# Board 26: Work in Progress: Technical Scientific Writing across the BME curriculum

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Communication skills are critical for engineers as they disseminate their novel solutions, experiments, and products. ABET has defined one of the seven student outcomes required for preparing students to enter the professional practice of engineering as "an ability to communicate effectively with a range of audiences" [1]. In past assessments of our Biomedical Engineering (BME) program, we have found from student self-evaluations, course assignments, and external reviews that students lack strong technical writing skills. Our university offers courses in technical writing, but the course topics are split into communication in engineering and technology and communication in science and research. BMEs must master both types of communication, which would require two separate courses. Other programs have seen similar issues with their university-provided technical writing courses and have addressed the problem by collaborating with the technical writing departments to tailor the instruction to BME students [2]. Alternatively, we have provided specialized writing instruction by developing evidence-based writing modules and scaffolding them throughout our core curriculum.

## Methods

This longitudinal study is being performed on two groups (A and B) of sophomore students in the Joint Biomedical Engineering Department at the University of North Carolina at Chapel Hill and North Carolina State University. Student participants were grouped based on the sequence in which they took two required second-year courses (Biomechanics and Biomaterials). Group A are students who enrolled in Biomechanics in the Fall 2022 (FA22) semester and Biomaterials in Spring 2023 (SP23). The instructors for Group A developed technical scientific writing modules that are being implemented in the lab portion of the course. Group B consists of students who take Biomaterials in FA22 and Biomechanics in SP23 without the technical writing component. Students from both groups will enroll in the same required Physiology course, which includes labs with multiple full scientific writing deliverables, in the Fall 2023 (FA23) semester. North Carolina State University's Institutional Review Board has reviewed and approved the procedures of this study.

The technical writing modules focus on one report section at a time, allowing students to use feedback to rewrite that section multiple times. For example, when learning about each section of a scientific report (e.g., Methods), students were provided a handout describing conventions of the genre and appropriate writing style. With this information, they wrote an initial draft that was anonymously reviewed by two peers. After using this feedback to make improvements, students submitted a second draft that received in-person, one-on-one feedback. The one-on-one feedback was either given by the instructor of record or the graduate teaching assistant who had both a science and technical writing background. The students then rewrote and submitted a final version of the section. This process was repeated for each scientific section covered by the course. Each course taken by Group A (FA22, SP23) covered different writing sections (Biomechanics: Methods, Results, Graphs, Tables, and Discussion; Biomaterials: Abstracts, Introductions, Hypothesis Formulation, and References). We planned the last assignment in each course to be a full lab report which includes all scientific writing sections.

A standardized rubric was developed for each scientific report section with criteria specific to that section. Intra-subject comparisons of participants in Group A were conducted for the FA22 semester between the first draft of an individual section and the same writing section submitted as part of the final report. The rubrics for each writing section were based on a four-point scale (1 – Not Addressed, 2 – Needs improvement, 3 – Needs minor improvement, 4 –Mastered) and were used to assess the draft and final report sections.

In the FA23 physiology course, students will be provided detailed writing rubrics and multiple opportunities to implement their scientific technical writing skills through four full lab reports. These newly developed writing modules are complemented by industry and FDA style deliverables (e.g., basic business plans, product launch plans, patents) already vertically integrated into the design curriculum.

*Surveys*

Pre- and post-course surveys were administered to Group A in FA22, and will be administered later in SP23, and FA23. Group B will take the pre- and post- course surveys in FA23 only. The pre-course survey asks students to evaluate their confidence in technical writing and the perceived value of gaining technical writing skills for future coursework, following graduation, and to reach their career goals on a 4 point Likert scale (strongly agree, agree, disagree, strongly disagree). In addition to the questions from the pre-course survey, the post-course survey collects student feedback on the efficacy of the technical writing instruction.

*Analysis*

To assess student improvement in technical writing skills within FA22, Hake's gain (HG = (post score – pre score)/(max score – pre score)) was computed between the initial draft and final lab report as a measure of normalized improvement on individual scientific writing sections [3].

Following SP23, Hake's Gain will be used to determine improvements in 1) student writing section scores between initial draft and final lab report within SP23 and 2) between FA22 and SP23 final lab reports. Ultimately, an inter-group comparison of the first lab report in the FA23 course will be used to assess the impact of the newly developed technical writing modules on technical writing proficiency.

## Initial Results

To date, we have 38 students enrolled (40 began study, 2 dropped course) in Group A that have completed one semester of the technical writing modules. Student scores improved significantly between the initial draft submission of each individual scientific section (methods, results, tables, figures, and discussions) as compared to that same section submitted in the full final lab report (Table 1).

**Table 1:** Student improvement in technical writing score by section

| | **Methods** | **Results** | **Tables** | **Figures** | **Discussion** |
|---|---|---|---|---|---|
| Avg. Draft | 2.40±0.66 | 2.09±0.85 | 1.77±0.64 | 1.78±0.63 | 1.85±0.54 |
| Avg. Final | 3.17±0.93 | 3.12±0.88 | 3.32±0.66 | 2.94±0.85 | 3.49±0.70 |
| Hake's Gain | 0.460 | 0.551 | 0.690 | 0.525 | 0.748 |

Post-survey results show students agreed (89%) that splitting the lab report into subsections aided their learning. There was also strong student agreement in the value of one-on-one feedback from the instructors, both when revising sections and writing the final lab report (Fig. 1). When asked in a free-response form which type of feedback was most useful, 86% of the students appreciated targeted and specific one-on-one feedback. Many students found the online resources helpful, but fewer valued peer review, with 27% and 32% of students disagreeing/ strongly disagreeing about its value (Fig. 1).

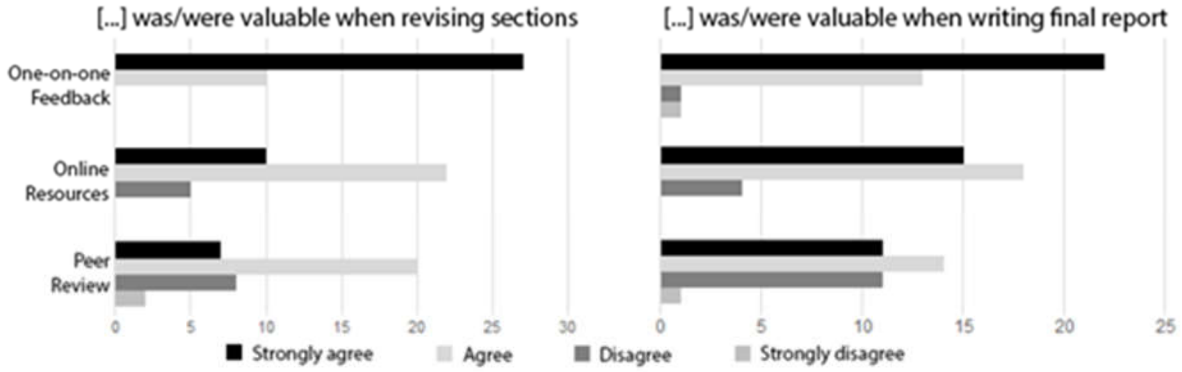


**Figure 1**: Post survey results on provided resources' value using a four-question Likert scale.

## Conclusions

This initial phase demonstrated the improvement in student writing proficiency with technical writing instruction. Notably, students found one-on-one feedback the most helpful resource for improving future work. Some of the preference for individual feedback may be attributed not only to useful general writing instruction but also specific information on how the instructor would deduct points. Some comments in the post-course survey suggested this, and we will decouple these two reasons in later surveys. A hesitation to integrating in-person, one-on-one feedback on student writing is expected; one of the biggest challenges being the educators' time [4]. With one dedicated teaching assistant working 10 hr/wk, however, we provided feedback to 50 students in three lab sections.

Peer-review feedback is critical for improving both the author's and reviewer's writing and for improving the reviewer's writing through exposure to a variety of examples and approaches [5, 6]. Because some of our students felt unqualified to assess others' work, they similarly reported that they felt the feedback was not useful. Teaching students how to provide feedback has been shown to further improve both the author's and reviewer's learning [7], and while this prior work was consulted, future iterations of the writing modules will spend more time on the peer-review process.

As this longitudinal study continues we will evaluate student retention, perceived value, and self-confidence in technical writing. By scaffolding the writing instruction across multiple semesters, students will have more opportunities to practice writing and receive feedback. We expect that with data informed adjustments the demonstrated success and insights gleaned from the first semester of the technical writing instruction, this scaffolding will not only improve student technical writing skills, but also their perceived value and self-confidence in technical writing.

**References**

[1] ABET Engineering Accreditation Commission. *2022-2023 Criteria for Accrediting Engineering Programs*. 2021. pg 8. https://www.abet.org/wp-content/uploads/2022/01/2022-23-EAC-Criteria.pdf

[2] J. Stella, S. Higbee, & S. Miller. "Thinking Beyond the Service Course Model: Intentional Integration of Technical Communication Courses in a BME Undergraduate Curriculum." *ASEE Conference Proceedings,* 2022.

[3] R. R. Hake, "Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses," *American Journal of Physics*, vol. 66, no. 1, pp. 64-74

[4] N. T. Buswell, B. K. Jesiek, C. D. Troy, R. R. Essig, and J. Boyd, "Engineering instructors on writing:Perceptions, practices, and needs," *IEEE Trans. Prof. Commun*., vol. 62, no. 1, pp. 55–74, Mar. 2019.

[5] K. Topping, "Peer assessment between students in colleges and universities," Review of Educational Research, vol. 68, no. 3, pp. 249–276, 1998.

[6] K. Cho, & C.MacArthur. "Learning by reviewing." *Journal of Educational Psychology,* 2011.*103*(1), 73–84.

[7] E. F. Gehringer, "Helping students to provide effective peer feedback, " *ASEE Conference Proceedings*, 2017.