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Development and Implementation of Professional Communication Activities for Undergraduate Engineering Curricula Based upon Industry Expectations

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Abstract

This work-in-progress paper presents an ongoing evidence-based practice implementing integrative professional communication activities derived from an investigation of professional communication expectations of industry co-curricular partners. Contemporary pedagogical approaches, such as problem-based learning and entrepreneurially minded learning, have as a central focus the desire to expose students to authentic experiences which integrate technical knowledge with workplace skills connected to professionalism, communication, collaboration, and leadership. This approach can conflict with traditional engineering curricula where the instruction of technical skills are frequently separated or deemed more important than "soft skills" instruction in interpersonal, professional, and technical communication. Acknowledging that this divide persists in engineering education, this paper reports on an ongoing study of industry and academic expectations for engineering students' professional communication to present the development and implementation of embedded professional communication topics in an engineering curricula. In prior work, observational data from interviews with human resource personnel, managers, and focus groups of early-career engineers at five companies of regional and national status reported on the genres commonly used in the workplace. The status of professional and interpersonal communication instruction was assessed in the current mechanical and civil engineering program curriculums at the University of Dayton, a mid-sized, private university in the Midwestern United States. Results indicated incongruities between current curricula and the expectations of industry partners in the areas of professional and interpersonal communication. This paper provides an overview of the development and implementation of two project-based assignments that address recommendations from industry partners within an integrative pedagogical approach that brings technical knowledge from engineering technology together with human-centered rhetorical knowledge from technical communication. Specifically, we report on the process of creating, implementing, and initial observations in evaluating a Specification Design Review assignment and a Heat Transfer Analysis assignment -- two separate technical communication activities in different courses within an engineering technology program. We provide a discussion of the desired technical and interpersonal communication skills each prototype activity is addressing and our procedures for implementing the assignments with students. In-progress results of students' performance on each task is provided.

Nomenclature

ABET	Accreditation Board for Engineering and Technology
MCT	Mechanical Engineering Technology
SDR	Specification Design Review

Keywords: Communication Skills, Industry Partners, Engineering Communication, Heat Transfer Analysis, Interdisciplinary Collaboration, Manufacturing Design Specification, Relational Communication, Scenario-Based Learning, Workplace Genres

Introduction

A critical component of the engineering curriculum (encompassing both engineering technology and engineering programs), beyond equipping students with technical proficiencies and knowledge of design processes, is the development of effective communication skills. The importance of communication is evident not only in the instructors' own beliefs about the centrality of communication for engineering students' development **[1]** but also in the accreditation standards for engineering; engineering accreditation organization ABET supports and solidifies the teaching of effective communication through the accreditation board's required learning outcomes. Specifically, ABET requires that students in accredited engineering technology programs are equipped with "an ability to apply written, oral, and graphical communciation in broadly-defined technical and non-technical environments" (similar requirements exist for engineering programs). **[2]** That communication appears as its own learning outcome - alongside outcomes related to designing systems and applying engineering knowledge to solve broadly-defined engineering problems signals the equal importance of developing students' communication skills alongside subject-specific proficiencies within engineering programs.

For this reason, many programs require that students complete coursework in technical communication as part of their degree requirements. **[3]** While academic faculty, program accreditors, and industry partners all agree on the critical role that communication plays, there is disagreement among how best to teach communication skills and practices. **[4] [5]** Further, not all engineering programs require a technical communication course, nor are all technical communication courses developed or taught the same way, as institutional contexts, histories, structures, and requirements impact whether and how technical communication courses are taught. **[6]** This is evident in the variety of engineering program designs for teaching technical communication: as a standalone course offering from external departments - primarily English **[4]**, to writing/communication across the curriculum models in which communication skills and practices are taught within the context of the engineering classroom. **[7]** Alternatively, integrative approaches that emphasize interdisciplinary collaboration between engineering and English offer the potential for faculty to integrate expertise within targeted engineering courses that fulfill accreditation outcomes. **[8]**

While each of these curricular designs offers tradeoffs in terms of how students' communication skills and practices are developed, this article reports on an ongoing collaborative approach between faculty in engineering and English at the University of Dayton. Stemming from a longer study of industry partners' expectations for and assessment of entry-level engineers' communication skills, this paper reports on curricular components that were developed to respond to industry partners' insights about students' communication proficiencies; namely, that while students displayed effective formal, technical writing skills, students struggled with less formal, and more relational skills of workplace communication - especially in oral modalities.**[9]** Moreover, interviews with industry partners indicated that students experience significant gaps in the communicative situations and genres of professional communication between the engineering classroom and the workplace context: while classroom genres were repeated across courses (i.e., lab report, pitch presentation), students encountered unfamiliar genres in their entry-level positions in which they were unable to rely on previous communication knowledge, such as submittals, team update reports, or reviews & audits.**[9]**

Background on the Current Project

This paper reports on the second phase of an ongoing study to assess the needs of communication in industry and the alignment of curricular content to meet these needs. Previously, the authors of this article reported on industry partner expectations and areas for continuous improvement for communication skills and practices of entry-level engineers.**[9]** Four industry partners of regional, national, or global presence and employing from a few hundred to several thousand were interviewed; interview participants included entry-level engineers, managers, and human resource representatives. The four industry partners represented employers from four distinct engineering disciplines that typically hire engineering graduates from the author's educational institute.

The industry partner interviews highlighted the importance of professional communication in the workplace. Not only is the ability to communicate a highly valued skill, it was found to be associated with other inferred abilities of the employee. A theme raised in several of the manager and human resource interviews indicated that a successful employee has the ability to communicate well, and that an employee who communicates well will be successful. As such, the importance of professional communication skills are seen by industry as equal to the technical engineering abilities of applicants.

While the importance of communication in the workplace was not an unexpected result in the initial study, the discord in communication genres used in industry and practiced in educational settings was a surprise. A comparison of workplace versus classroom communication genres indicated a significant disparity in the nature of professional genres emphasized in each setting. The academic preparation and practice of various communication genres did not not align with the stated needs of industry partners. Whereas current academic approaches emphasize formal written genres such as reports, lab notebooks, and technical drawings, more emphasis needs to be placed on concise written and oral progress reports, project pitch proposals or presentations, feedback & review, work instructions, and requests for information.

Therefore, with the repeatedly stated importance of professional communication from industry partners and the apparent incongruence in engineering education for the needed types of professional communication, the authors sought to develop strategies for improving the educational preparation. Rather than relegate communication activities to token courses (such as capstone design or project management-type courses), we concluded that effective and professional communication of various applicable genres needs to be practiced throughout the engineering curriculum. At present, repeated exposure to workplace communication genres is inconsistent across the curriculum; absent accreditation requirements, incorporating workplace communication practices is entirely at the course instructor's discretion. Numerous sources suggest that the lack of communication assignments is likely due to multiple factors, including: hesitancy on the part of engineering instructors to assess material beyond the technical components; the perception that additional time or instruction will be necessary; or a lower priority given to communication and a higher priority given to technical content. **[1], [5], [8]** To address these factors, the authors aimed for a strategy wherein:

- Any engineering assignment or activity could be modified to include some communicative component,
- Technical content and evidence of technical understanding was not diminished,
- Engineering instructors would have the ability to assess the technical material separately from the communicative genre,
- The duration, complexity, and effort required for the assignment was not significantly increased.

This paper reports on the work in progress integrating relational communication activities and new workplace genres within two engineering technology courses at the University of Dayton: a manufacturing technology course and a heat transfer course. One of these assignments, the Specification Design Review, aimed to help students engage with relational communication skills, such as perspective-taking and giving meaningful feedback, while engaging in a process-approach to developing manufacturing documentation. The second assignment, a Heat Transfer Analysis project, was designed with the goal of introducing students to unfamiliar workplace genres and the ways in which these genres shape interactions between engineering consultants and clients. In the following sections we report on the design, implementation, and preliminary evaluation of these integrative assignments and reflect upon the potential for cross-disciplinary collaboration toward student achievement of program outcomes related to communication.

Development of Prototype Assignments

Two courses were identified for introduction of an assignment in Spring 2021 that incorporated a significant component of professional communication in various genres: a course on manufacturing & product design and a course on heat transfer. Both of the courses were undergraduate Mechanical Engineering Technology (MCT) courses. The manufacturing & product design course was a required course in the MCT program of study. Student enrollment was approximately 33 students in their junior or senior years. The course instructor was a member of the MCT faculty and his/her involvement in the current study was limited to the implementation and evaluation of the prototype assignment. The prototype assignment was adapted from a prior assignment used by the instructor; development of a manufacturing specification. The adaptations made to the assignment incorporated a realistic component of communication based upon a typical engineering review cycle.

The heat transfer course was a technical elective course in the MCT program of study. Student enrollment was 6 students in their junior or senior years. The instructor was also a member of the MCT faculty and was one of the authors of this paper. The prototype assignment asked students to analyze for a client the heat transfer of an industrial/consumer product. This assignment was created from scratch with an emphasis on incorporating authentic scenarios for consultant (the student team) and client (the instructor) communication in all aspects of the assignment.

These assignments were developed in response to two overlapping and related learning goals. The first of these goals was the need, as identified by industry stakeholders, to improve students' skills related to informal, low-stakes communication situations. Frequently, industry stakeholders responded that while students from our programs were well prepared for formal communicative situations such as pitch presentations, interviews, and/or technical presentations, they generally observed students struggle with less rehearsed presentations or with documentation that was not prepared in advance. **[9]** Likewise, students reported confidence in their abilities to write technical reports and communicate with technical audiences. The insights from industry stakeholders reflect the need for interdisciplinary activities to inform the development of prototype assignments. Specifically, working as faculty in Engineering Technology and English, the prototype assignments discussed reflect a deliberate attempt to integrate disciplinary perspectives on the design of communication while also integrating industry stakeholder feedback regarding effective professional communication. Thus the development of our prototype activities reflects a contemporary approach to teaching communication *within*–rather than separate from–engineering design courses. This approach emphasizes collaboration, scenario-based learning in which students are positioned in authentic team-based situations, and reflective practices that guide students' metacognitive awareness of not only their design decisions but also their positions as technical communicators.

Evidence from industry stakeholders' perceptions of areas for student improvement, students' self-reported informal assessments of their communication skills and abilities, and programmatic evidence of students' communication skills relative to program learning outcomes, suggest that greater emphasis on informal, non-technical, and relational communication skills can improve students' preparation relative to industry expectations for workplace communication. These skills drive interpersonal relationship building and, within a workplace context, provide the necessary means of creating, sustaining, and dissolving relationships between co-workers, managers/supervisors, vendors, clients, and shop-workers. Further, such skills form the basis not only for positive employment outcomes, including cooperative work environments, effective delivery of organizational goals, and overall job satisfaction **[10]** but they also impact students' ability to advance in the workplace.

The second learning goal informing the design of these activities, informed by industry partners, is that students would be able to recognize conventional or typical workplace communicative genres and situations, and to engage in these situations in appropriate ways. In other words, not only should students practice working within typical workplace genres, but they should do so within similar kinds of communicative situations and constraints that mirror the roles they will assume in workplace contexts. Doing so not only introduces students to typical forms and practices of professional communication but also allows students to develop communication skills for the roles they will occupy with perspective on their relationships with other co-workers. The development and practice of relational communication skills is consequential to students' abilities to carry out typical workplace activities in writing or oral communication.

One recognized way to accomplish this is through process-based activities that help students to identify and reflect upon the ways that interpersonal interaction impacts the final deliverables of an activity.**[10]** Such process-based approaches are advantageous because the use of reflection and adaption provide students with opportunities to reflect upon decisions made during the communication activities and the range of possible approaches and perspectives informing their decisions. **[11] [12]** Beyond this, process-based approaches can also provide students with scenario-based experiences for navigating communicative situations that mirror workplace interactions. For instance, educators in business may use a scenario-based framework to teach students skills related to conflict management, [**11]**whereas educators in nursing may employ a scenario-based approach to teach nursing students how to prepare discharge orders for patients. **[12]** Because scenario-based pedagogy informs such a wide range of disciplines, instructional contexts, and professional communication skillsets, adopting such an approach seems not only appropriate but useful for our purpose of creating assignments that engage students in authentic scenarios for relational communication.

A. Development of a Manufacturing Specification Design Review Assignment

This prototype assignment revised an existing assignment in the manufacturing & product design course. The prior implementation of the assignment asked students to develop manufacturing specifications for either a household or an industrial appliance. The deliverable for the assignment was a detailed written manufacturing specification in a format that followed a typical industry template; that format was discussed during the course. In the prior implementation of the assignment, one identified workplace genre of professional communication was addressed; the written specifications align with work instructions. Interviews with industry partners highlight this workplace genre as important communication modality. **[9]** But, by slightly modifying the implementation of the manufacturing specifications assignment, additional professional communication workplace genres could be integrated.

These new components took the form of an interim review cycle. The students in the class were divided into Specification Design Review (SDR) teams composed of four-to-five individuals. The four or five individual manufacturing specifications were reviewed by each team in an organized fashion that incorporated formats of professional communication. For each specification, an SDR team member (not the author) was assigned the role of "compiler." This individual was responsible for shepherding that specification through the entire review process. For a given specification, team members who were not the author or the compiler, completed a review of the draft specification. Those team members submitted their written reviews of the draft specification back to the compiler. The compiler then compiled the two or three reviews into a summary review document that was provided to the author. The author reflected upon the provided feedback and responded in writing with an explanation (with justification) of what feedback was incorporated, what was rejected, and what was unclear, in the final specification. With the SDR complete, students submitted their final drafts of the manufacturing specifications to the instructor.

The prototype assignment maintains the original technical component of the assignment and workplace communication genre in the prior execution of the assignment, but incorporates the additional genres of team meetings, progress reports, and submittals.

B. Development of a Heat Transfer Analysis Project

This assignment was developed as a new project in a heat transfer course, as such, aspects of professional communication were incorporated into the assignment from its inception. The assignment asked students to conduct a complete heat transfer analysis on behalf of a fictional client's industrial or consumer product (the client for the purposes of the project was the course instructor). The actual industrial or consumer products of interest in the project were selected by the students themselves. Students worked on the assignment in teams. The teams created a project proposal for the client which included a statement of work, analysis methodology, analysis time frame, division of tasks amongst team members, and project deliverables. Cost and budgeting was not incorporated into this project. The proposal was delivered to the client in a short written report and in an oral presentation; both followed a template discussed in class. Modifications based upon client feedback required a revised written proposal from the student teams. Once the proposal was approved and signed off by the client, teams had three to four weeks to complete the proposed work and package their deliverables for the client; the final deliverable package required written and oral reports. All teams prepared weekly status updates in either a written status email or short oral presentation. The final oral report was given to the client and student peers. Peer students reviewed the project deliverables and provided a technical assessment of the presented work.

The prototype Heat Transfer Analysis Project incorporated several technical and communicative deliverables. From a technical standpoint, the student teams completed a heat transfer analysis of a complicated industrial or consumer product. The analysis work included the collection of pertinent parametric data to quantify the product and a quick assessment of the product to prepare the project proposal. Hand calculations established reasonable ranges for detailed calculations and simulation results. The communicative deliverables addressed several workplace genres specifically cited by industry partners. The written project proposal addressed the need for project submittals; the oral project proposal exercised the students in project pitch presentations. Weekly status updates practiced both written and oral formats of progress reports. The structure of the project necessitated student's teamwork development. Each of these communicative deliverables addressed an industry partner's workplace communicative genre, and several were genres that industry partners indicated engineering graduates were underprepared for in educational experience.

Implementation of Prototype Assignments

A. Manufacturing Specification Design Review Assignment

A primary concern in implementing this prototype assignment was to avoid significant interruption into the regular course content; instead, we aimed to contribute a prototype that was "minimally invasive" in that it represented a low-stakes opportunity for students to integrate an authentic workplace communication practice within a course that focuses on the technical subject of manufacturing design principles. The Manufacturing Specification Design Review (SDR) Assignment involved a week-long intervention into an existing Manufacturing Specification Report that included both in-class and out-of-class (asynchronous) components. While the SDR assignment extended the amount of time students worked on the specification report, the majority of this work was completed outside of class. The design specification report was assigned by the course instructor as part of the regular set of course assignments, and we made no interventions into the way the instructor introduced this assignment to the class. Indeed, we only took one class session to help students learn how to perform the review tasks; to provide a rationale and additional support for the SDR, we created an introductory video that was posted to the course website for students to view in advance of our live, 50-minute class session.

The SDR video introduced students to the goals of this assignment and explained how the SDR mirrored authentic workplace practices using examples drawn from our professional experiences. The video also provided an overview of the tasks that students were to perform, and the roles they would play as part of these tasks. Students viewed this video in preparation for our class visit, which coincided with the due date for the first draft of their specification report.

Our one class session served as a practice session for students to complete the SDR review on a sample specification. We began the session by reviewing highlights from our introductory video, including the rationale and roles/responsibilities for the SDR. We then grouped students into small groups of 4-5 and provided the groups with a sample specification report to use as a practice case for the SDR. The sample specification report was considered acceptable, but not exemplary by the course instructor. During this SDR review session, students read and performed reviews from multiple perspectives:

- *The Product Engineer:* this perspective evaluates the specification draft for aspects related to the production of the appliance, including the background and purpose statements of the report as well as whether the evidence statements appropriately align with the requirement declarations.
- *The Sales/Customer Support Representative*: this perspective evaluates the specification draft for aspects related to the purpose/solution, training, and how the requirements fulfill customer needs.
- *The Manager/Compiler*: this perspective is responsible for providing global feedback on the specification draft, especially evaluating how well the draft articulates a problem and whether the solution resolves the problem. The compiler offers additional questions regarding the completeness of the specification, and compiles the feedback from all three perspectives into a short response template.

While students rotate through all three positions as part of their peer SDR process, in this class session, the class reviewed the sample specification report from each of the three perspectives and practiced compiling a response for the sample report.

Based on this instruction, students returned to their groups and were assigned the role of Manager/Compiler for one of the other student drafts in their group. The Manager/Compiler assigned the roles of Product Engineer and Sales/Customer Support Representative to their team members. Each student completed 3 reviews, taking on each of the roles at least once. We used Google Drive folders to organize the drafts, feedback, and response templates for each student's draft, which also permitted students to complete these reviews outside of class time. Students were assigned to complete their team reviews over the course of a one weekend, and at the beginning of class the following week, the compiled SDR response was provided to each team member.

Student's were asked to reflect upon the compiled SDR feedback. As part of the reflection, students were instructed to create a short, informal revision plan for their specification report. The revision plan was a brief bulleted list that ensured students read and understood the feedback provided to them, but also provided a way for students to turn this feedback into actionable revisions for their reports. The revision plan was ordered in terms of priority. Students were asked: based on the feedback they received, what changes would they make to their specifications? What aspects of the specification will they focus on as they revise? Providing students the opportunity to make clear plans for their revisions based on feedback is crucial so that students can see the immediate usefulness of the SDR process as something more than a class exercise but as a means of helping them see their own work from multiple perspectives.

Students used the remainder of the second week of this assignment to revise their specification reports outside of class. Upon submission, students provided the instructor with the following materials: (1) the revision plan created earlier in the week; (2) a cover letter describing and justifying the revisions made to the report, (3) and the final, revised specification report.

Note that for the purpose of evaluation, the instructor did not receive more materials to grade. The specification draft, SDR review feedback, revision plan, and cover letter were required elements of the assignment, but the only deliverable that was evaluated formally was the final revised specification report. The inclusion of additional elements in this assignment were aimed solely to assist students in the process of practicing how to give effective feedback and how to use this feedback for the purposes of improving their written communication. These elements were collected for the purpose of our own research, but were not included in the students' evaluations. Such a distinction is important as a way to underscore the ways that students' classroom practices mirror the informal and often low-stakes (but highly important) nature of professional communication. In addition, as we are aware of our own positions as researchers invited into the class, we realized that it was neither necessary nor fair to ask students to be evaluated–or for the instructor to perform additional instructional labor–to accommodate our research project.

B. Heat Transfer Analysis of Industrial/Consumer Products

The objective of this assignment was to expose students to authentic client/consultant interactions while completing an in-depth technical heat transfer analysis of an industrial or consumer product. The technical requirements of the analysis were typical for a heat transfer project; hand calculations and computer simulations were required components of the analysis project. The communication aspects of the project aimed to integrate authentic workplace communication practices, with a particular focus on authentic consultant/client interactions.

Student teams prepared a project proposal based upon the consumer/industrial product that they selected for analysis. The proposal needed to include a statement of work, analysis methodology, timeline, list of deliverables, and agreement of division of tasks amongst team members. Class time was given to the teams to prepare their written and oral proposals. Delivery of the oral proposal was in class with the instructor acting as the client and other class members participating as technical reviewers. Technical reviewers rated the proposal based upon a prepared rubric which included technical and communicative components; reviewers were asked to justify their rankings. Each technical reviewer supplied the client written feedback on the proposal and the client either agreed to the team's proposal as prepared, agreed with minor modification, or rejected for significant modification. When both parties agreed to the proposed work, the technical analysis work commenced.

Three weeks were given to the student teams to complete their analysis (two classes each week were given to students for project work and/or status reporting). Weekly status reports in either written or oral formats (at the direction of the client) were issued by the teams. Based upon these status reports, the client issued at least one change in project scope to each team. The intention of these scope changes was to provide an authentic experience in the engineering workplace: most engineering projects have some type scope change or scope creep. Communicating with the client to understand why scope has changed, the impact of that change on other aspects of the project (timeline, deliverables, resources, etc.) were discussed in class.

At the conclusion of the project time frame, students submitted a final written report that included the technical analysis and agreed upon deliverables. A final oral report was given to the client and technical reviewers in class. The client and reviewers assessed the presentation on technical merit and completion of the proposed deliverables. The quality of technical reviews by students factored into their individual grade for the project. Aside from these technical review assessments students individually assessed their own team performance, including review of the agreed division of tasks and assessment of teammate contributions to the final project. Additionally, each student reflected upon the client/consultant interaction model of the project. The reflection material was collected for the purposes of assessing the impact of this prototype assignment and did not impact the students grade on the project.

Discussion of Prototype Assignment Implementation

A. Discussion of the Manufacturing Specification Design Review Implementation

A total of 31 out of 33 students (93.9%) successfully completed the Specification Design Review process. This process required students to engage in multiple perspectives while collaboratively producing feedback; take on administrative roles in teams to compile, summarize, and deliver team feedback on draft specifications; and receive, interpret, and use team feedback to revise their specifications. In doing so, students practice both giving and receiving effective feedback, communicating in team-based scenarios, and engaging in perspective-taking from multiple points of view to understand how different audiences interpret their Specifications. The high number of students completing all stages of this process suggests that students were successful in engaging in the SDR process and that the process, which was completed entirely in an asynchronous online format, was helpful to students' successful completion of the MFG 240 Specification assignment.

Revision to technical documents can take multiple forms, including: addition, deletion, substitution, permutation, or consolidation. Generally, in this section of the course, students' final specifications indicate that the SDR process resulted in students expanding their specifications, as length of final drafts were greater than those submitted for team review. Rough drafts averaged 605 words and final drafts averaged 775 words. While development in terms of length may signal successful revision of the specification in terms of adding necessary details that SDR teams found lacking, it is important for students to balance additions to these texts with other considerations for their specifications. For instance, concision is a necessary quality of technical documents, and a quality that the course instructor continually reiterated in the assignment. How students manage concerns for detail alongside concerns for concision represent not only part of the complexity of technical communication that students must learn, but also a nexus point at which students must integrate technical knowledge and communication knowledge. Recognizing the intersection of technical and communicative knowledge is one way in which technical educators might integrate interdisciplinary approaches to teaching technical content.

Beyond such concerns, students demonstrated considerable technical knowledge in writing their transmittal letters. These 1-page cover letters written to the instructor required students to explain and justify their revision decisions based on the SDR team feedback. Here, students' demonstrated understanding of the technical aspects of their selected object for the specification assignment. In many instances, students explained why they disagreed with team feedback, and did so by demonstrating their understanding of product design. Again, this opportunity provided students with an indirect opportunity to demonstrate their technical knowledge in writing, one that also signalled students' metacognitive abilities in thinking about the integrated rhetorical and technical functions of the specification.

Further data collection and analysis is required to more fully understand students' performance in the SDR communication tasks. One data collection strategy currently underway is a retrospective interview with the MFG 240 instructor to ascertain the effectiveness of implementing process-based, collaborative team review activities. In other words, it is necessary to know whether, from the instructor's perspective, the implementation of a new communication activity resulted in better student performance on their specification assignments. As the instructor regularly teaches this course, a retrospective interview would provide useful information regarding student performance in this section of the course as compared to prior sections–especially since programmatic constraints prevent a true quasi-experimental design to answer this question.

Continued analysis of students' process-based work is required to understand more fully the ways in which team reviews impact the revision practices of students in this assignment. This process will move beyond quantitative comparisons of draft documents (initial and final drafts) to include an analysis of the feedback provided to students by their assigned SDR teams as well as comparisons between feedback provided and student uptake of feedback for the purpose of preparing the final specification. In other words, it is necessary to analyze (1) what kinds of revisions SDR teams suggest during the review process and (2) whether and how students employ this feedback in making revision decisions for their final specification. Answering such questions will provide insight not only into the ways to enhance the SDR process to increase its efficacy but also into the ways students are able to read and interpret peer feedback as actionable in the context of their written technical communication assignments.

Even so, initial results from the SDR indicate that students found the process useful for understanding more fully the requirements of the specification genre and the ways that different kinds of audiences read and interpret their specifications.

B. Discussion of the Heat Transfer Analysis Implementation

Due to the timing of the heat transfer project and submission of this conference paper, the project is still on-going in the course. As of the writing of this paper, the student engineering teams have completed the proposal phase of the project. Only the written and presentation components of the proposal will be discussed.

The proposal assignment (written and oral components) was presented to the students as a communication genre from the engineer to the client meant to serve two purposes: (1) it is a marketing tool meant to sell your skills as an engineer to the client and (2) it must sufficiently demonstrate to the client that you possess the engineering skills to complete the proposed work. Most engineers, particularly those who enter consulting or sales work, need to possess the ability to craft and effectively communicate technical proposals. Several students expressed excitement about the proposal preparation task with one stating, "this is the kind of writing that I like to do."

The quality of the submitted proposals ranged from excellent to subpar where the distinguishing characteristic was the distillation of what information was needed to fulfill the two purposes of a proposal listed above. One team created a highly detailed CAD model of the engine block they had selected as their product, but did not effectively use images or video of the model to convey in the proposal what nor how they were going to analyze from a heat transfer perspective. Whereas, another team created a (by comparison) crude hand sketch of the cooling mat they had selected, but with labels, descriptions, and color selection, it was readily apparent where the coolant tubes were located, how it flowed, and what was its temperature. The first team spent a significant amount of time creating a technical model that wasn't used effectively to communicate their proposal, whereas the second team mocked up a quick sketch that easily and effectively communicated their approach. This was readily apparent to the students during the presentations based upon what questions were and were not asked of either team. Where the audience seemed confused by the proposed analysis of the first team and asked questions to that effect, the audience and client were able to probe deeper into the assumptions and analysis methodology for the second team.

Mentioned previously, during the proposal presentations, students in the class played the role of the client's engineering team. They were tasked with assessing the proposal pitch from a technical perspective and reporting to the client on how effective the product was described, assessing the technical merits of the proposed heat transfer analysis, and rating the ability of the team to complete their stated deliverables. Completing this assessment necessitated the reviewers to ask questions and probe deeper into the presented proposal. An interesting phenomenon emerged between the in class Q&A and the written review feedback. While in-class, many of the student reviewers asked pointed questions (some with and some without prompting by the instructor) of the presenters. The questioning was never combative, but a couple of the reviewers relished the role and pushed the presenting team for explanation. By contrast, the written feedback forms mostly complementary and predominantly highly rated. Several reasons for this discrepancy are possible and warrant further investigation; some that the authors have considered include: (1) the reviewers were not explicitly told that their written feedback was not going to be seen by the presenting teams therefore causing them to tone down their feedback in case the other students would read the feedback, (2) the reviewers knew they were going to be graded on their engineering feedback, perhaps they thought positive feedback would result in a better review assessment, (3) the students are all juniors or seniors and have been in class with one another for 3-4 years, providing positive written feedback might be a result of the camaraderie formed during that time. A better explanation of the purpose of the review feedback and the reflection intention of the activity to improve the student's ability to participate in workplace audits is likely warranted prior to the final project presentation and reviews.

Outstanding activities for the heat transfer analysis project include two weekly status updates (one as a written email memo and one as an informal desk meeting), the final written report, the final presentation, and the final project technical review assessment. Throughout this project, the students have been or will be exposed to several authentic workplace scenarios such as presenting a proposal pitch and reviewing a peer engineer's technical work. These are necessary and formative communication skills that our industry partners need and expect engineering graduates to possess.

Conclusion

This work in progress is successfully demonstrating that engineering course work can convey aspects of professional communication without hindering the technical content presentation; in fact, the injection of authentic engineering communication skills often helps to improve the student's technical understanding. Further work to develop mechanisms that effectively assess students' communication skills quantitatively and qualitatively will assist in drawing conclusions about the continued efficacy of interdisciplinary and integrative approaches to teaching communication within engineering technology courses.

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