Student Technical Editors as Writing Consultants for Mechanical Engineering Capstone Design Teams: A Case Study in Interdisciplinary Curriculum Development

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Abstract. This case study describes the conditions, outcomes, and pedagogical implications of a project in which technical and professional communication (TPC) students worked as technical editing consultants for a mechanical engineering instructor to support the communication needs of five undergraduate mechanical engineering teams during the final semester of their client-driven capstone design projects. Study results revealed that the participants, including the instructor and internship advisor, thought the project was worthwhile as workplace preparation and as an undergraduate capstone experience that improved TPC competencies on ABET standards for professional communication. Additional themes developed from data analysis included insights on previous course preparation, editor-team communication and workflow, and leadership/power issues between editors and team members. Recommendations for further curriculum development included considering ways to integrate student editors more fully into the teams, increasing support for effective collaboration strategies, increasing client feedback, and providing a pedagogical structure for accountability to monitor team participation in the editorial process.

Keywords: Capstone Courses, Mechanical Engineering, Pedagogy, Technical Editing, Technical and Professional Communication, Team Communication

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The Accreditation Board for Engineering & Technology (ABET) for undergraduate education has mandated that engineering students should demonstrate "an ability to communicate effectively with a range of audiences" and "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" (Criteria, 2019, p. 4-5). These two outcome-based criteria, first outlined by ABET in 2000, have formed the foundations from which colleges and universities have begun to develop initiatives to integrate technical and professional communication (TPC) competencies into engineering curriculums.

However, the development of communication skills for engineering undergraduates remains an ongoing challenge as students move from the classroom to the workplace. A recent mapping review of 187 empirical research articles investigated professional competencies of engineers and found that the needs for formal and informal communication skills were "most common" in the scholarship:

> Despite…different methodologies and whether this question was asked for all engineers or a specific discipline, all these studies came to the same conclusions: among all the competencies that engineers need, professional competencies (e.g., team-work, communication skills) are as important, if not even more important, than technical competencies, and engineers tend to have not developed professional competencies during university as much as required for practice. (Mazzurco et al., 2021, p. 10)

Consequently, engineering instructors have been challenged in their efforts to increase effective pedagogies for teaching communication skills. For example, ABET criteria for communication and teamwork are not well assessed in capstone design courses (McKenzie et al., 2004). This problem may be explained in part by the need for instructors to balance many student learning objectives in these courses that showcase students' entire range of competencies while they work on a client-oriented final project. Thus, while engineering instructors understand the importance of writing skills, they find that constraints on time and resources decrease their ability to teach strategies for effective communication concurrently with technical content (Buswell et al., 2019).

This pedagogical dilemma may contribute to a dissociation between TPC programs and the engineering programs that may depend on them for curricular support. A survey of technical writing

instructors (n=70) from colleges and universities across the U.S. found that a large percentage of "technical communication programs provide a service course for engineering programs," though "there is virtually no collaboration between the two in terms of the design or teaching of that course" (House et al., 2007, p. 3). For example, Susan Conrad's (2017) comparison of engineering student writing with professional engineer writing revealed "less accurate word choice, more errors in grammar and punctuation, and less linear organization" in the student texts caused in part by student misperceptions about workplace writing (p. 191). Furthermore, a case study at a large research university found that writing assignments in engineering courses may not reflect effective strategies for writing instruction and that "departmental curricula do not distribute writing across the four-year programs" (Yoritomo et al., 2018, p. 1).

Marie Paretti (2008) called for further investigation of several research questions related to developing a robust communication curriculum in engineering design courses including best practices for oral and written assignments, faculty training and participation, and the role of interdisciplinarity in pedagogical initiatives (also refer to Goldberg et al., 2011; Paretti et al., 2019). In response, this study seeks to answer the following research question: How do undergraduate technical editing students and teams of mechanical engineering (ME) students work together to produce written and oral communication for industry clients in a capstone design course?

We explore this research question by reporting on a case study of an interdisciplinary undergraduate curriculum initiative in which two technical writing students served as interns for an instructor teaching five student teams (16 students) in one section of an ME capstone design course in a college of a large research university. The student editors (one English major and one public affairs major) were technical writing minors and had completed at least 18 credits in six or more courses that included technical editing, communication design and production, and rhetorical analysis. The editors' internship advisor was also their instructor for some courses in the technical writing minor curriculum. Keeping in mind William Zinsser's (2006) observation that "Writing is hard work. A clear sentence is no accident. Very few sentences come out right the first time, or even the third time" (p. 9), we had two major goals for the curriculum development project: (1) ensuring that the ME students engaged in writing, reviewing, and revising documents throughout the semester and (2) improving the quality of the final report to the client. This case study contributes to research about pedagogical strategies that may improve the

communication skills of undergraduate engineering students and the professional editing skills of undergraduate technical writing students in smaller or developing programs and departments.

We begin with a review of pertinent academic literature. Then we discuss our research methodology and methods. The case study follows with themes developed during interviews with the student editors, ME team members, the course instructor, and the internship advisor as well as assignment drafts. We conclude with observations and recommendations for continuing curriculum development.

Scholarly Background

TPC's inherent grounding in rhetoric invites interdisciplinary work with many other academic and professional areas, and the relationship between TPC and engineering has been strong for several decades (Harlow, 2010). This association parallels TPC's own development from its origins as a service field for teaching writing skills to undergraduate engineers to its broader contexts as an autonomous discipline (Schriver, 2012). Since Jack Selzer's (1983) study of a single professional engineer's communication strategies, scholars in TPC have researched the writing processes of engineers both in academia and in the workplace. Scholarship has expanded, for example, to analyzing document usage and revision among a group of engineers (Paradis et al., 1985), tracing knowledge and skill transfer from undergraduate programs to the professional office (Winsor, 1990), and reporting on communication competencies in project management (Wisniewski, 2018).

Writing in the Disciplines and Across the Curriculum

This interdisciplinary relationship between engineering and TPC has continued with an emphasis on improving the communication competencies of both undergraduate engineering majors and TPC students through curricular development in writing across the curriculum and writing in the disciplines (WAC/WID), interdisciplinary teams, client-oriented communication, and knowledge transfer. Efforts in curriculum development have produced several strategies that may benefit both engineering majors and students who are pursuing majors, minors, or certificates in TPC. Natasha Artemeva, Susan Logie, and Jennie St-Martin (1999) found that communication assignments in engineering that include oral and written components can increase understanding and improve rhetorical skills such as audience adaptation. David Russell (2007) reviewed research in business and technical communication that focused on WID and distilled several

themes that supported "engaging students in coconstructing knowledge" and "socializing students into their discipline" (p. 254-260). Paretti et al.'s (2019) study of engineering students, faculty, and administrators in a European university found that communication assignments increased understanding of engineering information, selecting important information for clients, and justifying design choices. The assignments generally improved student metacognition and strategies for problem-solving. Furthermore, Julie Ford (2012) detailed the development of an interdisciplinary relationship between the mechanical engineering and the TPC programs at New Mexico Tech in which faculty members worked together to design and evaluate client deliverables. This integrated approach foregrounded the need for engineering students to achieve both technical competencies and communication competencies simultaneously while supporting TPC students' practicum experiences.

Producing Client-Oriented Communication

In addressing the disparity of perceptions between academia and the professional engineering workplace about student writing competency and preparation, Jeffrey Donnell, Betsey Aller, Michael Alley, and April Kedrowicz (2011) advocated that universities and colleges continue to develop partnerships with industry clients that support opportunities for students to produce professional communication, especially in capstone design courses. The authors called for further research "to determine what important things about communication we are teaching well and what we are failing to teach, based on students' needs and professional activities beyond the classroom" (p. 22). Paretti (2011) reported that integrated assignments with an outside client as the primary audience were effective at replicating actual workplace genres and professional contexts (also refer to Kreppel & Rabiee, 2003). Rose Norman and Robert Frederick (2000) detailed variations of curriculum development initiatives in which integrated teams of engineering students and technical editing students worked on client-driven design projects. Technical editing students participated as full members of teams or as separate members of editorial teams that worked on deliverables with several engineering teams. Each configuration produced pedagogical benefits and drawbacks based on team dynamics and "positive interdependence" between technical editing students and engineering students (p. 186).

Transferring Knowledge from Academia to Industry

In discussing the need for building on previous report-writing assignments with ME students, Ford (2012) found that "Frequent reinforcement of writing a variety of related documents" is "key to promoting low-road transfer—application of knowledge to situations similar to the context in which they are learned" (para. 25). Knowledge transfer may work in at least two ways. In the broadest sense, instructors in interdisciplinary communication projects can support content and competencies that students can transfer to more than one discipline (Ford, 2012). For example, engineering students should understand and apply communication theory such as audience analysis and genre structures, while TPC students should understand and apply those competencies to specific engineering projects on which they work. This pedagogical strategy also supports transfer of skills and competencies developed in academia to applications in the professional workplace (Narayanan et al., 2010). More specifically, several studies have found that internships and practicums in TPC supported skills transfer from academia to the workplace (Cordiero & Sloan, 1996; Bourelle, 2015; Narayanan et al., 2010). For example, Elisabeth Kramer-Simpson, Julianne Newmark, and Julie Dyke Ford (2015) found that the knowledge gained in interdisciplinary undergraduate client projects transfers to workplace skills such as adapting to audiences, attention to deadlines, and reporting progress (also refer to Bourelle, 2015; Kramer-Simpson et al., 2015).

Methodological Framework

Harlow (2010) argued that "Interdisciplinary research straddles multiple bodies of knowledge, in the process circumventing conventional reasoning, employing, or constructing unfamiliar methodologies, or taking another philosophical path entirely" (p. 325). With this broad context in mind, the present study is informed by situated learning theory (Lave & Wenger, 1991; also refer to Vygotsky, 1978), which encourages instructors to introduce students to communities of practice/discourse communities (Henry, 2013) where participants communicate using genres that define the communities (Luzón, 2005).

Situated learning theory is manifest in WAC/WID initiatives (e.g., Bazerman & Russell, 2003; Mackiewicz, 2012) in which TPC instructors collaborate with colleagues in other disciplines to integrate curriculums, often with the goal of supporting transfer of communication competencies from academia to the workplace (Dyke & Wojan, 2000). Herrington (1985) observed that "writing can

serve in introducing students not only to the intellectual activities of a discipline, but also to the social roles and purposes of various disciplinary communities" (p. 331). Jeff Froyd, Anneliese Watt, and Julia Williams (2002) observed that "The purpose of a senior capstone design course is to provide students a situated learning experience that is relevant to their future professions as engineers" (p. 3). Jean Lave and Etienne Wenger (1991) extended situated learning to include legitimate peripheral participation such as the one addressed in the present study, which explores dimensions of editor and team communication among stakeholders in a capstone design project (also refer to Carter et al., 2007).

Method

Case studies offer robust descriptions of participants and research contexts using data collected from several sources (Eaton, 2010; Yin, 2018). Researchers used purposeful sampling to determine participants, who were recruited from students (n=16) enrolled in the second semester of a two-semester capstone design course for ME majors in their last undergraduate semester in a college of a large research university. Additional participants were two students minoring in technical writing in their final undergraduate semester and who were enrolled in a three-credit internship course. The instructor and internship advisor were also participants as well as researchers. Participants were recruited via email and class announcements by the ME instructor during early team meetings. The research was approved by the authors' institutional review board.

Researchers collected data from transcripts of participant interviews, project status memos from the student editors to the instructor, document drafts with editorial comments, and final versions of project reports and slide presentations from each team. Structured interviews with all participants were recorded using Zoom and were transcribed for analysis. Open-ended interview questions addressed topics such as preparation for professional communication, workflow, interactions between team members and editors, and ways to improve communication opportunities in the course. Following Yin's (2018) recommendation, researchers triangulated all qualitative themes to provide a robust data set. Researchers used thematic analysis (Braun et al., 2019) supported by NVivo 11 qualitative analysis software to interpret all documents, which were first open coded for salient themes based on the structured interview questions. Open codes were refined during axial coding to derive the final themes (i.e., selective coding).

Case Study Results

Five ME students (about 33 percent of the students enrolled in the course section), both student editors, the course instructor, and the internship advisor consented to participate in the research. Four of the five teams in the course were represented by at least one team member. All study participants reported varying degrees of satisfaction with the course processes and products and made recommendations for improving their experience. We begin the case study by describing the pedagogical context, including curriculum development and course workflow. Then we move to address themes related to scaffolding and course preparation, editor-team communication roles and workflow, improvement of technical communication competencies, and leadership/power issues. We conclude with recommendations for improving the next iteration of curriculum development and application.

Pedagogical Context

Penn State Harrisburg is a doctorate-granting college in Penn State University with an undergraduate population of about 5,000 in five schools that include Science, Engineering, and Technology (SET) and Humanities. The ME Program, in the School of SET, serves about 60-80 undergraduates. The Technical Writing Minor Program, in the School of Humanities, was recently founded and has produced 10 minors in its first four years. One author (Kirkscey) has research interests in undergraduate capstone experiences and is the director of the Technical Writing Minor Program. The other author (Attaluri) is the instructor for the ME capstone design experience, a two-semester course in which teams of ME students work with industry clients on research and development projects.

In a brief discussion with the director of the School of SET, Kirkscey inquired about a possible interdisciplinary collaboration on curriculum development. The SET director agreed, placed the topic on the agenda of a planning meeting for all engineering capstone experience instructors, and invited Kirkscey to attend. During the meeting, Attaluri requested writing support for teams in the second half of a two-semester ME capstone design course, and the two authors agreed to develop a curriculum initiative to provide writing support. After reviewing scholarly literature, course enrollment numbers, and scheduling constraints, the authors decided to adopt a writing consultant model as a workplace/internship structure for the student editors (e.g., Carnegie, 2018; Mackiewicz, 2012) rather than moving to integrate the student editors into the teams (e.g., Dyke &

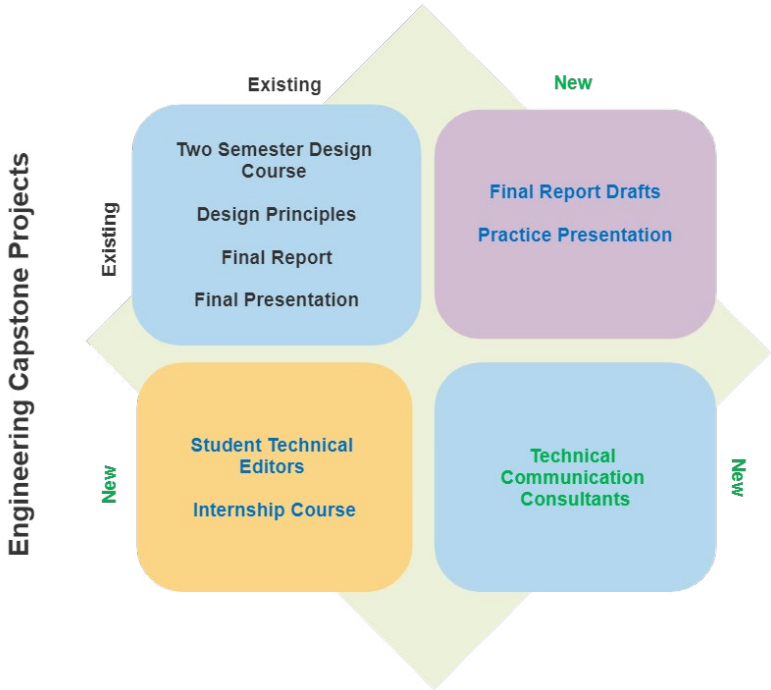
Wojan, 2000). Kirkscey served only as the technical editing students' internship advisor and did not communicate with Attaluri or the ME teams during the semester except to attend a rehearsal for each team's final presentation at the end of the semester. The project served as a capstone experience for the students, all of whom were in their last semester before receiving their baccalaureate degrees.

Curriculum Development

All students participated in an intertwined situated learning experience that would closely resemble a workplace context (e.g., Artemeva, 1998). The ME teams, as subject matter experts, worked with an editor outside their team organization in an iterative process to provide written and oral presentations to their project clients. Previous versions of the capstone design course required only the submission and grading of the final report and oral presentation for the client. Teams did not submit document drafts for instructor evaluation but instead produced brief update memos to report progress on the document and presentation. In the revised curriculum, the student editors as interns worked for the ME instructor to provide expertise to the ME teams. Furthermore, the revised curriculum required two drafts of the final report in four-week intervals during the 14-week semester. Teams also submitted one draft of the final presentation for instructor grading and feedback about halfway through the semester (refer to Figure 1 on the next page).

The instructor also requested that the student editors research and provide the teams digital links to instructional materials for formative assignments such as team project update memos to clients and to the instructor based on topics in Michael Alley's *The Craft of Scientific Writing* (2018) including formatting, figures, tables, equations, references, and writing style. Consequently, the student editors created and/or adapted templates and a style guide for the document genres and wrote memos to the instructor detailing progress on their work with the teams and on the instructional materials. Instructor grading for the written assignments and PowerPoint presentation was based on an assessment rubric developed by ABET representatives (Warnock & Rogers, 2018). Performance indicators included articulation of ideas, professionalism, organization, quality of work, and use of graphs/tables (provided in Appendix).

Figure 1. Existing vs Revised Curriculum Models for Task Roles and Assignments



Note: The curriculum initiative added two final report drafts and a presentation draft to the teams' deliverables in the semester.

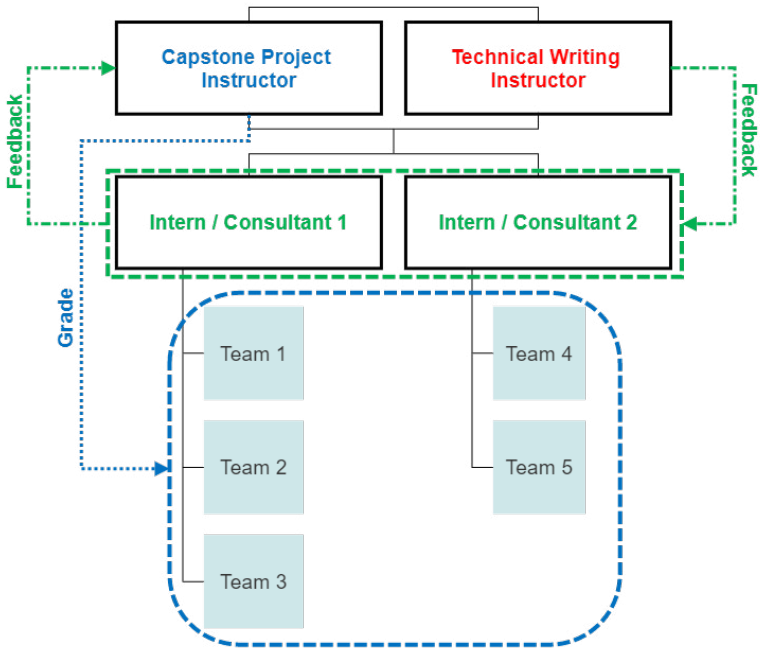
Course Workflow

In an initial meeting with the student editors, the instructor briefed them on their duties and reviewed the specific assignments and due dates. During the semester, the teams and student editors participated in an iterative process of drafting and revising all assignment submissions before submitting the final products to the instructor for evaluation and grading. The editors' and teams' primary goals in the course were to produce drafts and final versions of two summative assignments: a final project report for an industry client and slides for a multimodal presentation (i.e., voice-over PowerPoint talk on Zoom) for the client and a general audience of stakeholders including other possible clients, prospective employers, university administrators, friends, and relatives. Teams, with editorial support from the editors, produced two drafts of the final report that were due at the four- and eight-week points during the semester (refer to Figure 2).

To balance the student editors' workloads, the instructor

requested that one student editor work with three teams who had completed more substantial drafts of the project reports during the first semester of the capstone experience, while the other student editor worked with the two remaining teams, whose documents needed additional editorial attention. The instructor used Microsoft Teams as a communication tool with the teams and included their respective editors in the platform. All students also had access to an online course management system (Canvas) for the course materials, including assignment descriptions, due dates, and web links to sites about technical communication. The ME instructor requested that the editors work individually with their teams to create drafting and editing schedules based on the due dates of the drafts and final report. Student editors also created their own internal workflows for producing a style manual and finding other writing support materials (e.g., information on grammar, punctuation, syntax, and visual design) that the teams used during the semester (Figure 2).

Figure 2. Workflow for Project Participants



Note. Information about the drafting process and writing support materials circulated among the student editors (interns/consultants) and the instructor. The instructor provided graded feedback of assignment drafts to the teams. The technical writing instructor (internship advisor) interacted only with the technical editors during the semester.

Scaffolding and Previous Course Preparation

All team members and student editors had completed at least nine credit hours in required general education written and oral communication courses: first-year composition, public speaking, and a discipline-specific second-year technical writing course. Additionally, ME students had been introduced to professional workplace writing during a first year (cornerstone), three-credit engineering design course.

Student editors and team members in general felt that their preparation in previous technical communication courses supported the goals of the capstone course and enabled them to participate fully in developing the summative course documents. In addition to completing courses for the technical writing minor, one student editor had gained project management competencies during another internship. The other student editor had taken an introductory technical writing class designed for engineering and science majors, which contributed to a deeper understanding of style and content issues specific to the internship needs:

> This [internship] would have absolutely blindsided me had I not kind of been introduced to it…and then kind of used each of those courses as a steppingstone to get here. Those preliminary or prerequisite courses are absolutely vital from my experience. (Student Editor)

Team members also benefitted from the two required general education courses in technical writing for engineering students and in public speaking. Additionally, one team member reported some benefits from taking the cornerstone engineering design course for first-year engineering students. While at least two upper-level ME courses also required lab reports, they were graded on content alone and not as technical communication documents adapted to a particular audience other than the instructors.

Improvement of Technical Writing Competencies

Instructor perspective. The course instructor was generally satisfied with improvement of the teams' technical writing competencies during the curriculum development initiative. At the conclusion of the first semester of the course, all teams scored either *not acceptable* or *below expectations* on all ABET communication performance indicators (refer to Appendix) on a draft of the final report. In the revised curriculum, all teams demonstrated improvement on *Professionalism*, *Quality of Work,* and especially on *Use of Graphs/Tables*. In the latter performance indicator, two teams

exceeded expectations, two teams met expectations, and one team was below expectations. However, limited improvement was observed on *Organization* and *Articulation of Ideas*. Teams continued to struggle with writing clearly and concisely with coherent transitions; only two teams met expectations, while two teams were below expectations, and one team's work was not acceptable.

Student perspectives. Team members and student editors noted that their general technical writing competencies improved during the semester of situated learning. For example,

> When I took my technical writing class, it was very helpful for me to learn how to properly structure things and write in a technical manner. But then actually having to do it with this project and incorporating all the presentations and everything kind of really brought it together. So, I feel like now, I have the confidence to write a technical paper or give a technical presentation. (Team Member)

All students and the instructor especially saw improvement in the visual communication elements in the project reports and presentation slides. One student editor discovered a deeper understanding of the value of multimodal communication in a different discipline:

> I guess I never really thought about how important those graphics would be. In my mind, as an English major, they never come up anyway. This is math and science, and it's really cool to see how writing and those things come together. But it was also a culture shock in a lot of ways. (Student Editor)

Team members specifically noted progress in their final presentations because of the editorial work on the PowerPoint slides, which also improved their oral presentations.

Several team members also increased their understanding of audiences and the need to produce technical communication at a more general level while also including more detailed information for subject matter experts: "And if they want to ask more questions, you open the floor at the end, and you can answer in a more technical manner" (Team Member). The instructor agreed that the student editors embodied an excellent general audience for the team members that sensitized them to differing needs for explanation of the projects: "When someone steps in new that knew that insight, I keep telling them, did you think about the audience? But rather than telling, practicing helps them" (Instructor). Team members also realized that one of the audiences for their report and presentation

consisted of members of their own team, some of whom only understood the technical aspects of certain parts of the project (and thus, only specific sections of the project report and presentation). This context emphasized to teams that technical communication was more than just explaining engineering topics to non-experts. It also underscored the need to ensure that all team members had a working understanding of all parts of the project.

Editor-Team Communication Roles and Workflow

To grant autonomy for working within the schedules of each team and student editor, the instructor purposely under-defined the parameters for editor-team communication. However, the student editors would have preferred more defined roles and expectations to understand the communication and workflow needs of the teams in the scope of the assignments and deadlines.

> In the very beginning of this internship, I felt overwhelmed with the expectations laid before me. I was just expecting to have a few meetings with my teams and edit their work as needed. I had no idea we would be creating a style guide, let alone a comprehensive 12-page one that took a couple of months to complete, especially after initially being told it was to be completed during the second week of classes. (Student Editor)

This aspect was especially important during the iterative process of drafting and editing necessary for the final submissions of the summative documents (i.e., the final report and PowerPoint slides for the final presentation).

The instructor also suggested that editors only communicate with team leaders. However, the editors thought that at least initial meetings with all team members were important to establish communication roles, norms, and expectations in the first weeks of the course. There was some initial confusion about whom should be communicating since the Microsoft Teams platform allowed for both individual and group messaging, so the editors defaulted to posting all messages in the group chat platform so that all participants received all messages. Team members were satisfied with this decision: "I think it's important to make sure that everyone is held accountable for what it is that they're actually doing" (Team Member). The editors responded to all members who communicated, regardless of their leadership statuses on the teams

The student editors and teams settled into a negotiated process that improved as the course progressed. A student editor noted:

> I definitely felt all the groups maintained slightly better communication because they were more comfortable with my role in their projects and were more willing to implement my edits once they got to know me and understood my perspective for improving their work. (Student Editor)

Nevertheless, the editors and team members admitted that the iterative process was difficult:

> Some [members] of my team were good with communication; others weren't. And to me, it seemed like sometimes some of my group had seen the information or the questions going into the group chat but weren't responsive. So, I learned that it can be frustrating when getting no answers when there's a deadline to meet. (Team Member)

While the student editors felt that they were responsible for leadership on the editing processes for the assignments, their outlook remained positive:

> Almost every time I received communication from my teams, I was the one to initiate it. Even then, it would sometimes take days to get a response, and sometimes, I was altogether ignored. When they did reach out to me, though, it was meaningful. (Student Editor)

Turnaround time for document drafts was especially problematic for the editors. The editors and teams generally agreed that teams should give editors 48 hours to complete their work on a draft. While some teams provided their drafts in a timely manner, others asked the editors to provide feedback in as little as nine hours, and still other teams completely missed deadlines during the process.

Student editors attended few (virtual or in-person) meetings with the instructor and team members. When the instructor, teams, and editors did meet, one team member commented that the instructor consistently placed more emphasis on the project's subject matter without contextualizing the information in a discussion of how to present the information using appropriate technical communication strategies. Both student editors expressed a desire to become more familiar with their teams at the content level and at the interpersonal/team-building level. Additionally, the editors never met with the clients or discussed client needs with the teams.

The student editors also would have liked more specific instructions from the instructor on their roles as editing consultants. While the instructor had initial meetings with both student editors, the instructor determined that one of the student editors needed additional information because of an extended absence, so the

instructor chose to task one student editor to deliver messages to the other about course content, the iterative editing process, and communication strategies

Leadership and Power Issues: Defining Roles

The student editors felt that the instructor did not give them enough detailed guidance throughout the course. Their internship advisor explained to the student editors that part of their experience was to work within the constraints given to them by their employer, and that professional positions often entailed an increased need on their part to negotiate with the employer to better define their tasks. However, the student editors remained uncomfortable with this task during the semester. This discomfort with establishing the roles of the student editors in the writing process stemmed in part from the instructor's giving the student editors and teams the autonomy to create their own workflows for drafting the assignments. Except for the due dates for the two report drafts and the final report, the editor-team iterative process did not appear in the course schedule or assignments. While drafts of the reports were graded in part on the teams' incorporation of editor feedback, the editors did not have access to the instructor's comments to the teams and so did not know how to (or if they should) address workflow issues that could support improving the writing process.

The instructor's choice to give the student editors and teams autonomy to work out their own workflows revealed a liminal impasse (e.g., Jeyaraj, 2004) for the interns, who were neither part of a team nor an instructor and did not have the power to control the workflow:

> [The instructor's] notion that [we] should formally assign anything to our teams felt both unbalanced and unfair; we cannot simultaneously be their equals in this project and be given duties of an instructor. That felt too much like project management as opposed to technical editing. (Student Editor)

Though the instructor provided a schedule and grade for internal draft submission deadlines (i.e., grades for participation in the iterative work between the drafts), some teams did not respond in a timely manner (or at all) to student editor requests for drafts and revisions. And, because of the student editors' position in the liminal spaces among the teams and the instructor, they had no way to guarantee production of workflow drafts or to know whether the teams submitted the drafts.

Recommendations: Moving Forward

As we begin to formalize plans for future opportunities for student editors to work with engineering capstone design teams, we will consider several modifications. Providing effective pedagogy to the course experience will take additional planning and deployment, including increasing editors' participation on teams, supporting effective collaboration strategies, incorporating client feedback, monitoring team participation in the editorial process, and improve the scope and sequence for prerequisite courses that address TPC learning objectives. Moreover, to distribute TPC education and assessment across the typical ME undergraduate four-year program, we will further align and revise a scope and sequence for ABET TPC objectives in the first-year, three-credit cornerstone engineering design course, the general education course in technical writing for engineering, and the two-semester capstone course.

Increase Integration of Student Editors on Teams

The results of this study point to a need for student editors to become more integrated members of teams instead of serving as outside consultants. Several of the ME team interview participants and both student editors advocated that the technical editors should participate in both semesters of the capstone course instead of beginning only in the second semester. Furthermore, both editors reported that they spent an inordinate amount of time gaining the content knowledge necessary to support the communication of complex engineering topics to various stakeholders. This move to full participation from project inception will decrease the need for technical editors to catch up with invention and team norming processes that occur at the start of a project (Dyke & Wojahn, 2000). Through increasingly mediated collaboration, technical communicators in industry are revising their functions on teams to increase the flow and quality of communication (Conklin, 2007). Consequently, future versions of this capstone/internship experience should move past a narrow focus on writing and editing documents and toward a broader participation of student editors "working on teams and planning and facilitating communication processes, not just products" (Hart & Conklin, 2006, p. 395) and provide opportunities for editor-team relationship building (Gaitens, 2000). These communication opportunities play an essential role in the success of "interdisciplinary, capstone design courses" in engineering (Wojahn, 2004, p. 156). Working as part of integrated teams in project-based and/or service-learning activities with outside clients, TPC students and engineering students alike have benefitted

from increased opportunities for teamwork on oral and written communication products (Paretti et al., 2007; also refer to Mackiewicz, 2012).

Increase Support for Effective Collaboration Strategies

For more comprehensive participation on the teams, student editors and team members should be introduced to effective collaboration strategies that emphasize the relationships among the different stakeholders (including the instructor), client communication assignments, and professional workplace communication (Dyke & Wojahn, 2000; Ford & Riley, 2003). Cooperative learning involves, among other topics, "positive interdependence, individual accountability, face-to-face promotive interaction, social skills, and group processing" (Dzemidzic et al., 2019, para. 1; also refer to Johnson & Johnson, 2011). The team-building process also underscores the need for inter-team accountability. During the team-forming stage, members should review or identify their communication proclivities using a platform such as the Gallup organization's CliftonStrengths (Soliman & Al-Bahi, 2020). Team member evaluation tools such as the Comprehensive Assessment of Team Member Effectiveness (CATME) (Loughry et al., 2007; Ohland et al., 2013) can be used throughout the project to monitor internal and external communication competencies among students.

Incorporate Client Feedback

Though data from ME team study participants' interviews suggested that their clients were satisfied with their final communication products, the authors will encourage more structured and measurable feedback from clients by developing a rubric that clients can use to monitor and report on communication interactions with their teams (for example refer to Maleki, 2006; Rover et al., 2014).

Monitor Team Participation in the Editorial Process

Individual accountability is one of the foundational goals of cooperative learning (Johnson & Johnson, 2011), and finding ways to emphasize and measure individual participation should increase the accountability of all students as they participate in the editorial process (Norman & Frederick, 2000). The instructor, in collaboration with the TPC advisor, should clearly define assignment expectations and team roles as well as create strategies for holding all team members accountable throughout the editorial process. This move will decrease the undefined autonomy for planning and enacting

the writing process that teams and student editors encountered in the present study. Furthermore, grading of the draft reports will be changed to an incentive model (extra credit) instead of penalizing ME teams who choose not to work with the student editors. Integrating a more specific technical writing rubric into the final report should also provide additional control to the student editors. The rubric will also decrease the need for student editors to take on leadership duties that give them too much power over their peers.

Shift Model from Internships to Undergraduate Teaching Assistants

To give more control to the editors, the instructor plans to move from an internship model to an undergraduate teaching assistant (UTA) model. Using engineering UTAs for engineering capstone design courses has become more widespread in the last two decades (Schiano, 2012; MacNevin et al., 2016). Early research in using UTAs who are engineering majors trained in technical writing has shown promise for future curriculum development projects using this model (Jenkins, 2021; Kecskemety et al., 2015). Additionally, the emphasis on training to write appropriate feedback (Jenkins, 2021) may be reduced or eliminated when using undergraduates who are relatively more prepared than their engineering counterparts to engage in professional editing strategies. In the next iteration of curriculum development, students who are minoring in technical writing and have completed a technical editing course will become UTAs by enrolling in an independent studies course with a TPC faculty member who will provide pedagogical support to the students, work with the engineering instructor(s), and design reflection assignments to monitor team progress. The UTA designation will also allow the editors access to the instructor's feedback to the teams in the learning management system. This move will encourage the UTAs to give teams feedback that the instructor can view on the draft submissions. The next version of curriculum development should also better reflect the academic nature of the work while still providing some internship features such as independent work for clients.

Conclusion

This case study described the conditions, outcomes, and pedagogical implications of a project in which TPC students worked as technical editing consultants for a mechanical engineering instructor to support the communication needs of five undergraduate mechanical engineering teams during the final semester of their client-driven

capstone design projects. Though this curriculum development project was limited by a small sample size, the research methods and outcomes contributed to empirical scholarship that explores challenges and possible solutions for interdisciplinary undergraduate capstone experiences, especially ones at smaller or developing programs.

Study results revealed that the participants, including the instructor and internship advisor, thought the project was worthwhile as workplace preparation and as an undergraduate capstone experience that improved TPC competencies and met ABET standards. Moreover, several themes that emerged from the study data warranted reflection and curriculum revision before we attempt to move forward. Instructors and internship advisors should consider ways to fully integrate student editors into the teams. Furthermore, instructors should increase support for effective collaboration strategies and provide a pedagogical structure for accountability to monitor team and student editor participation in the editorial process.

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Appendix

Table A1. Rubric for Assessing ABET Written Communication Criteria (Warnock & Rogers, 2018, p. 70)

Performance Indicator	Not Acceptable	Below Expectations	Meets Expectations	Exceeds Expectations
Articulation of Ideas	Student does not articulate ideas at all	Text rambles, points made are only understood with repeated reading, and key points are not organized	Articulates ideas, but writing is somewhat disjointed and difficult to follow	Articulates ideas clearly and concisely
Professionalism	The writing style is inappropriate for the audience and for the assignment	Style is informal or inappropriate, jargon is used, improper voice, tense, etc.	Usually uses good professional writing style	Uses good professional writing style
Organization	Little or no structure or organization is used	Some structure and organization are used	Generally organized well, but paragraphs combine multiple thoughts or sections are not identified clearly	Organized written materials in a logical sequence to enhance the reader's comprehension
Quality of Work	Work is not presented neatly; spelling/ grammar errors present throughout more than 1/3rd of the paper	Work is not neatly presented throughout; one or two spelling/ grammar errors per page	Written work is usually presented neatly and professionally; grammar and spelling are usually correct	Written work is presented neatly and professionally; grammar and spelling are correct
Use of Graphs/ Tables/etc.	No Figures, Tables, or graphics are used at all	Figures, Tables, and Graphics are present but are flawed (axes mislabeled, no data points, etc.)	Use of Figures, Tables, and Graphics that are usually in the proper format	Use of Figures, Tables, and Graphics that are all in proper format

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