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Integration of Professional Communication Competence in a Design Thinking Course

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Communication competence is among the top four career competencies most valued by employers, as reported by the National Academy of Colleges and Employers (NACE). In a 2019 job outlook survey, oral and written communication was rated consistently high in the past three years. Also, proficient communication is essential for engineers in the 21st Century to create an inclusive environment and engage multiple stakeholders, as indicated by the National Academy of Engineering. In particular, the ability to communicate effectively to various audiences across the STEM disciplines and the public is a great need. The engineering program at the University of South Florida (USF) aims to fulfill the NACE's professional competencies for career readiness by devising new methodologies for communication-oriented pedagogy. Current research shows that integrating writing assignments into discipline-specific coursework is an effective strategy to accomplish this objective. Thus, the USF has explored implementing oral and "process writing" assignments into creative thinking engineering undergraduate coursework to fulfill a state communication requirement and satisfy the NACE professional proficiency.

In an attempt to teach students how to develop and communicate ideas within the engineering field to a wide range of audiences, USF integrated pre-writing, co-authoring, revising, and editing strategies into a first-year engineering design course. In so doing, an aspect of the oral and written communication needs between industry and academia should be mitigated. Though the student's learning outcomes are assessed prematurely, the proper impact of such implementation might take extended periods when these students advance to upper-level courses. Hence, promoting students' communication capabilities in engineering courses would require future evaluation. However, herein students develop technical writing and oral communication skills individually and collaboratively. Documentation formats consist of process writing exercises, executive summaries, scientific research reports, and other forms of engineering communication. The approach presented may prompt a feasibility study for specific integration of communication competencies in traditional coursework in other engineering programs. Therefore, induce a transformative representation of a range of professional applications of communication skills that STEM programs foster.

Introduction

What if Alexander Graham Bell never told anyone about his idea for a telephone? What if Henry Ford had not been able to communicate how he wanted to build cars to his initial investors? What if Steve Wozniak had not been able to communicate to Steve Jobs his plans to add a hard drive to the original Apple computer? Becoming an engineer is a challenging task for any young person. However, it turns out that they may be facing an even greater task: developing the ability to communicate their ideas to others clearly [1]. Having a good idea is where engineering innovation starts; however, having the ability to communicate that idea to others is a critical part of being a successful and effective engineer.

The National Academy of Colleges and Employers (NACE) *Job Outlook 2020* survey found that outside technical skills, high academic performance, working as part of a team, and good

communication skills are essential attributes reported by their employer members [2]. More than 77 percent and 69 percent of employer respondents seek candidates with written and verbal communication skills, respectively. Many engineering students face the challenge of simply not knowing the best method to communicate their ideas to others. They understand that they have various applicable tools: the written word and their voice being two of the most powerful instruments. However, many have never been trained on how these resources can be harnessed to communicate technical ideas to others in their discipline to get them to understand new ideas and then take action based on that information [3]. This challenge is prevalent in academia, more specifically in engineering-serving institutions.

Engineering programs across various institutions have integrated professional communication skills through community engagement projects, dovetailed with existing assignments in engineering courses, or have developed a separate communication for engineers course [4-7]. These programs have utilized collaborative efforts from Engineering, English, Communication, Education, and Applied Linguistics faculty [7-11]. The challenges often encountered are the integration techniques and logistics. How can communication skills be implemented into existing curricula, and to what extent? Such that its integration does not comprise the technical engineering fundamentals but is an added value. With logistics, some programs have had to hire faculty from other colleges, which could be a budgetary constraint [12]. Others have had to create an additional engineering course thereby increasing the total credit hours that may impose a time constraint to graduate or reduce the existing engineering core credit hours [12-15]. Also, there is a lack of motivation from engineering students and faculty who have considered communication assessments in engineering curricula unnecessary and should be taught in one of the General Education courses [4, 16-18].

Students' ability to communicate with applied critical thinking skills, cohesion, and analysis is expected at the upper-level courses, where students must take the senior design course. Comprehensive writing assignments are encountered at the end of a design project. This practice is less effective in teaching students about communication since it comes late in the curriculum. Earlier exposure and practice are recommended for students to hone the skills required upon graduation. The incident writing approach which occurs throughout the course, provides an avenue for students to improve their writing and learn the art of communicating technical materials [6, 14]. Petraglia showed incidental writing to be an effective strategy if it involves writing in the discipline (WID), especially at the first-year level [19].

To prepare engineering graduates with effective communication skills employing a robust assessment strategy is integral to achieving the learning outcome. Students have to be given constructive feedback in a timely fashion with opportunities to improve the quality of their writing [4, 7, 10, 11]. One main challenge in integrating professional communication skills in traditional engineering courses is the perceived time intensiveness in grading the writing exercises. Some courses grade based on only completion, while others use grading rubrics to convey expectations and standardize the grading process. Unequivocally, adopting sound assessments, a holistic rubric, and an effective grading technique like peer assessments, self-assessments, and co-teaching faculty graders or Teacher Assistants (TA) remains a challenge.

Communication skills and associated projects could be embedded across the engineering curriculum to enable students to hone WID and learn effective communication techniques. However, retention of communication skills could be lacking if well-designed integration and assessment processes are not implemented. Hence at the University of South Florida (USF), we have embarked on developing courses that attempt to bridge this gap and ensure undergraduates possess the necessary communication skills to become successful engineers. For instance, a foundation engineering laboratory course was developed for first-year students in different engineering disciplines and computer science majors. This course aims to introduce students to the engineering design process and teach them how to communicate their design models to others within a semester. We describe the approach used to integrate student communication competence and the corresponding learning gains with minimal disruption to learning fundamental engineering design concepts.

University of South Florida's Integration Approach

The USF first-year Foundations of Engineering Laboratory course (EGN 3000L) employs a project-based learning approach built on a design-thinking framework [20, 21]. Professional communication competence is integrated into the course to develop the engineering mindset and to gain communication skills while working in teams. The student's project is to design and build a robot to meet the educational needs of 5^{th}-grade STEM students. Students first work individually to understand and develop unique technical skills in engineering data analysis, hardware, programming, circuitry, and 3D printing concepts before being paired in groups [22]. Writing assignments are also embedded throughout the course. The concept generation phase requires each engineering student to communicate (both in written form and orally) their proposed ideas and rationale behind the team candidate design selection to the class and the university community. The written communication assignments utilize a "process writing" technique [4, 23-25] whereby two submissions of the same assignment are assessed.

The EGN 3000L course is part of the University's General Education Curriculum, certified for Creative Thinking, and it also meets the State communication core requirement. Students in this course must submit copies of writing assignments for review as part of the assessment effort. The General Education curriculum is designed to ensure students' success and acquire competence relevant to the 21st global community. For the creative thinking learning outcomes, students will

1. Create an original contribution within a specific discipline.
2. Break down complex problems to examine, propose, and support potential solutions, even if those solutions deviate from acceptable, mainstream solutions.
3. Demonstrate responsiveness within an established disciplinary context to new information, experiences, and ideas through a process of re-evaluating the ideas and/or approaches.
4. Evaluate the limitations imposed on any new approach or solution within a discipline to propose original contributions to problems.
5. Synthesize disparate or conflicting thoughts when evaluating questions/problems to form cohesive and collaborative solutions.

The general education attributes (GEA) for learning outcomes 1 and 2 are structured through oral, writing, and reflection activities. Therefore, the developed communication module includes basic writing and editing original contributions, writing scientific abstracts, and manuscripts, oral communication (speaking clearly and effectively), formulating and asking sound questions, and seeking stakeholder advice and mentorship. The course teaches students how to write discipline-specific written deliverables. Students write a professional memo for the first writing exercise and a final technical report (with an embedded one-page executive summary) for the second exercise. An initial draft of each assignment is necessary for the "process writing" approach. Each student drafts a memo about their group projects following a prescribed format and guidelines. After providing feedback, students develop a revision plan with specific details to incorporate into the final submission.

Assessment Rubrics

The course instructional, administrative team consists of faculty and student learning assistants who assess the "process writing" assignments and oral communication. The team assesses students' oral communication skills during a mid-semester design review presentation. Students participate in-class presentations using prepared PowerPoint to communicate their design concepts, highlight their ideation process, and articulate their solution strategy. The presentation captures the breaking down of a complex problem towards providing potential solutions to an audience and reveals the group's process towards breaking down a design problem. The rubric in Table 1 is used to evaluate the presentation length, content, audience engagement, the quality of figures/tables/texts, and the delivery. Each criterion is linked to the communication learning outcome, and different scales are used to distinguish between what is acceptable and what needs improvement.

Written communication is assessed through course learning outcome 1: "Upon successful completion of this course, students will be able to *create an original contribution* within a specific discipline." Therefore, a written communication deliverable at the end of the ideation and fabrication phases of the design project is required. A memo assignment that captures all of the group's design ideas is expected at the end of the ideation phase. While a written final report documents the final design specifications at the end of the fabrication phase. Each deliverable is submitted using two submissions per assignment for the "process writing" technique.

Students submit a draft of the writing assignment and receive constructive feedback to improve their rewriting quality. Each of the written communication deliverables is worth 8% of the final grade. This 8% is divided into 4% for the initial submission and 4% after process writing. A project showcase is used to document project functionality. The final report deliverable requires the students to describe the robot's functionality, while the showcase provides a forum for them to present their project to a wide range of audiences. Table 2 displays a summary of the Outcome 1 assessment, showing that it is worth 20% of the grade and that each submission is worth 4%.

Table 1: Assessment Rubric for Oral Presentation

Criteria	Ratings	Points
Length Is the presentation 6 minutes or less?	Yes (0.25) No (0)	**0.25**
Content • Does the presentation include a cover, overview, and motivation slides with relevant content? • The motivation answers the question of why the project is being done. • The weighted benefit analysis table is calculated correctly. It is used to make informed decisions on the selected candidate designs. • Does the presentation include a conclusion slide and an outline of the next steps? • Conclusion slide succinctly summarizes the work done.	Complete (1) Mostly Complete (0.75) Partially Complete (0.5) Incomplete (0.25)	**1**
Audience Engagement Aware of audience and adjusts presentation accordingly. Able to convey content to increase understanding of technical content.	Strong (0.25) Moderate (0.2) Needs Work (0.1)	**0.25**
Quality • Presents figures and tables using a compare and contrast approach. And has proper formatting guidelines. • Texts are legible, not overcrowded, and relevant.	Good (0.5) Fair (0.25) Poor (0)	**0.5**
Delivery Presenter's appearance, voice projection, eye contact, body language, tone, pacing, and poise level.	Proficient Apprentice Novice	**2**
		4 points

Multiple submissions to encapsulate the creative thinking learning outcomes are necessary because it reflects a sustained effort to break down complex problems towards creating an original contribution to the discipline and the written documentation of the process itself. Activities that correspond to #GEA2 are multifaceted and require a varied assessment. Table 3 provides the assessment rubric for both Written Comm. 1: Memo (a Sub-assignment 2A) and Written Comm. 2: Memo Process Writing (Sub-assignment 2B). As part of their process writing, students develop a plan for correcting their memo, expand the content of their original memo to outline their potential for an original contribution adequately, and rewrite their memo considering the engineering technical content and formatting. The grading rubrics used to assess each assignment

are provided to students, and they highlight the necessary process writing aspects of the written communication deliverables.

Table 2: Summary of Outcome 1 Assessment with Each Submission Listed as a Sub-Assignment

#GEA2 Creating an Original Contribution			
Criteria	**Ratings**		**Pts**
Written Comm. 1: Memo *Sub-assignment 2A*	4 to >0 pts Full Marks	0 pts Incomplete	4 pts
Written Comm. 2: Memo Process Writing *Sub-assignment 2B*	4 to >0 pts Full Marks	0 pts Incomplete	4 pts
Showcase *Sub-assignment 2C*	4 to >0 pts Full Marks	0 pts Incomplete	4 pts
Written Comm. 3: Final Report Introduction and Results/Discussion *Sub-assignment 2D*	4 to >0 pts Full Marks	0 pts Incomplete	4 pts
Written Comm. 4: Final Report Appendix and Formatting/Section Content *Sub-assignment 2E*	4 to >0 pts Full Marks	0 pts Incomplete	4 pts
			Total Points: 20

Sub-assignments 2D and 2E document the final specifications of the design that led the group to create an original contribution to the discipline. This original contribution is framed against the engineering education literature. The final report is written in two parts. The first submission is Written Comm. 3: Final Report Introduction and Results and Discussion, an executive summary that provides the basis for the project and documents the project characteristics with discussion. Students receive feedback on these sub-sections before submitting the full report so that improvements can be made. The second submission is Written Comm. 4: Appendix and Formatting/Section Content, which provides all materials to replicate the project in a discipline-relevant technical report format. Table 4 provides the rubric for assessing Written Comm. 3 and 4. To further document the students' writing process, the worksheet embedded in Appendix A is used to improve their written communication assignments. This worksheet is for the "process writing" of the memo. As shown, the worksheet requires students to critically reflect on all parts of the writing assignment. In addition, students must document what changes should be made to the document formatting and structure after the students' learning assistants have provided constructive feedback. Students must submit their complete worksheets documenting necessary changes and their revised written document.

Table 3a: Assessment Rubric for Both Written Comm. 1 and 2 Memo Writing Assignments.

Criteria	Ratings						Pts
Criteria 1C: Heading and Formatting	0.5 pts Correct	0.4 pts Formatting with minor errors. Heading correct	0.3 pts Heading incorrect. Formatting correct otherwise	0.2 pts Formatting with major errors. Heading correct.	0.1 pts Formatting with minor errors. Heading incorrect	0.0 pts Incorrect	0.5 pts
Criteria 2C: Opening	0.5 pts Correct	0.4 pts Main ideas with minor errors. Opening concise.	0.3 pts Opening not concise (reads like a description of what was done as opposed to a summary of main ideas and deliverables). Main ideas given with numerical deliverables (if necessary)	0.2 pts Main ideas with major errors. Opening concise.	0.1 pts Main ideas with minor errors. Opening not concise (reads like a description of what was done as opposed to a summary of main ideas and deliverables).	0.0 pts Incorrect	0.5 pts
Criteria 3C: Middle	0.5 pts Supporting details provided, complete, and enumerared.	0.4 pts Supporting details provided with minor errors and enumerated correctly.	0.3 pts Detail enumeration exists but enumeration does not separate independent points. Supporting details provided and complete.	0.2 pts Supporting details provided with major errors and enumerated correctly.	0.1 pts Supporting details provided with minor errors. Detail enumeration exists but enumeration does not separate independent points.	0.0 pts Incorrect (points may be correct but if no enumeration is present this will be an automatic 0)	0.5 pts
Criteria 4C: Closing	0.5 pts Closing clearly explains the action required from the information given and is concise.	0.4 pts Closing explains action with minor errors and is concise.	0.3 pts Closing not concise (provides information that should be located in the opening or middle) but clearly explains the action required from the information given.	0.2 pts Closing present but does not indicate actions required. Closing is concise and seems to be well thought out.	0.1 pts Closing present but does not indicate actions required. Closing not concise (provides jnformation that should be located in the opening or middle)	0.0 pts Poorly executed	0.5 pts
Tables and Figures	0.5 pts Figures and tables formatted correctly with a descriptive label below for a figure or above for a table.	0.4 pts Figures and tables have minor formatting errors with a descriptive label below for a figure and above for a table.	0.3 pts The location of figure or table labels is not followed for all figures but the label is present and descriptive. Figures are otherwise formatted correctly.	0.25 pts Figures and tables have minor formatting errors. Label is not descriptive but located properly	0.2 pts Figures and tables formatted correctly with no descriptive label	0.1 pts Figures and tables have major formatting issues but a descriptive label exists below for a figure and above for a table	0.0 pts Figures and tables missing or the majority of figures and tables are improperly labeled and formatted	0.5 pts
Memo length	0.5 pts Major error with acceptable content on the first page of the Memo. Memo length is correct.	0.4 pts Memo exceeds 1 page by a sentence or two. All figures, tables, and equations not included in this first page of content.	0.3 pts Memo exceeds 1 page by a sentence or two. Minor error with figure or equation placement on the first page of the Memo.	0.2 pts Memo heading, opening, middle, and closing less than 1 page and all figures, tables, and equations not included in this first page of content	0.1 pts Minor error with acceptable content on the first page of the memo. Memo length is correct.	0.0 pts Poorly Executed	0.5 pts
Content of Appendix	1.0 pts Appendix is completed correctly and professionally with required content	0.8 pts Minor errors with content in the Appendix. Appendix is completed professionally.	0.7 pts Minor errors with Appendix content and formatting. Appendix completed professionally.	0.6 pts Appendix is completed but there are some minor errors with its content and/or Figures/Tables have a minor issue with clarity or professionalism	0.5 pts Appendix is completed professionally and with good effort but there is a conceptual misunderstanding that leads to major errors in its contents	0.3 pts Appendix has minor omissions. There is a a conceptual misunderstanding that leads to major errors in its contents	0.0 pts Poorly executed	1.0 pts
Process Writing - Prewrite	1.0 pts Student completes pre-writing assignment in class		0.5 pts Student partially completes pre-writing assignment in class		0.0 pts Student has poor effort on pre-writing activity in class			1.0 pts

Table 3b: Assessment Rubric for Both Written Comm. 1 and 2 Memo Writing Assignments.

Criteria	Ratings				Pts
Process Writing - Expansion of ideas to adequately outline original contribution	1.0 pts Student outlines quality revisions based on feedback from instructor	0.7 pts Student partially outlines revisions based on feedback from the instructor but with good effort	0.4 pts Student partially outlines revisions based on feedback from the instructor with limited effort	0.0 pts Student has poor effort on expansion of ideas to incorporate instructor feedback	1.0 pts
Process Writing - Rewriting quality to capture proper formatting	1.0 pts Student rewrites memo to address all formatting issues	0.7 pts Student rewrites memo to address most formatting issues	0.4 pts Student rewrites memo to partially address formatting issues but with good effort	0.0 pts Student has poor effort revising memo to incorporate feedback	1.0 pts
Process Writing - Rewriting quality to capture proper content	1.0 pts Student rewrites memo to address all content issues	0.7 pts Student rewrites memo to address most content issues	0.4 pts Student rewrites memo to partially address content issues but with good effort	0.0 pts Student has poor effort revising memo to incorporate feedback	1.0 pts
					Total Points: 8.0

Implementation of Learning Objectives

The standard curriculum in research-intensive engineering institutions mostly has one core engineering communication course. Is this efficient in educating students with good oral, visual, and written communication skills needed to interface and thrive with global stakeholders in the government, private and public sectors? Employing an instructional scaffolding strategy for learning communication skills across engineering curricula with well-crafted activities and assignments offer a promising means of reinforcing this essential competency within the discipline.

The communication skills requirement is consistent with the Accreditation Board for Engineering and Technology (ABET) student outcomes three (SO#3), which states that students must demonstrate "an ability to communicate effectively with a range of audiences." And ABET SO #5 states "an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives." Therefore by the end of the program, engineering students must be able to engage and interact with a wide range of audiences verbally or in written communication.

The written and oral communication assignments implemented in this foundational engineering course create a context for technical communication in the discipline. These assignments encompass elements of technical writing with a clear purpose, an audience in mind, logically utilized format and style, proper presentation of figures and tables, drafting standard operational procedures, and application and citation of literature reviews.

Table 4: Assessment Rubric for Written Comm. 3 and 4 for the Final Report.

Final Report									
Criteria	**Ratings**								**Pts**
Introduction that provides the basis for the creation of a contribution to the discipline	2.0 pts Literature review complete and technical information provided for project understanding	1.8 pts Technical information with minor errors but literature review complete	1.6 pts Literature review with minor errors but technical information complete	1.3 pts Literature review and technical information with minor errors	1.0 pts Technical information with major errors but literature review complete	0.8 pts Literature review with major errors but technical information complete	0.5 pts Major and minor errors with both technical information and literature review but completed with decent effort	0.0 pts Incomplete or done with poor effort	2.0 pts
Results and Discussion towards the creation of an original contribution to the discipline	2.0 pts Results complete and thoughtful discussion provided for project understanding/future work	1.8 pts Discussion with minor errors but results complete	1.6 pts Results with minor errors but discussion complete	1.3 pts Results and discussion with minor errors	1.0 pts Discussion with major errors but results complete	0.8 pts Results with major errors but discussion complete	0.5 pts Major and minor errors with both results and discussion but completed with decent effort	0.0 pts Incomplete or done with poor effort	2.0 pts
Role specific materials and appendix	2.0 pts Role specific materials complete and other aspects of the appendix provided for project implementation	1.8 pts Appendix with minor errors but role specific deliverables complete	1.6 pts Role specific deliverables with minor errors but appendix otherwise complete	1.3 pts Role specific deliverables and rest of the appendix with minor errors	1.0 pts Appendix with major errors but role specific contribution complete	0.8 pts Role specific deliverables with major errors but rest of the appendix otherwise complete	0.5 pts Major and minor errors with both role specific deliverables and the rest of the appendix but completed with decent effort	0.0 pts Incomplete or done with poor effort	2.0 pts
Discipline specific formatting and professionalism	2.0 pts Formatting follows discipline specific guidelines and section content completed with professionalism	1.8 pts Formatting with minor errors but section content complete and professional	1.6 pts Section content with minor errors but formatting done professionally	1.3 pts Formatting and section content with minor errors	1.0 pts Formatting with major errors but section content complete	0.8 pts Section content with major errors but formatting done professionally	0.5 pts Major and minor errors with both formatting and section content but completed with decent effort	0.0 pts Incomplete or done with poor effort	2.0 pts
									Total Points: 8.0

Writing in the Discipline and Learning

Incorporating writing assignments in this design-thinking course improved students' confidence. Students adequately expanded on their ideas and provided an original contribution. Process writing activities decrease negative writing perceptions and reduce students' anxiety about failing [9]. We taught process writing with full disclosure on the assessment rubrics for all Written communication assignments (Table 2) and instructions, Figure 1. Student scores from the previously written assignments are factored into subsequent submissions to increase student participation. Most Written Comm. 2 submissions typically show improvements from the Written Comm. 1 document, Figures 2 and 3. Motivated and dedicated students improve their writing by submitting their best material in the previous assignment; they benefit significantly from process writing.

In agreement with Palmist's work, writing in disciplines is high-stakes. It is categorized on the higher levels of the six domains of the cognitive skills framework developed by Benjamin Bloom

and his collaborators [3]. Students in the course learned to articulate their project design solutions with measurable outcomes by utilizing the writing templates covered during lectures. More than 90% of students who participate in the process writing exercises and adequately revise their documents based on the feedback received get improved scores of up to the full credit for the assignment. Thus, students deepen their knowledge of engineering concepts and writing skills.

Process Writing Improved Written Communication Skills

We assessed learning gains by observing student performance on writing assignments to evaluate improvements from one writing assignment to another. We determined that the elements of process writing embedded in the course showed significant learning gains. The second submission's rewriting quality and technical content increased after students reviewed their feedback and revised their documents. We found that the constructive feedback did broaden students' perception of the particular element that needed to be conveyed in the document submitted. Students' writing materials demonstrated improvements in grammar, mechanics, structures, information data representation, and technical content, an observation consistent with Bayat's studies [9].

Students' feedback indicates improvement in written and oral communication assignments

A pilot survey was conducted with a sample size of 82 students. The questionnaire included six main areas of competencies/skills that were developed or reinforced throughout the semester. More precisely, students were asked: "After taking this course, do you believe your knowledge in the following field has improved?". The communication section surveyed 1) Basic writing and editing, 2) writing scientific abstracts and manuscripts, 3) Oral: Speaking clearly and effectively, 4) Formulating and asking sound questions, and 5) Seeking advice from advisors and mentors.

As displayed in Figure 4, more than 80% of students believe the course improved their communication skills. We also estimated the percentage of students who believed that they improved a specific number of communication skills: No more than two skills (~ 13% of students), precisely three (11%), four (23%), and all five skills (52%). These positive results encourage continuing the communication integration pursuit across the curriculum.
It is important to note that 4 out of the 82 students affirmed that only one competency was developed within the course. One of those students failed the course (F grade), the other three earned B grades, and one received an A grade. The relation between the student who failed and the corresponding survey response is understandable. However, the case of the other students who passed the course but believed that the course did not improve their communication competencies needs further investigation. We hypothesize that these three students may have previous communication knowledge.

Written Communication 1 & 2 Assignment Instructions

This is a core assignment meaning a file upload is required. You must upload the required file by the due date to receive credit. No hard copy submission will be accepted for this assignment.

**Failure to submit a first draft of the memo by the due date will result in a 0/8 on the Written Communication 1 & 2 assignment.
**The first page of this submission should be individual work. If the first page of the memo doesn't reflect an original composition by the writer a 0/8 will be assigned for Written Communication 1 & 2. Rewording someone else's writing is not considered an original composition.
For this assignment, you will write a memo that presents the defining characteristics of your group's candidate designs.

- Your boss specifically would like you to describe both candidate designs and compare and contrast them upfront. Therefore, this information should be in the opening section.
- You also should present your design process in the memo in detail. Therefore, the middle section should discuss the group's customer needs and the group's engineering specifications.
- You should provide insight into the impact of the design review process on creating your candidate designs to provide your boss with additional context on how the experience impacted the creation of candidate designs. If the design review process didn't impact your candidate designs, please explain why. This information should also be provided in the middle section.
- Be sure, in the closing of the memo, to ask your boss for action.
- The appendix of the memo should begin on page 2. The items in the appendix can be identical between group members. Note that you may use figures and tables from your Design Review. But ensure they have the proper format. You must include the following items in your memo's appendix:
- Properly formatted table of your group's customer needs, engineering specifications, and candidate designs
- Figures and tables must be centered on the page.
- Figure labels should be placed below the figure, and table labels should be placed above the table. If in doubt about what a table is and what a figure is, please ask.
- Each label must be descriptive. Descriptive means the label allows for the figure or table's content to be understood outside of the document's context.
- The label should begin with “Figure #_” or “Table #_” where it follows that tables are numbered chronologically in order of appearance in the document starting at 1, and figures are labeled chronologically in the document starting at 1 as well.
- You must write in complete sentences and use a grammatically correct sentence structure.
- If you need help with writing, reach out to the administrative team.

Figure 1: Process Writing Assignment Instructions for Written Communication 1 and 2.

Memo

Each candidate design we selected surrounds the theme of "video games". Our team believes video games to be the best way for students to interact with technology and engineering while still having fun and connecting to their learning. Therefore, our top two candidates were a Minecraft and a Pacman robot. The Minecraft robot was a "Steve", the base character in Minecraft. Students might prefer this design idea because members of this age group are typically more acquainted with Minecraft than Pacman. Although our team took this into consideration, our team leaned more toward a robot that would bring us closer to our engineering specifications. The Pacman design is more fleshed out and includes the task of following cherries. The Pacman design also includes features improved upon by the heuristic cards. The opening will be hollow and available for storage of motors, wires, and the following object. The Pacman will also be on wheels as opposed to the Minecraft robot which would have moved with mechanical legs, making functionality more efficient.

Throughout the design review process, our team was able to collaborate and take only the most outstanding of our ideas into the next phase of creation. Most of us had chosen to create our individual cosmetic designs using the video game theme. We also benefited greatly from conversation surrounding how we could improve our initial group design of Pacman. Our conversation surrounding the heuristic cards was enlightening, and we were able to come up with the retractable wheels and the lights we'll put behind the Pacman's eyes as our novel implementation. The review of customer needs and engineering specifications also brought to our attention the need for these extra precautions like a smooth exterior with little protruding elements and the novel idea within the robot (the flashing lights that signal when the Pacman has reached the cherries).

Please let me know what you think about these designs. Our goal is to make this robot at peak functionality and educational value. If you have any questions or concerns, please contact our project lead, [redacted].

Figure 2: Student Sample Document Submitted for Written Comm. 1.

Challenges to Writing in the Discipline

In the four years of employing "process writing," we have learned that this approach's outcome depends on the instructional team. A trained administrative team is needed to provide consistent and constructive feedback. Faculty commitment is required to conduct process writing activities efficiently. Getting buy-in from engineering faculty to integrate writing in theoretically intensive courses could be challenging. The activity theory analysis of [invisible] writing practices in the engineering curriculum report that some engineering faculty believe "it's not my job to teach writing" [16]. And that the most significant outcome is to have students gain disciplinary technical knowledge and processes. Different frameworks have shown the enrichment of writing in the discipline and learning outcomes if communication skills are integrated into technical courses [3, 4, 26]. Communication enhances critical thinking skills and lays the groundwork for gaining knowledge in the field. So do we teach communication skills at the expense of technical knowledge? No. Proper integration techniques and effective assessment tools are sufficient to couple both technical and communication skills.

Other challenges may exist, i.e., budgetary and resource constraints, credit hour constraints, time constraints, lack of expertise, and low faculty motivation. These factors could be detrimental to implementing this robust and productive writing experience [4]. From the student's perception, writing and revising their original work is time-intensive. In terms of grading, there is a chance of writing misconduct, given the level of writing exercises students are required to write. Using a plagiarism detection tool, we have reduced the number of students who venture into such practices.

DATE: 10/26/2021
TO: Faculty
FROM: [redacted] from GROUP 8
SUBJECT: DEVELOPMENT OF FUNCTIONING PACMAN TO MEET CUSTOMERS' SPECIFIC NEEDS AND SPECIFICATIONS

Each candidate design we selected surrounds the theme of "video games". Our team believes video games to be the best way for students to interact with technology and engineering while still having fun and connecting to their learning. Therefore, our top two candidates were a Minecraft and a Pacman robot. The Minecraft robot was a "Steve", the base character in Minecraft which students might prefer because members of this age group are typically more acquainted with Minecraft than Pacman. Although our team took this into consideration, we chose a robot that would bring us closer to our engineering specifications because the Pacman design is more reliable and includes the task of following cherries.

Throughout the design review process, our team was able to collaborate and take only the most outstanding of our ideas into the next phase of creation.

1. The review of customer needs and engineering specifications brought to our attention the need for extra precautions like a smooth exterior with little protruding elements which will be accomplished through electrical tape and a round shell.
2. A novel idea within the robot was added through heuristic cards (the flashing lights that signal when the Pacman has reached the cherries).
3. The enclosure will be hollow and available for storage of motors, wires, and the following object.

Please contact our project lead, [redacted], to let us know if these goals are realistic and aligned with intent of the project by November 3rd.

Figure 3: Student Sample Document Submitted for Written Comm. 2 excluding page 2.

Figure 4: Preliminary sampled results from a pilot survey.

Future Plans

Integration of communication skills is essential to understanding technical knowledge in the profession. An appropriate synergy between the two competencies is needed to produce engineers in the 21st Century. We propose further studies to learn effective integration of communication across the engineering curriculum that yields tangible NACE and ABET outcomes. In doing so, we would like to address whether it is relevant to mitigate the effect of different communication backgrounds, such as culture, writing anxiety, interpersonal competency, and previous writing backgrounds at the first-year undergraduate level.

We intend to study this question to observe the effects on student learning outcomes. Where applicable, an experimental design strategy that conducts feasibility studies and/or evaluates the pre-and post-test control groups to determine a significant observation would be employed. A longer duration may be required to conduct the effects of learning communication on various dependent variables. We anticipate that a two-factor Analysis of Covariance may be applied.

Conclusions

Integrating communication skills into existing engineering courses should not devalue students learning the technical content. This article presents a successful approach for incorporating writing and oral communication into an engineering first-year design course. The implemented process writing approach improved students' writing skills and appeared to reduce communication-associated anxiety. Applying well-constructed communication assignments, a holistic rubric, and a constructive feedback mechanism can provide transferable skills to other writing contexts in upper-level undergraduate courses and ultimately prepare students for the engineering profession.

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References

[1] P. Anderson *et al.*, "How writing contributes to learning: new findings from a national study and their local application," *Peer Review*, vol. 19, no. 1, pp. 4-9, 2017.

[2] U. National Academy of Engineering, *The engineer of 2020: Visions of engineering in the new century*. National Academies Press Washington, DC, 2004.

[3] M. Palmquist, "A Middle Way for WAC: Writing to Engage," *WAC Journal*, vol. 31, 2020.

[4] T. Cary, K. J. Brent, B. Josh, B. Natascha Trellinger, and R. E. Rebecca, "Writing to Learn Engineering: Identifying Effective Techniques for the Integration of Written Communication into Engineering Classes and Curricula (NSF RIGEE project)," New Orleans, Louisiana, 2016/06/26. [Online]. Available: https://peer.asee.org/27060.

[5] J. D. FORD and L. A. RILEY, "Integrating Communication and Engineering Education: A Look at Curricula, Courses, and Support Systems," *Journal of Engineering Education*, vol. 92, no. 4, pp. 325-328, 2003, doi: https://doi.org/10.1002/j.2168-9830.2003.tb00776.x.

[6] B. Gunnink and K. L. S. Bernhardt, "Writing, critical thinking, and engineering curricula," in *32nd Annual Frontiers in Education*, 6-9 Nov. 2002 2002, vol. 2, pp. F3H-F3H, doi: 10.1109/FIE.2002.1158211.

[7] D. Missingham, "The Integration of Professional Communication Skills into Engineering Education," 2006.

[8] A. Nylén and A. Pears, "Professional communication skills for engineering professionals," in *2013 IEEE Frontiers in Education Conference (FIE)*, 23-26 Oct. 2013 2013, pp. 257-263, doi: 10.1109/FIE.2013.6684828.

[9] K. Walker, "Integrating Writing Instruction into Engineering Courses: A Writing Center Model," *Journal of Engineering Education*, vol. 89, no. 3, pp. 369-375, 2000, doi: https://doi.org/10.1002/j.2168-9830.2000.tb00538.x.

[10] H. Warren, W. Warren, and B. David, "Assessing The Integration Of Communication Into Engineering Curricula," Honolulu, Hawaii, 2007/06/24. [Online]. Available: https://peer.asee.org/1940.

[11] E. Yong and P. J. Ashman, "Integration of the structured development of communication skills within a chemical engineering curriculum at the University of Adelaide," *Education for Chemical Engineers*, vol. 27, pp. 20-27, 2019/04/01/ 2019, doi: https://doi.org/10.1016/j.ece.2018.12.002.

[12] J. L. Craig, N. Lerner, and M. Poe, "Innovation Across the Curriculum: Three Case Studies in Teaching Science and Engineering Communication," *IEEE Transactions on Professional Communication*, vol. 51, pp. 280-301, 2008.

[13] R. J. Bonk, P. T. Imhoff, and A. H.-D. Cheng, "Integrating Written Communication within Engineering Curricula," *Journal of Professional Issues in Engineering Education and Practice*, vol. 128, no. 4, pp. 152-159, 2002, doi: doi:10.1061/(ASCE)1052-3928(2002)128:4(152).

[14] S. Hawkins, M. B. Coney, and K.-E. Bystrom, "Incidental Writing in the Engineering Classroom," *Journal of Engineering Education*, vol. 85, no. 1, pp. 27-33, 1996, doi: https://doi.org/10.1002/j.2168-9830.1996.tb00204.x.

[15] S. Manuel-Dupont, "Writing-Across-the-Curriculum in an Engineering Program," *Journal of Engineering Education*, vol. 85, no. 1, pp. 35-40, 1996, doi: https://doi.org/10.1002/j.2168-9830.1996.tb00205.x.

[16] R. Goldsmith and K. Willey, "“It’s not my job to teach writing”: Activity theory analysis of [invisible] writing practices in the engineering curriculum practices in the engineering curriculum," *Journal of Academic Language and Learning*, vol. 10, no. 1, pp. A118-A129, 2016.

[17] D. K. Ludlow and K. H. Schulz, "Writing Across the Chemical Engineering Curriculum at the University of North Dakota," *Journal of Engineering Education*, vol. 83, no. 2, pp. 161-168, 1994, doi: https://doi.org/10.1002/j.2168-9830.1994.tb01097.x.

[18] W. Zhu, "Faculty views on the importance of writing, the nature of academic writing, and teaching and responding to writing in the disciplines," *Journal of Second Language Writing*, vol. 13, no. 1, pp. 29-48, 2004/03/01/ 2004, doi: https://doi.org/10.1016/j.jslw.2004.04.004.

[19] J. Petraglia, *Reconceiving writing, rethinking writing instruction*. Routledge, 2013.

[20] O. Akintewe, J. E. Gaines, A. M. Bateman, and L. Chisholm, "Work in Progress: Professional Development Module in First-year Engineering Courses," in *2020 ASEE Virtual Annual Conference Content Access*, 2020.

[21] K. Ulrich and S. Eppinger, *EBOOK: Product Design and Development*. McGraw Hill, 2011.

[22] O. Akintewe, "Remote Teaching Robotics Design Project," in *2021 First-Year Engineering Experience*, 2021.

[23] N. Bayat, "The Effect of the Process Writing Approach on Writing Success and Anxiety," *Educational Sciences: Theory and Practice*, vol. 14, no. 3, pp. 1133-1141, 2014.

[24] M. Deane and P. O'Neill, *Writing in the disciplines*. Bloomsbury Publishing, 2011.

[25] M. R. Kuhn and K. Vaught-Alexander, "Context for writing in engineering curriculum," *Journal of professional issues in engineering education and practice*, vol. 120, no. 4, pp. 392-400, 1994.

[26] R. W. Hendricks and E. Pappas, "Writing-and communications-across-the-curriculum in the Materials Science and Engineering Department at Virginia Tech," in *Proceedings Frontiers in Education 1995 25th Annual Conference. Engineering Education for the 21st Century*, 1995, vol. 2: IEEE, pp. 4a4. 10-4a4. 14 vol. 2.

Appendix: Memo Process Writing

Name_____ Date_____ Student Number _____

What changes will you make to your memo heading? What changes will you make to your memo subject line?

What changes will you make to your memo opening?

What changes will you make to your memo middle?

What changes will you make to your memo closing?

What changes will yo umake to your memo appendix?

What changes will you make to the general formatting of text on the first page of your memo?

What changes will you make to the formatting of proper figures and tables?

What misconceptions did you have about customer needs and/or engineering specifications?

How much time did you spend writing your memo first draft?

What are you still unsure about? What questions do you have?