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Knowledge Transfer from a First-Year, Stand-Alone Technical Communications Course into Second-Year Laboratory and Design-Focused Courses

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Reinforcement of First-Year Technical Communications Skills in Middle Years Courses

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Introduction

The ability to communicate technical information in written, graphical, and verbal formats is an essential durable skill for engineering students to develop as undergraduates and carry forward into the workplace [1,2]. The importance of technical communication skills is emphasized in the core ABET outcome "3. an ability to communicate effectively with a range of audiences." Undergraduate engineering programs tend to adopt one of two strategies for technical writing instruction, either offering a stand-alone course that is frequently taught out-of-discipline or embedding technical communications skills within-discipline in laboratory or design classes [4,5]. Despite these efforts, employers still report that novice engineers' technical communications skills do not meet industry expectations.

Prior work by our group [3] addressed this skills gap through the design and implementation of a unique stand-alone technical communications course that was specifically created for first-year mechanical engineering students and centered on multiple, industry-aligned modalities of communication. Preliminary evaluation of this new curriculum showed that students demonstrated substantive gains in self-efficacy for nearly all technical communication skills covered in the course, including synthesis of background research, graphical representation of data, basic statistical analyses, and composition of technical reports and presentations in a variety of formats. To ensure that students' technical communications skills are reinforced throughout the entire engineering program of study, we developed stand-alone learning modules (Canvas LMS) that feature video tutorials, grading rubrics, and worksheets from the first-year course. These modules have been integrated into several design and lab-based courses in the sophomore, junior, and senior years and highlighted by instructors in particular assignments and lectures.

In this paper, we will examine whether the technical communications skills developed in the freshmen year are reinforced in middle years courses. In particular, we will focus on whether students perceive specific technical communications skills, like generating graphs, to be relevant to courses taken one to three semesters later. We will also assess whether middle years coursework changes students' self-confidence in technical communications tasks. The results of this study will be used to refine our first-year technical communications course and modify the strategies that we are using in later lab and design courses to activate prior technical communications knowledge (e.g., review exercises, exemplars, and common rubrics). More broadly, our approach to developing and reinforcing industry-aligned technical communications skills throughout our undergraduate curriculum may be of interest to other programs seeking to improve student outcomes in this area.

Methods

The setting for this study is a mid-sized, ABET-accredited mechanical engineering undergraduate program at a public, land-grant institution in the MidAtlantic US. All students who participated in the study consented to participate in a voluntary, online survey (Qualtrics) that was administered in the final week of the Fall 2024 semester. Participants were recruited from one of two required mid-years courses, specifically: (1) a second-year Statics course typically taken the semester following the technical communications course (+1 Semester); or (2) a third-year Fluid Mechanics lab course taken three semesters after technical communications (+3 Semester). The +1 Semester course included a substantive design project with written and presentation-based project deliverables; and the +3 Semester course involved graphical and narrative deliverables for multiple experiments. For both courses, students worked in small teams (3-5 individuals) that were assigned by the instructor, and student teams were encouraged to evenly distribute the technical communication workload. The few students in these mid-years courses who had not yet completed the required first-year technical communications course were excluded from this study.

The survey instrument focused on three themes for each of eight (8) specific technical communications skills that were potentially relevant to the mid-year course: (1) perceived importance of the skill; (2) self-efficacy related to the skill; and (3) personal involvement with the skill for team-based deliverables. The technical communications skills that were assessed were aligned with the learning objectives in the first-year technical communications course [3], e.g., graphical representation of data, basic statistical analyses, and composing clear narratives. Optional, open response questions allowed participants to comment in general on their preparedness to engage in technical communications in middle years courses.

Survey data were analyzed as follows. Descriptive statistics and bivariate statistical comparisons (Chi-Squared, $p<0.05$ for significance; JMP Pro 17) were used to compare Likert-scale responses for each theme and technical skill between the +1 and +3 Semester courses. General comments were subjected to thematic analysis in alignment with the three major themes of the survey.

Results

Students perceived that nearly all of the major skills covered in the first-year technical communications course were relevant to the mid-years' course experiences (Figure 1). The most relevant skills were writing reports, organizing data, generating graphs and tables, and performing statistical analyses. +3 Semester students were more likely to use MS Excel for data analysis and to generate graphs from data sets ($p<0.01$, Chi-Sq).

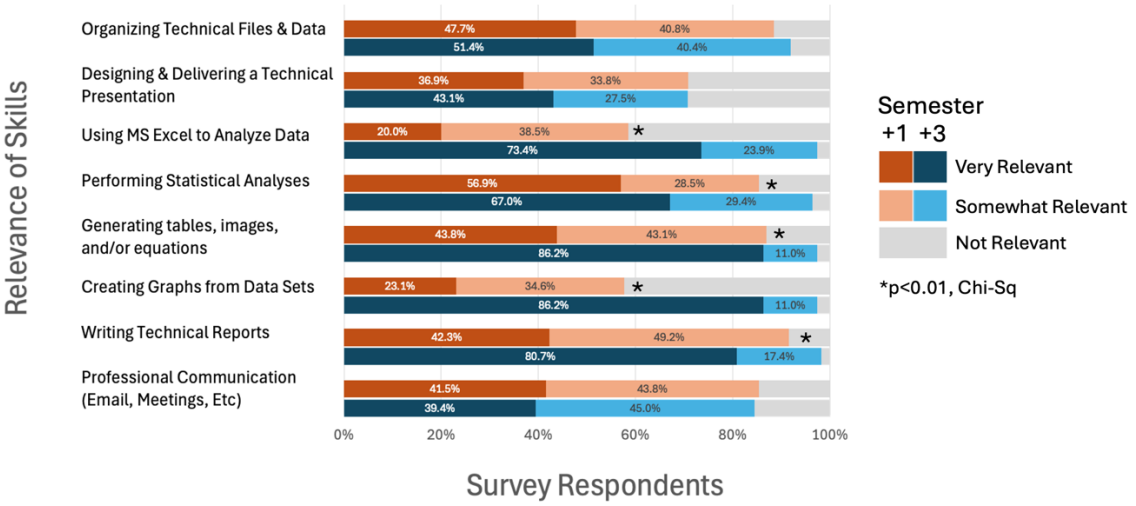

Figure 1: Student responses to the prompt "How relevant were each of the concepts or skills below to the course for which you are taking this survey?" *p<0.01 for Chi-Squared comparison of response profiles between +1 and +3 Semester groups.

Students perceived growth in some, but not all, technical communications skills as a result of their middle years courses (Figure 2). Approximately two thirds of students in the +3 Semester course reported growth in their ability to generate tables, images, equations, and graphs, as well as writing technical reports. Effects were more muted for +1 Semester students, who reported the greatest rates of growth in data organization, writing reports, and statistical analyses. As compared to the +1 Semester course, the +3 Semester course was more likely to result in growth in data analysis, generating tables, images, equations, and graphs, and writing reports (p<0.01, Chi-Sq).

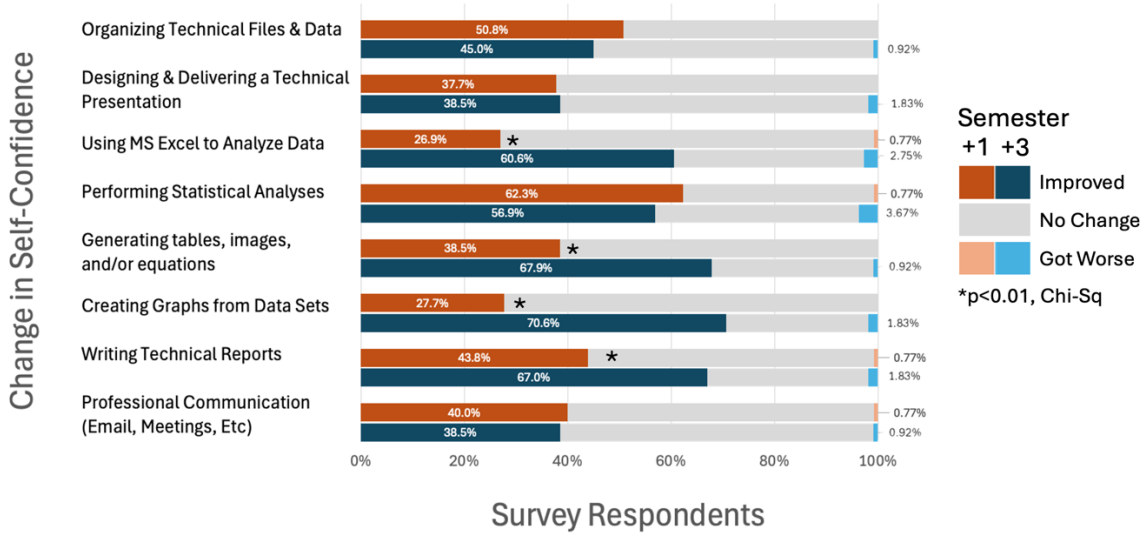

Figure 2: Student responses to the prompt "As a result of the [+1 or +3 Semester course], how has your confidence with each of the following concepts or skills been affected?" *p<0.01 for Chi-Squared comparison of response profiles between +1 and +3 Semester groups.

As a whole, individual students reported that they contributed to most, but not all, technical communications skills related to team deliverables (Figure 3). Equitable involvement was reported by over half of all survey respondents for every task; and fewer than 10% of students reported less involvement on tasks than their peers. Report writing and data organization demonstrated the most involvement overall, with statistical analyses and data analysis having the least involvement. As compared to +3 Semester students, +1 Semester students were more likely to report the same level of involvement as teammates in data analysis and graphical generation tasks.

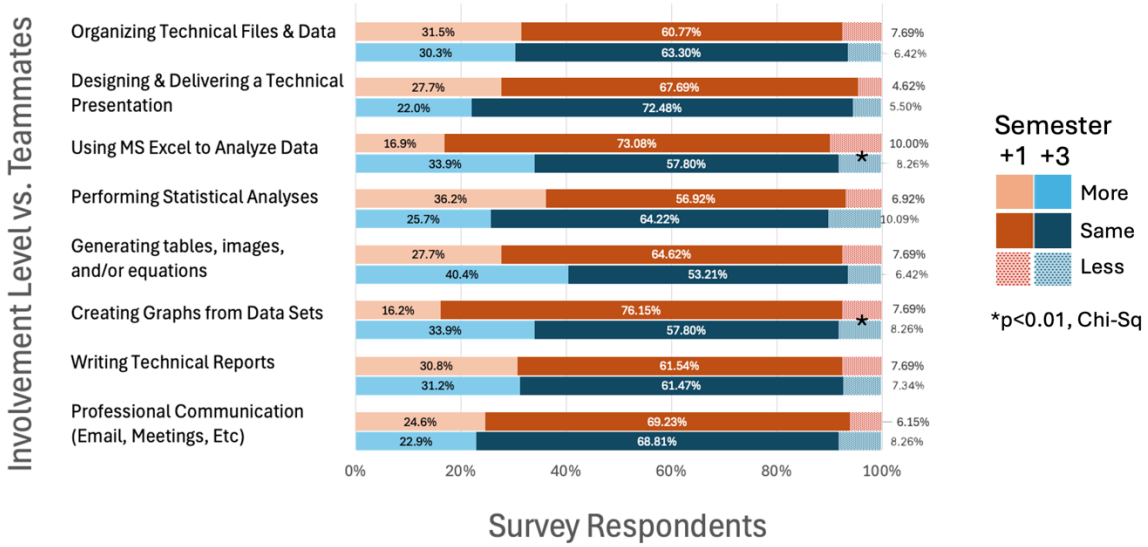

Figure 3: Student responses to the prompt "How involved were you - compared to others (like teammates or peers) - with each concept or skill below?" *p<0.01 for Chi-Squared comparison of response profiles between +1 and +3 Semester groups.

Comments from students are shown in Table 1 below. In aggregate, they suggest that students feel well prepared for technical communications in middle years courses. Both +1 and +3 Semester cohorts frequently attribute their preparedness to the first-year technical writing course. Writing reports and generating tables was relevant to both +1 and +3 Semester cohorts; and +3 Semester students mentioned that the first-year course was good preparation for data analysis and graphing of data.

Table 1: Comments from students related to their preparedness to engage in technical communications in middle years courses.

+1 Semester	+3 Semester
Writing coherent reports and analyzing data by hand were very important topics in this course. Tech com provided adequate preparedness.	*Technical report formatting, yes I was adequately prepared. Its nice to look back to [Tech Com] on canvas to use the resources*
There wasn't a huge amount of data analysis besides doing the calculations on the bike and comparing metrics in a table. The class for technical communications involved more professional design briefs and such. I felt well-prepared for these concepts in class.	*Writing reports and analyzing data was very important in fluids lab, and after taking [Tech Com] I feel very prepared. [Tech Com] is fantastic, when taking it initially I was uninterested and assumed that these things were common knowledge, but seeing how much my reports have improved after taking that class I am very pleased with it being a required course.*

Discussion

The results of this study indicate that the skills developed in a first-year, discipline-specific technical communications course are mostly reinforced in middle years courses. Three skillsets, namely, report writing, data management, and generating tables, images, and equations, were highly relevant for middle years design projects and lab experiences. Not surprisingly, data analysis and graphical representation of data were found to be more relevant to lab experiences and not heavily emphasized in design projects. In middle years courses, students maintained or improved prior levels of self-confidence for most technical communications skills; and there were substantive self-confidence gains in the lab course related to data analysis, statistics, and graphical representation of data. Despite the team-based deliverables, most students directly engaged with all technical communications tasks in middle years courses, which suggests that teaming does not undermine individual growth.

The promising results of this study are likely attributable to the discipline-specificity of our first-year technical communications course [3]. The learning objectives for this course were tightly aligned with communications standards from middle years courses in the mechanical engineering program. In these later courses, student resources from the first-year course, such as video tutorials, exemplars, and rubrics, were available to trigger prior knowledge and reinforce performance expectations. Study results indicate that design- and lab-based experiences reinforce different technical communications skills and that both course types may be needed to provide opportunities for student growth in the middle years.

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