WORK-IN-PROGRESS: An Interdisciplinary Model for Teaching Technical Communication in Multidisciplinary Capstone Courses

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Introduction

Capstone courses are often the culminating piece of the undergraduate engineering experience, giving students the opportunity to apply their acquired engineering knowledge to a semester- or year-long sponsor-based design project as part of preparation to enter the engineering field. In addition to working through the engineering design process to meet a sponsor designated need, students must also practice and apply professional practices: project management, meetings (team, advisor, sponsor, instructors), presentations, and project documentation. Developing effective technical and professional communication practices are an essential component of student learning outcomes for the course and are linked to student success beyond graduation. This is acknowledged in ABET Criterion 3 which requires accredited programs to document effective communication to a range of audiences as a student outcome [1].

Research demonstrates that sustained, iterative practice in writing strengthens students' knowledge transfer and critical thinking skills [2-4]. Further, we know there is industry demand for graduates with both technical and professional skills who can put those skills to immediate use in their careers. [5-10]. The American Society of Mechanical Engineers (ASME) define professional skills as: "problem solving, teamwork, leadership, entrepreneurship, innovation, and project management" [11]. From this research, we believe a co-teaching model bringing together engineering faculty and faculty with expertise in technical communication may improve students' professional communication skills. Our hypothesis is that this co-teaching model will result in a strengthening of student writing/communication outcomes while also demonstrating the interdisciplinarity students will need in their engineering careers.

Given the capstone course's unique positioning as the bridge between student and engineering professional, and the extensive technical/professional communication practices vital to the success of the design project, a co-teaching model was proposed and implemented beginning with the 2020-2021 academic year. This model embedded a member of the department's technical communications faculty as a co-instructor to enhance technical communications in the course by:

- developing and delivering technical and professional communications-focused course content,
- providing graded and non-graded feedback and support to students, and
- reviewing course materials and modifying as needed to strengthen student communications outcomes.

This collaborative approach is intended as an innovative and proactive effort to provide students with focused instruction on technical/professional communication topics, alongside and integral to their capstone experience. It is further meant to provide additional opportunities for students to iteratively practice and receive feedback on their communication skills throughout the two-semester course sequence.

In addition to demonstrating by practice the interdisciplinary nature of course project teams, a multi-year study was developed to explore the impact of this co-teaching approach on student perceptions and outcomes. Our research questions are:

> RQ1: How do students rate their preparedness in technical/professional/workplace communications when entering this interdisciplinary co-teaching model capstone course, at the mid-point of the course, and at the end of the course?
>
> RQ2: Do demographics have any impact on student self-reported preparedness in technical/professional/workplace communications?
>
> RQ3: Does a communications-enhanced co-teaching model in capstone courses improve communication outcomes for students based on a comparative evaluation of student work completed before and after the implementation of the co-teaching model?

This work-in-progress paper will explore initial data collected from students regarding their perception of preparedness in technical/professional/workplace communications skills throughout the two-semester Multidisciplinary Design Capstone course sequence to address RQ1 listed above.

Background

At The Ohio State University, the college of engineering offers a Multidisciplinary Design Capstone (MDC) program to both engineering and non-engineering students. MDC is offered through the college's department of engineering education and gives senior engineering students the opportunity to fulfill their respective program's capstone requirement. Non-engineering students enroll in MDC to meet their Engineering Science Minor requirement. The program's instructional team consists of a program director, engineering senior lecturer, and a technical communications faculty who also is the director of the technical communications program within the department of engineering education. MDC forms teams of 5-7 students from different disciplines to complete a sponsored project over the two-semester course sequence. The MDC program's annual enrollment is 70-80 students. Student teams are formed for 15-20 projects. The teams execute a design process that includes problem identification, conceptual generation, detail design, and validation. Students document and share their work through a range of written documentation assignments and by delivering oral presentations at critical stages of the design process.

MDC's curriculum is a combination of lecture and student-led project work designed to introduce/guide students through the engineering design process. The instructional team met several times to discuss desired improvements to curriculum and student communication outcomes. Based on those initial meetings, the technical communications faculty developed activities and delivered lectures over a range of topics including:

- Writing for audience and purpose
- Common professional genres (emails, memos, reports)

- Technical communications style
- Best practices for developing and delivering presentations
- Best practices for poster presentations
- Best practices for document design
- Providing peer feedback
- Data visualization and effective graphics
- 5 C's of technical communication: concision, clarity, coherence, correctness, confidence

The technical communications faculty reviewed existing course materials and revised course assignments and rubrics to clearly align with desired technical and writing outcomes for documentation and presentations. Assignments are scaffolded and are both formative and summative in nature. Assignment instructions and rubrics are discussed with and made available to students in advance.

For the duration of the course, the instructional team meets weekly to discuss overall student progress, projects, team dynamics, and grading/feedback. The instructional team assesses the capstone teams' written assignments and presentations with defined rubrics. Students receive a score and feedback for all assignments, with formative assignments and activities designed to lead to improved work in the higher stake assignments. Assignment feedback focuses on both technical/engineering and communication standards. The largest writing assignment—the design report—is completed over the two semesters. The report is broken into chapters with each chapter being submitted at the completion of a design milestone (e.g., problem identification, conceptual design, detail design and validation) along with the previous chapter(s). The technical communications faculty modified the assignment rubrics to account for this revision model, providing graded incentive for students to engage in iterative writing practice by reviewing and incorporating previous instructor feedback on an earlier chapter to earn points for revisions.

In addition to the engineering-focused advising of students by members of the instructional team, the technical communications faculty instituted additional office hours and availability to meet with students individually or as a team for assistance with technical communication and/or professional support.

Method

Our multi-year mixed method study began gathering data during the 2020-2021 academic year by gathering data in two ways:

1. Anonymous surveys at the beginning, middle, and end of each academic year.
2. Collecting student writing/communication samples submitted during the two-semester course.

Surveys

All students enrolled in the capstone course, engineering majors and non-engineering majors, were invited to participate in the study. Students agreeing to participate were distributed

anonymous Qualtrics surveys at the beginning, middle, and end of the course sequence. Each survey collected the following demographic data (with an option for declining to answer):

- Age
- Gender
- Race
- Ethnicity
- Major and Minor
- First generation status
- L2 status
- Previous writing courses

Students were asked to rank their perceptions, abilities, and experiences related to writing, technical/professional communication, and teamwork using the following questions:

- How important do you believe technical writing skills will be in your career?
- How important do you believe professional communication skills will be in your career?
- In honestly assessing your current abilities, how would you rate your ability to write in a technical writing style?
- How would you rate your experience in preparing professional workplace communications (emails, reports, memos, preparing and delivering presentations)?
- In honestly assessing your current abilities, how well do you work collaboratively/as part of a team?

Each survey asked students to assess their current level of preparedness in the areas outlined in Figure 1 at the time of the survey's distribution.

	Not Prepared	Minimally Prepared	Somewhat Prepared	Adequately Prepared	Very Prepared
Overall writing skills needed for job performance	◎	◎	◎	◎	◎
Communication skills relevant to engineering	◎	◎	◎	◎	◎
Interpreting data and communicating about its meaning	◎	◎	◎	◎	◎
Ability to communicate for many purposes	◎	◎	◎	◎	◎
Ability to re-purpose communications in a variety of forms	◎	◎	◎	◎	◎
Ability to edit your own writing	◎	◎	◎	◎	◎
Ability to write collaboratively with a diverse group of people.	◎	◎	◎	◎	◎
Ability to collaboratively edit the writing of your peers	◎	◎	◎	◎	◎

Figure 1 Student Preparedness Ranking - All Surveys

In the end survey, students were provided an additional prompt asking them to rate their preparedness in the areas noted in Figure 2 at the completion of their technical/professional communication enhanced version of the multidisciplinary capstone course.

	Not Prepared	Minimally Prepared	Somewhat Prepared	Adequately Prepared	Very Prepared
Communicate effectively in common professional communication genres (emails, reports, etc.)	◎	◎	◎	◎	◎
Communicate using technical communication conventions and style	◎	◎	◎	◎	◎
Communicate professionally and efficiently within a team	◎	◎	◎	◎	◎
Prepare professional, effective presentation visuals	◎	◎	◎	◎	◎
Deliver professional, effective oral presentations	◎	◎	◎	◎	◎

Figure 2 End Preparedness Ranking

In all surveys, students were also given the opportunity to complete the following open-ended questions with modifications to the language based on the survey's distribution schedule (noted in parentheses):

- Please describe your experience (past, present) with technical writing. (all)
- Please detail how your technical writing and professional skills might be improved. (all)
- Please detail how, if at all, your technical writing and professional skills have improved since the beginning of the course sequence (mid-point, final)
- Please detail how, if at all, your technical writing and professional skills have improved since the beginning of the course sequence (mid-point final).

Student Work

While not part of this work-in-progress paper, the authors are collecting documentation produced as part of the capstone course to evaluate and share in the future as part of the ongoing study.

Results

Since this is a work in progress, the purpose of this paper is to look at student self-perceptions from the 2020-21 and 2021-22 academic years as it relates to RQ1. The following sections review and compare the survey results at the beginning, middle and end of the capstone course as

it pertains to technical communication categories. The authors reviewed the 2020-21 and 2021-22 survey data in the following charts to determine trends. This analysis is not to be considered a detailed review but a brief look at the initial data. A more detailed analysis including comparing student perceptions, student work, and demographics will be done in future publications once the research study has completed (RQ2 and RQ3).

The total number of respondents for the 2020-2021 academic year was 41 for the beginning survey, 43 for the middle survey, and 47 for the end survey. The total number of respondents for the 2021-2022 academic year was 53 for the beginning survey, 80 for the middle survey, and 64 for the end survey. These respondents included both engineering and non-engineering students. In the following figures (Figures 3-9), the values indicate the average score of all respondents based on the Likert scale as follows:

5 – Very Prepared
4 – Adequately Prepared
3 – Somewhat Prepared
2 – Minimally Prepared
1 – Not Prepared

The average Likert score of respondents is on the vertical axis and the level of preparedness is on the horizontal axis. The title on the figures is the academic year and category. The expected overall outcome from the beginning survey to the end survey would be observing respondents indicating that they became more prepared (e.g. an increase in the Likert score) as they progressed through the two-semester course.

From the data, the trends indicate that respondents reported being more prepared for the professional environment as they progressed through the course sequence for both 2020-2021 and 2021-2022 academic years. These trends are shown in Figures 3 and 4.

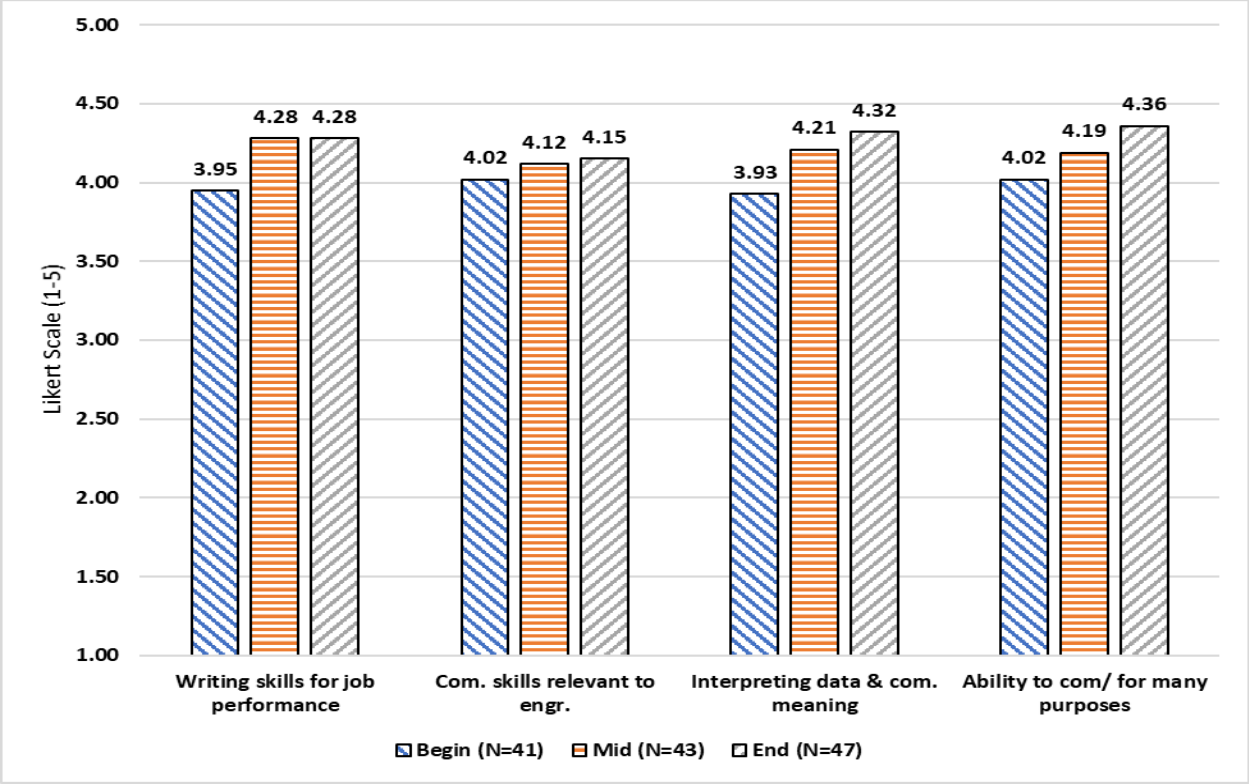

Figure 3 2020-2021 Student Preparedness for Professional Environment

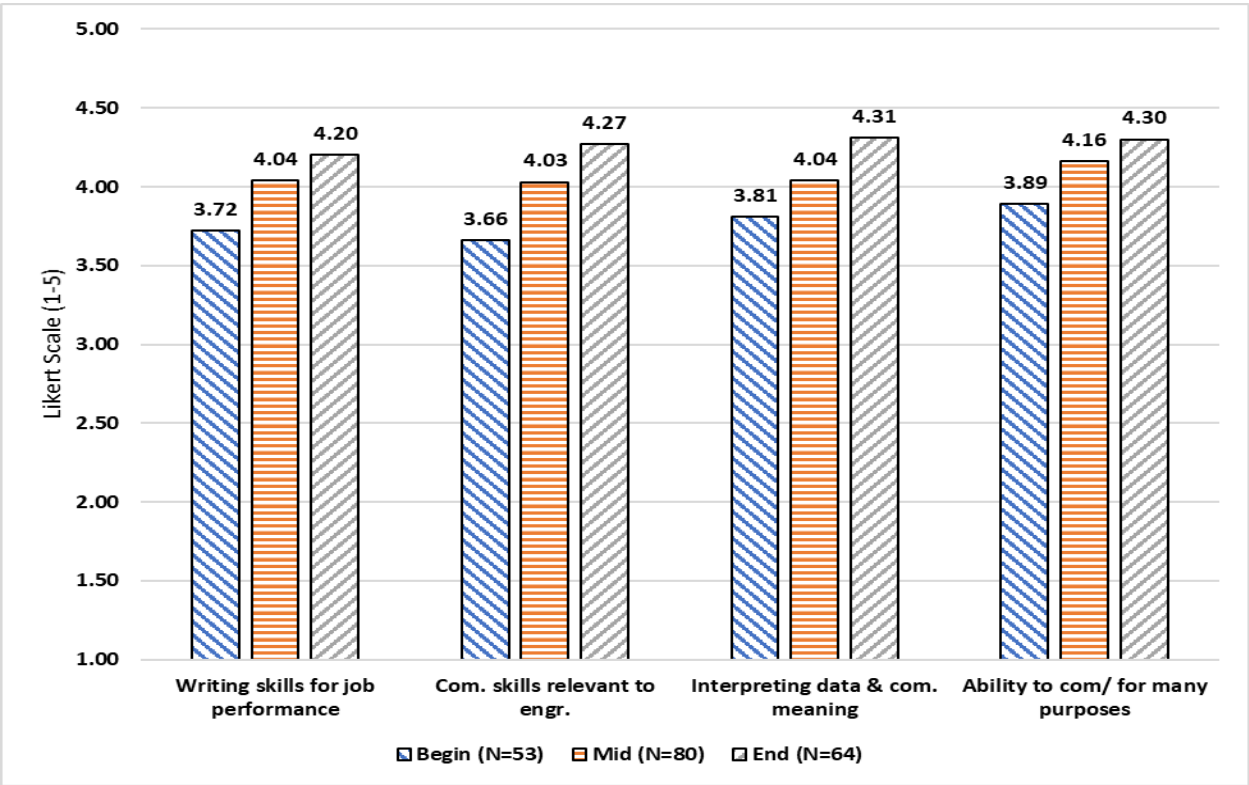

Figure 4 2021-2022 Student Preparedness for Professional Environment

The authors then compared the changes from the beginning of the course sequence to the end of the course sequence for both academic years. The difference was calculated by subtracting the end score from the beginning score for each of the four categories for each academic year. There was an increase in student preparedness in all four categories from the beginning of the course to the end of the course. In addition, the 2021-2022 students identified more of an increase in each of the categories when compared to the 2020-2021 students. This increase may be related to the change in instruction and student project work methods (from 2020-2021 hybrid to 2021-2022 in-person) due to the COVID-19 pandemic. In addition, the 2020-2021 academic year was the first year of this co-teaching model which was used to identify improvements to the course communication content and delivery. Figure 5 represents these results.

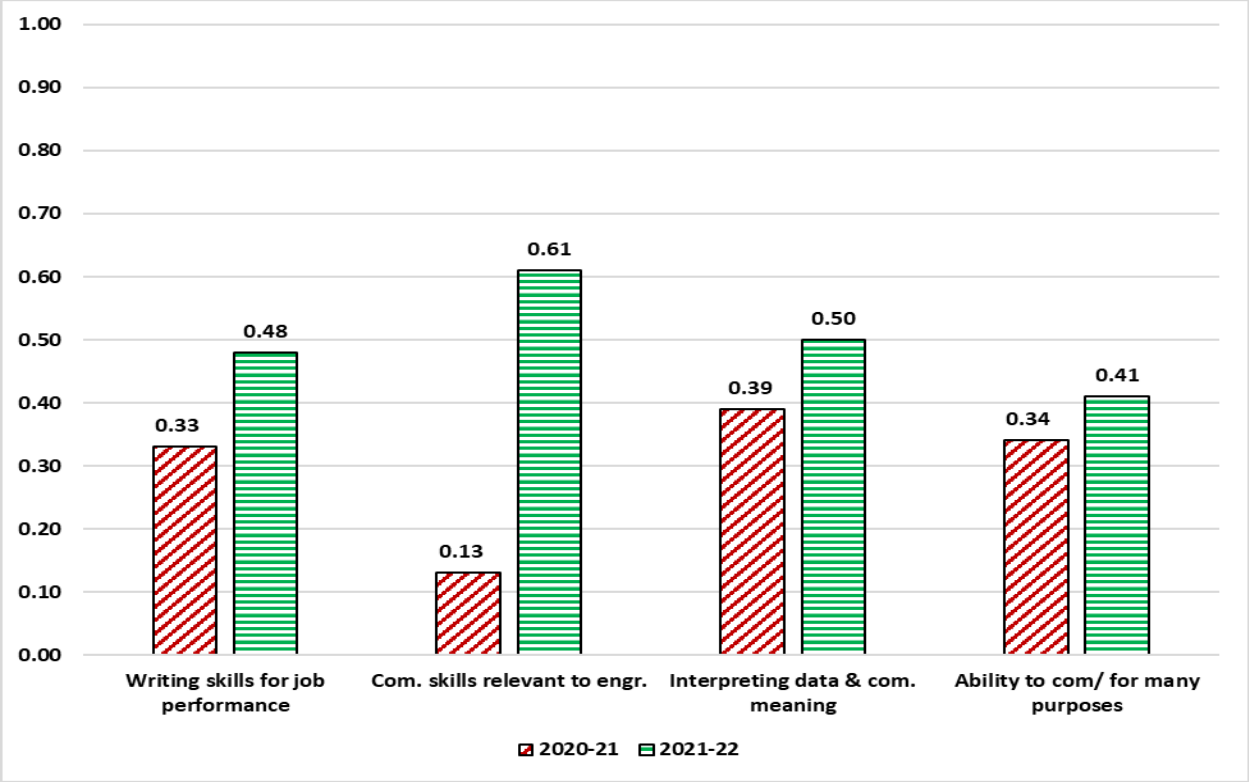

Figure 5 2020-2021, 2021 2022 Begin/End Comparison Professional Environment

When reviewing the written communication themed categories, the authors noted very similar trends in which respondents indicated they became more prepared as they progressed through the course sequence for both 2020-2021 and 2021-2022 academic years. These trends are shown in Figures 6 and 7.

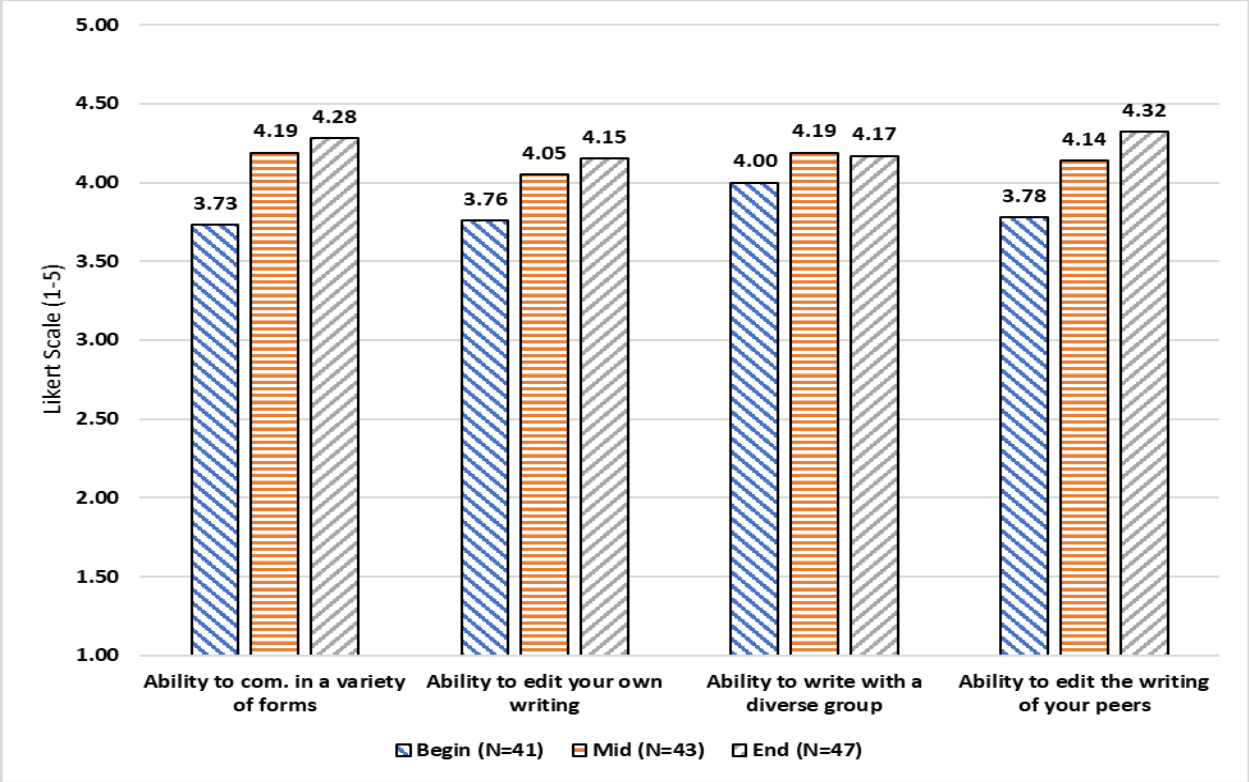

Figure 6 2020-2021 Student Preparedness for Written Communications

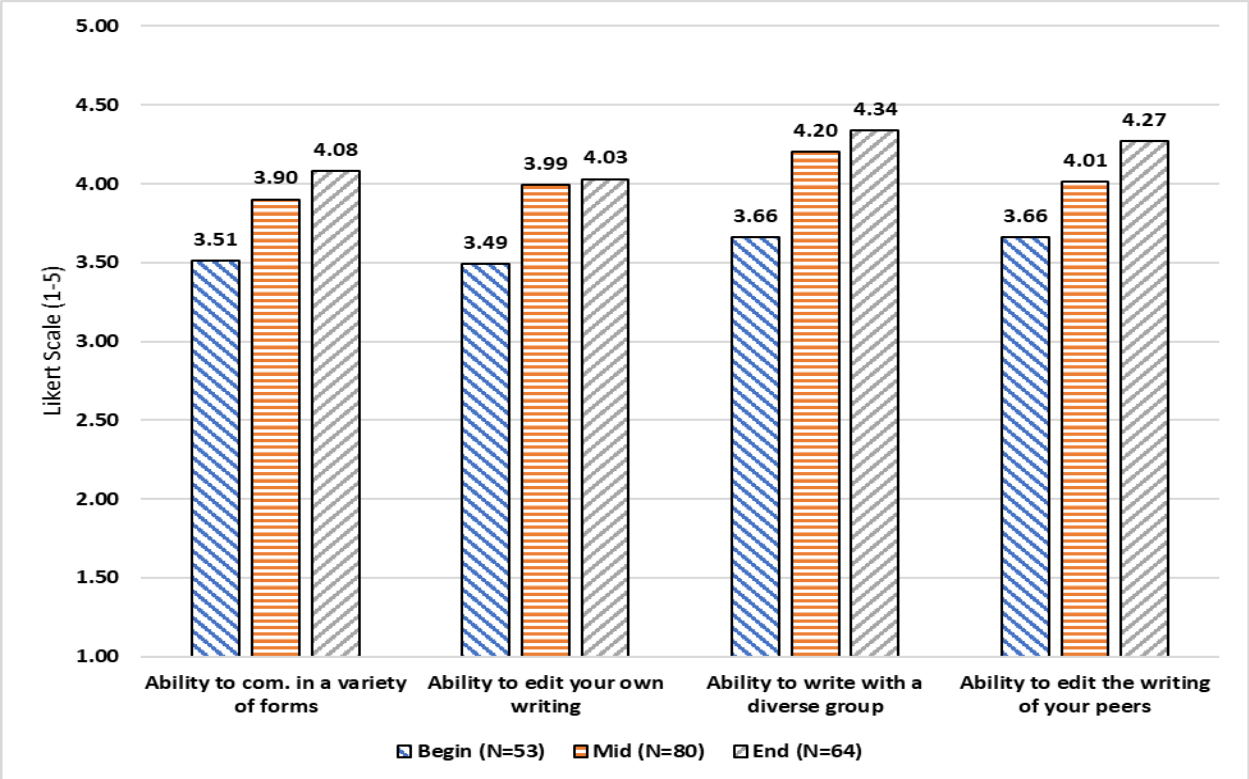

Figure 7 2021-2022 Student Preparedness for Written Communications

The authors then compared the change from the beginning of the course sequence to the end of the course sequence for both academic years for the written communication themed categories. As in the previous professional environment categories in Figure 5, there were similar results with the four categories as shown in Figure 8. The 2021-2022 students responded with a higher gain in preparedness than the 2020-2021 students which, as previously mentioned, may be related to the instruction and student work environment related to COVID-19. The greatest change from the two student cohorts with the ability to write with a diverse group. The authors are contributing this difference to the increased communication lectures and activities focused on giving and receiving feedback from multiple stakeholders on written documentation.

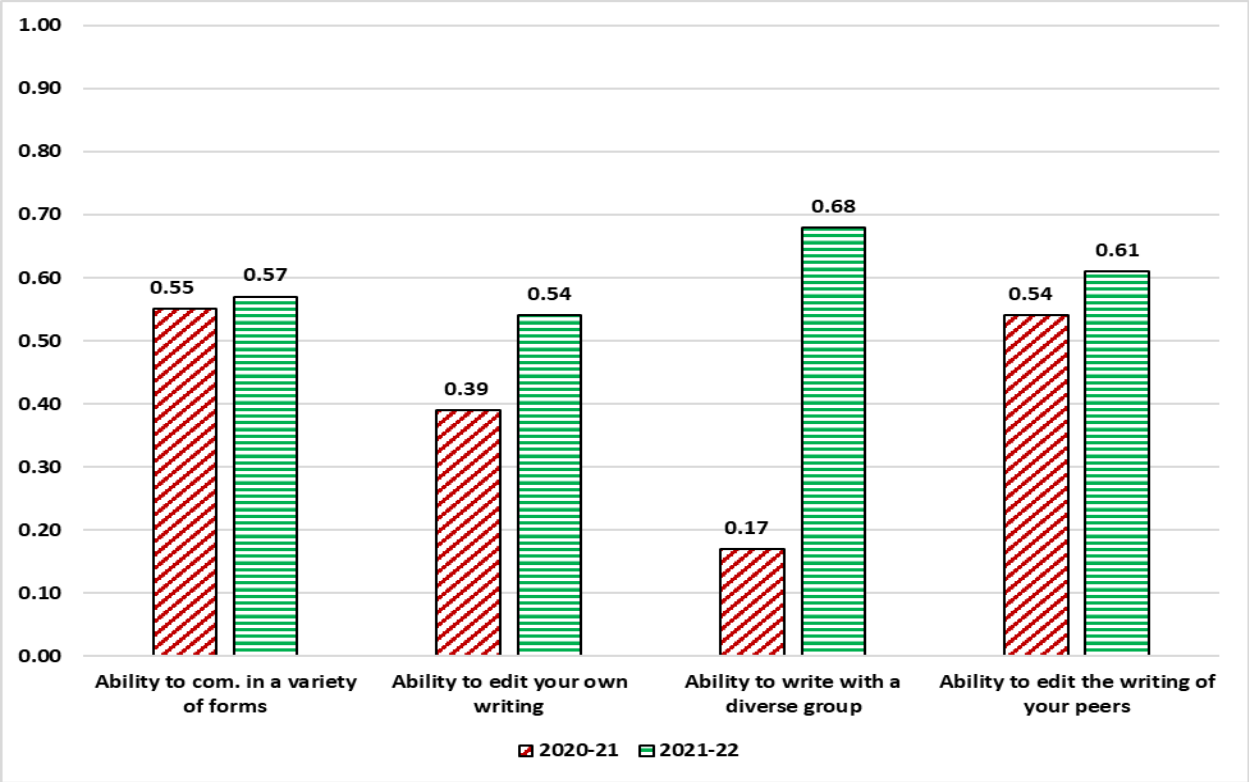

Figure 8 2020-2021, 2021 2022 Begin/End Comparison Written Communications

In the ending survey, students were asked to identify how prepared they were to communicate in five areas. In Figure 9, a comparison of the 2020-2021 student respondents was compared to the 2021-2022 respondents. The authors observed very similar Likert score averages in all areas and from year to year. This indicates that the students' perceptions of their preparedness were consistent in the first two years of this study at the end of the course sequence.

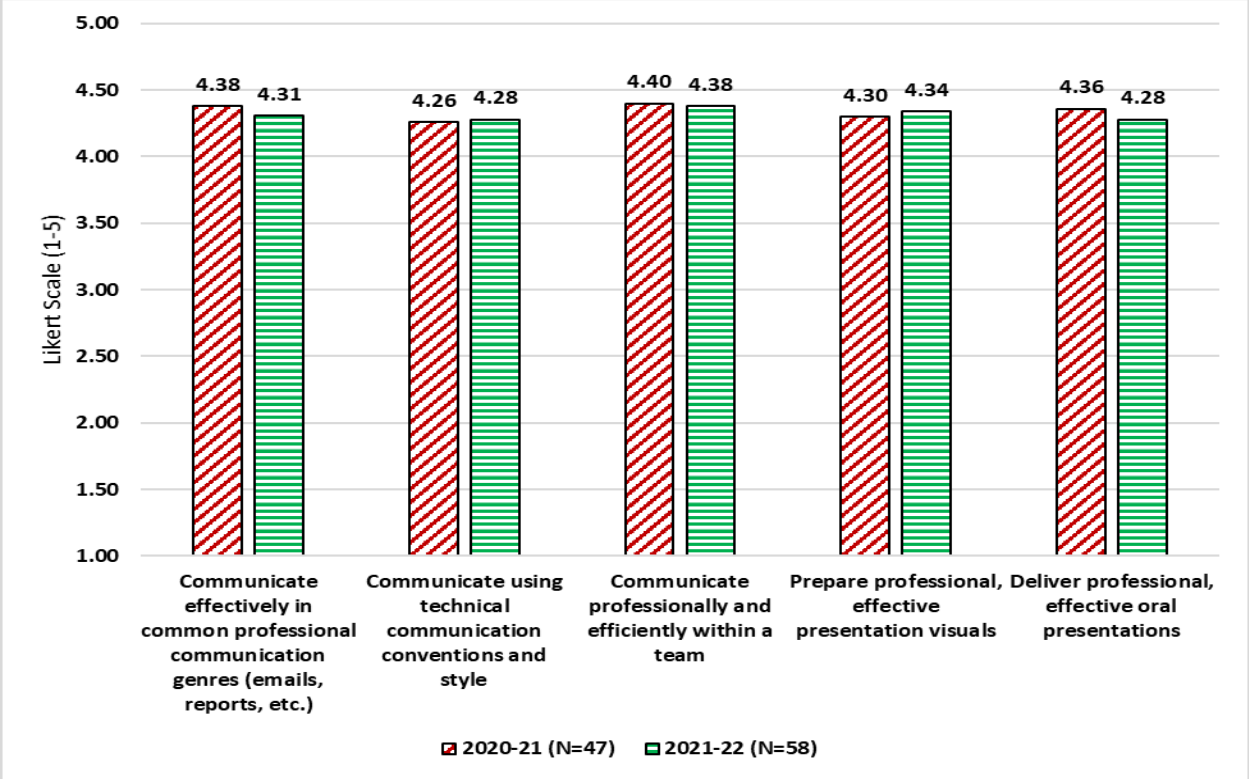

Figure 9 2020-2021 & 2021-2022 Student End of Year Preparedness

Conclusion

This work in progress paper reviewed the structure and initial survey results of a co-teaching model that included a technical communication instructor as an integrated part of a Multidisciplinary Design Capstone two-semester course sequence. The authors identified the following three research questions to guide in the development of the research methods to answer them.

> RQ1: How do students rate their preparedness in technical/professional/workplace communications when entering this interdisciplinary co-teaching model capstone course, at the mid-point of the course, and at the end of the course?
>
> RQ2: Do demographics have any impact on student self-reported preparedness in technical/professional/workplace communications?
>
> RQ3: Does a communications-enhanced co-teaching model in capstone courses improve communication outcomes for students based on a comparative evaluation of student work completed before and after the implementation of the co-teaching model?

The initial two years of student survey results were reviewed with positive effects in student self-perceptions of their preparedness in technical communications to initially address RQ1. There was a small increase in student-reported average preparedness over the course of the two-semester sequence from the beginning of the first semester to the end of the second semester. The difference in results may have been related to the instruction and student work environment during COVID-19 as a hybrid model versus an in-person model. In addition, modifications to the course related to technical communications from 2020-2021 to 2021-2022 may have also influenced students. These changes included:

- Increased number of lectures and activities on giving and receiving feedback on oral presentations and written documents from various stakeholders (e.g., interdisciplinary instructional team, student peers).
- Modified grading rubrics in the form of detailed criteria and scoring emphasizing technical communications.
- Added opportunities for students to receive feedback on written report drafts from the instructional team before submitting for a grade.

However, a limitation of this work-in-progress is the fact that the preliminary results were in aggregate form and full statistical significance is not completed at the time of this study. Further statistical analysis is needed to determine the strength of these differences. With these initial findings and their experience in the classroom, the authors observed that this co-teaching model has benefits to students' growth in learning and practicing good communication methods in preparing them for their future professional careers. From this conclusion, this co-teaching model will continue at Ohio State in the Multidisciplinary Design Capstone program.

Future Work

The authors seek to continue the student perception surveys over the next two academic years with new groups of Multidisciplinary Design Capstone students. The results will be evaluated based on student demographic differences and similarities to evaluate research question 2 (RQ2). One comparison that will be made will be comparing the results from the engineering students to the engineering science minor students. Full statistical analysis will be completed on the overall results and the results of each subgroup. In addition, student work will be collected as part of the course curriculum assignments to evaluate and compare to student perception surveys. The authors plan to directly assess students' works as it pertains to research question 3 (RQ3) listed above. Student perceptions can then be compared to a direct assessment of their work to determine similarities and differences. This work is an ongoing evaluation of the co-teaching model in a capstone course sequence.

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