station System Project

Dimension	Expectations
Overall Quality of Memo (20%)	• Organized paragraphs. • Precise & consistent terminology. • Proper use of units and notation; e.g. mL not milliliters
Heading (5%)	• Complete heading according to guidelines. • Includes date, recipient, sender (author), and subject line. • Precise subject line.
Summary Paragraph (15%)	• Concisely addresses readers' questions. • Rephrases the primary question as a statement to open the memo, followed by secondary questions/results and important conclusions.
Relevant Background (15%)	• Discusses hydrogen as renewable energy source. • Explains how fuel cells work. • Discusses how system diagrams are used in designing the system. • Explains purpose for each experiment conducted. • Includes schematic of renewable energy system.
Discussion of Design Calculations (20%)	• Explains calculations and relevant equations included in explanation. • Identifies assumptions. • Summarizes results from experiments and explains how results are used in design calculations.
Recommendations (10%)	• Recommendations based on data presented. • Comments on feasibility of the renewable energy system. • Discusses future work to be done or alternative to the design.
Graphs and Tables (10%)	• Tables are organized and summarize pertinent data. • Graphs/figures and tables are labeled by number with captions. • Captions for tables are above table and captions for figures are below figures.
Attachments (5%)	• Includes list of attachments at end of memo. • Labels each attachment. • References attachments in memo.

Overall Grade		
	Percent	Grade
Technical Memo	50%	
Spreadsheet & Design Calculations	30%	
Experimental Data Used	4%	
Schematic Diagram	1%	
System Diagrams (3 Diagrams, 5 pts. each)	15%	
TOTAL GRADE		

EASC 1107: Introduction to Engineering
Advice Table for Technical Memos

Advice	Explanation	Example
Respond to your reader's needs. Most work assignments should respond to a reader's specific request for information	Consider the factors that govern your reader's interest in your memo and address those factors in the way you organize your memo: • Has the reader asked for specific information, often in a list of questions? • Is the reader aware of the subject and its importance? • Why does the reader need this information? • What level of detail or evidence will the reader require to accept the content of the memo?	Rephrase the primary question as a statement to open your memo. That way you make sure you place the most important information *first*. • Here are the data you requested regarding the thermal diffusion experiments. The results should be useful to the Composite Materials Group and should answer their questions regarding our procedures. The attached graphs illustrate our specific results.
Use the ***Subject*** *line to your advantage.*	Focus the reader's attention by using a subject line that highlights the critical ideas in your memo. Make the subject precise. A generic subject line can mask the importance of the information.	*Prefer* a subject line such as: **Subject**: Serious Violations of Safety Regulations—Building A3 *Avoid* generic or overly broad subject lines such as: **Subject**: Safety Inspections
Get to the point.	Except for "bad news" situations, begin your memo with the major point you wish to make. Don't make the reader search for the answers to the important question (s).[1]	*Prefer* a direct, specific opening: We believe the equations used in our procedure are valid for use in the design you propose (*followed by a list of reasons why and any limitations or qualifiers to your statement.)*

[1] This custom holds true in Western cultures. In some Eastern cultures, it is considered rude to get right to the point.

Give structure to the information.	Make sure that headings, paragraphs, and lists reflect distinct groups of information arranged in an order that makes sense to your reader. The reader needs to follow the strict line of reasoning and evidence that leads to your primary points. Avoid mixing ideas or going off on points that are not centrally related to your conclusions.	*Prefer* a structure that illustrates the structure of ideas: The equations we used would not suit your design for two reasons: • The 30 ft. depth of your tanks will introduce stratification; • The use of salt water in your tanks will create a variation in specific gravity. *Avoid* mixing unrelated ideas in a single chunk of information or hiding structure in linear text: The equations we used would not suit your design for two reasons. According to the hydrostatic theory, the forces act at the center of pressure of the submerged area The 30 ft. depth of your tanks will introduce stratification. Another reason is that the use of salt water in your tanks
Use a direct, personal tone	Remember that memos are written *by people for people* (normally within the same organization). Address your reader directly in a level of formality that is appropriate to your working relationship with the reader and to the purpose of the memo. So in most technical memos at work, the tone would be less formal than in a lab report written for company archives or a report in a professional journal.	Prefer a direct style: We remain available to answer any questions you have about these findings. *Avoid* stiff, institutional prose: It is stated here that investigators in the Engineering Applications Division will continue to remain available to render assistance in the understanding of the above listed findings.

Maintain precision in your writing.	The words and the data need to match in ways that precisely characterize the technical content.	*Prefer* modifiers that appear closely linked to data: The coils continued to function within design parameters even at temperatures up to 145° F. *Avoid* using modifiers that don't connect to data: The coils functioned well even at high temperatures.
Place subjects and verbs in proximity.	You can sometimes produce unclear sentences when you place too many words between the subject of a sentence and its verb. Multiple sentences instead of one long one can sometimes improve clarity.	Prefer close proximity between subject and verb for clarity such as: In order to measure the daily total precipitation, data were compared and averaged at each point (from both the tipping bucket rain gauge and the plastic rain gauge). Avoid too many words and prepositional phrases between subject and verb such as: Data at each point, from both the tipping bucket rain gauge and the plastic rain gauge, in order to measure the daily total precipitation, were compared and averaged.
Label tables and graphs.	• All tables and graphs are labeled using a number and caption describing the content of the graph or table. • Caption titles are placed above the table, and below the figure or graph. Titles contain enough detail to make the content clear at first glance.	Table 1. Homestead Wood Products Test Values Figure 1. Distribution of Test Results: Homestead No. 2 White Pine--Compressive Strength of 30 Samples Tested to Failure.
Summarize data and results in tables	Use tables to summarize data and/or results to make it easier for the reader to find this information in the memo.	

Reference all tables and graphs in main body of memo.	When discussing data or information contained in tables and/or graphs, be sure to reference table/graph by number regardless if it is in the main body of the memo or as an attachment.	
Use consistent and proper terminology	Repeating the same word for the same term can help readers when material is complex and terms have specific meanings that are tied to specific words. Use proper engineering terminology when explaining design calculations or concepts.	Prefer the same word such as: A thorough assessment of the potential of the proposed advanced ***control concept*** will require significant additional work. This current proposal will be the beginning of a more elaborate effort to evaluate and finally test the new ***control concept*** in real-world roadway networks.