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Thinking Beyond the Service Course Model: Intentional Integration of Technical Communication Courses in a BME Undergraduate Curriculum

Julie Stella

Julie Stella is a Visiting Lecturer in the Technology Leadership and Communication de- partment of the IUPUI School of Engineering and Technology. She teaches writing and communication to undergraduate engineering students at IUPUI. She has also taught courses at the graduate level in education technology, usable interface design, and ed- ucation public policy. Her background is fairly diverse, though it centers on writing and teaching. Ms. Stella spent 11 years working as a software engineer and consultant in MN before moving to the east coast of the US and beginning her graduate-level education. Her MA degree was in Professional Writing and Rhetoric, and her doctoral work was in Special Education at George Washington University in Washington DC. She completed additional graduate work at Johns Hopkins University (JHU) in Baltimore MD, which has been particularly influential to her teaching style and her philosophy as an educa- tor. The program was called The Mind, Brain, and Teaching, and it focused on applying research from the fields of cognitive science, developmental science, neurology, and neuroscience to education practices in grades K-16. Ms Stella's research interests include educational measurement, rhetoric/persuasion in technical communication, education technology, instructional design, inclusive design practices, and technology usage/digital inclusion for students with disabilities.

Steven Higbee (Clinical Assistant Professor)

Clinical Associate Professor of Biomedical Engineering at Indiana University-Purdue University Indianapolis (IUPUI).

Sharon Miller (Clinical Associate Professor)

Dr. Sharon Miller is a Clinical Associate Professor of Biomedical Engineering (BME) at Indiana University Purdue University Indianapolis (IUPUI). Dr. Miller received a Bachelor of Science degree in Materials Science and Engineering from Purdue University and a Master of Science and PhD in Biomedical Engineering from the University of Michigan. She currently serves the IUPUI BME Department as Associate Chair and Director of the Undergraduate Program helping develop and implement curricular changes to embed engineering design, ethics, and technical communication throughout the BME curriculum. Prior to joining the faculty at IUPUI, Dr. Miller's P-20 educational efforts included curriculum writing and program development for the John C. Dunham STEM Partnership School and Michael J. Birck Center for Innovation. Since joining IUPUI, Dr. Miller has been awarded internal and external grant funding to realize BME curricular changes and to pursue engineering education research of BME student self-efficacy toward design.

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Introduction

In technical plans of study, such as Biomedical Engineering (BME), students are often required to take an undergraduate level course in technical communication, which supplements the freshman-level communication courses required by a college or university. These courses tend to be generalized, and they are taken by students in a wide variety of majors such as engineering, technology, the sciences (physics, chemistry, etc.), healthcare, and other fields. As a discipline, Technical Communication is taught from a genre perspective where a genre is a set of report-level standards or conventions, and research suggests that a genre-based approach can improve student writing in engineering lab courses [1, 2, 3]. As such, students in these courses learn to produce specific reports; however, since the course must be useful across a wide range of majors, students learn to write general reports that are applicable to a wide variety of workplaces such as the progress report, the recommendation report, the formal letter, and others. Generalized technical communication courses are useful to students in most majors, but BME students may benefit from a more specialized model because BME is a discipline that requires specialized and specific documentation (FDA standards, lab reporting, etc.). Knowing this, the BME program at our university partnered with the technical communication program to develop a strategy for integrated and highly specialized courses for BME majors. In this document, we describe the effort to deconstruct boundaries between disciplinary content proficiency and effective communication. The strategy involved: realigning and integrating an inclusive writing and communication practice into BME curriculum, implementing a Communities of Practice model to allow a continuous exchange of ideas, and using summative signature assignments, which are completed and submitted both to the TCM instructor and to the BME instructor near the end of a course to assess student learning [4].

Realignment of Technical Communications Content within a BME Curriculum

ABET accredited undergraduate engineering programs require graduates to have the ability to communicate effectively with a range of audiences and to work effectively on a team [5]. Technical communication courses often provide students opportunities to learn and to improve both written and oral communication skills. These courses also integrate student opportunities to learn inclusive teaming and to develop effective habits around scheduling, planning, and goal setting. Here, we describe how we updated our technical communication course requirements as part of a BME undergraduate curriculum after recognizing limitations. Unintentional consequences included the inability for students to practice learned communication skills throughout their major coursework and a missed opportunity for instructors to hold students accountable for technical communication skills emphasized.

Synchronous enrollment on a plan of study in general technical communication courses can be difficult to achieve for students within a given major. Similarly, enrollment caps prevent students within the same major from enrolling in the same sections. Prior to our curricular change, BME students were required to take a 2-credit technical communication course, TCM 36000, and often co-enrolled in sections with other engineering majors. In reviewing three academic years of BME student enrollment in the required technical communication course (Fall 2016 through Spring 2020 of TCM 36000 enrollment), our program found that nearly one-third (32%) of our students enrolled in TCM 36000 in their final year. This resulted in students taking technical communication courses concurrently with their two-semester capstone experience and after 200- and 300-level BME coursework that involves team-based and individual design

projects and laboratory reports. In doing so, some BME students were limited in their ability to implement learned communication skills throughout their major design deliverables (e.g., team presentations fall semester senior year). BME faculty and design instructors reported they recognized this limitation when observing final presentation, design report, and design poster assignments during the senior year.

The two-credit TCM 36000 course does teach skills for engineering students such as planning, drafting, and revising professional engineering reports; planning and delivering oral presentations; organizing information; and developing persuasive arguments. While co-enrolling with students from different engineering disciplines can be beneficial, the field of biomedical engineering is heavily regulated (e.g., Food and Drug Administration regulation of medical devices) and requires discipline-specific guidance on quality documentation. Thus, our program looked toward a combined course approach between technical communication and biomedical engineering. In doing so, BME students were able to use BME specific laboratories or design projects as the basis for their technical communication course deliverables. The existing 2-credit technical communication course requirement (TCM 36000) was replaced with a new model where students take a one-credit technical communication course (TCM 21800) with a 200-level BME course and another one-credit technical communication course (TCM 35900) with a 300-level BME course (Table 1). These BME-specific TCM courses offer weekly instruction, which took place immediately after the paired BME lab course in the same laboratory room.

By integrating the technical communication courses earlier in the program, we highlight how BME sophomores are now able to apply writing skills immediately to classroom assignments and continually grow their communication skills over the course of the program. Furthermore, BME juniors practice and receive individual feedback on oral presentation skills allowing instructors in technical communication and BME to continuously hold students accountable for technical communication skills learned.

Table 1: TCM Course Titles and Descriptions

TCM Course	Credit Hours	Course Description
TCM 36000: Communication in Engineering Practice	2 credits	The application of rhetorical principles to written and oral communication in the engineering professions. Topics include planning, drafting, and revising professional engineering reports; planning and delivering oral presentations; organizing information; developing persuasive arguments.
TCM 21800: Introduction to Engineering Technical Reports	1 credit	This integrated technical communication course introduces foundational skills for technical reports in engineering. Students will practice a recursive writing process and use techniques for analyzing content for different audiences and purposes.
TCM 35900: Technical Data Reporting and Presentation	1 credit	This integrated technical communication course builds advanced data reporting and presentation skills for technical and non-technical workplace audiences.

The TCM curriculum for the BME paired courses was focused on building relationships and establishing trust, increasing the relevance of the writing assignments, and allowing students to practice writing and read exemplary work before their own writing was graded. Classroom communities and student-student

relationships were grown and nurtured through technical peer review, collaborative writing, and team membership (roles, relationships, management, leadership). The writing instructor provided individualized written feedback on all graded assignments and general feedback for the entire group for assignments that used low-stakes specifications grading (complete/incomplete) [6]. The relevance of the writing was achieved through overlapping assignments that were drafted and polished in the TCM class then submitted for a technical grade to the BME course instructor. The genres of writing taught in the TCM course were limited to those commonly found in the BME field (industry and academia). The use of standardized rubrics is an evidence-based practice for assessing writing in engineering courses [7]. As such, rubrics published by the American Association of Colleges & Universities (AAC&U) were chosen as a standardized way to assess a culminating written and/or oral communication assignment near the end of the semester to establish benchmarks for student growth and continuous improvement of the curriculum [8].

The TCM 21800 and 35900 courses are taught by a single, dedicated instructor over a student's sophomore and junior year. The consistency of the instructor allows an opportunity to develop positive and trusting instructor/student relationships. The TCM 36000 course, which students took prior to changing to the paired BME/TCM model, is taught by many different full-time and adjunct instructors.

Both the BME and TCM departments are housed in the larger School of Engineering. The BME/TCM courses have 2 sections in Fall semester, and a single section in Spring semester with maximum capacity of 20 students in each section. The Fall sections usually have 15+ students, while the Spring sections are smaller.

The Sophomore-level Paired Courses: BME 24300 (Biomechanics Lab) and TCM 21800 (Introduction to Engineering Technical Reports)

The first integration of technical communication and biomedical engineering courses is the sophomore-level biomechanics lab paired with introduction to engineering technical reports. The biomechanics laboratory intends to introduce students to the fundamentals of mechanics and biomechanics. As the major learning objectives of laboratory course centers technical knowledge and collaboration, the pairing with TCM melds the technical communication expectations of biomedical engineers in a regulated healthcare environment through a parallel workflow.

Throughout the semester, the instructors use the structure of laboratory report writing to align the learning objective of the courses as the signature assignment. Laboratory reports have a common goal of presenting results of an experiment to internal and external audiences. Depending on the audience, the format may vary. However, many report forms (e.g. research papers, verification, and validation summary reports) include the following topics:

- introduction of experimentation goals and hypotheses;
- delineated methods of testing and required materials;
- analysis of collected data and summary of key results; and
- Interpretation of the significance of key results.

Each week the biomedical engineering students conduct an experiment in BME 24300 course. The instructor uses the key components of a laboratory report to support students in documenting their experimental procedures and data in a laboratory notebook. At the conclusion of the lab period, students use their experience from the laboratory and data collected in TCM to understand the key

components of laboratory reports and practice technical communication in real-time. By sharing our courses in the university Learning Management System (we use Canvas) and collaborating engagement, the instructors can be consistent in language, meaning, and expectations. At the conclusion of the semester, students submit a written laboratory report that communicates key findings and their significance from an experiment evaluating the impact of different storage solutions on the mechanical properties of mouse bones.

In addition to content alignment, the BME-TCM partnership uses a shared assessment strategy. Students submit the signature assessment to both instructors for preliminary review and final submission. In the preliminary review, both instructors provide feedback. The technical communication instructor provides feedback on writing style, narrative quality, and genre of laboratory reports. The engineering instructor provides feedback on the analysis of the collected data, summary of key results, and the interpretation of experimental significance. The goal of the iterative feedback cycle before final submission is to improve alignment and transparency to reduce inconsistencies.

Table 2: BME 24300/TCM 21800 Topics Spanning the Courses

BME 24300 Topic	**TCM 21800 Topic**
Introduction, statistics, lab safety	Introduction, solving problems with words, "writing is thinking"
BME Design Project intro	Audiences Lab report best practices
Tissues lab	Methods and materials section (write it for the tissues lab)
Vector lab	Peer review methods and materials section Workplace reporting in general Precision in language Unity in paragraphs Reverse outlining (a tool for excellent writing)
Review for exam	No class
Force plates and moments	Introduction section (write it for the force plates lab) Workplace research
Strain Gauges	Peer review introduction section A second look at the introduction section (using example from Ingenium [9] IEEE style
Mechanical testing (tension)	Visual technical communication

Review for exam	No class
Mechanical testing (compression)	Adding visuals to a document (best practices) Cohesion and coherence
Mechanical testing (bone bending)	Results/discussion/conclusion sections of the lab report (write it for the bone bending lab)
Review	Peer review results/discussion/conclusion section Full lab report (write it for the bone bending lab)

As can be seen in Table 2 above, the BME 24300 course and the TCM 21800 course explore complementary topics and material each week. For example, when students do the tissues lab in BME 24300, they write the Methods and Materials section of the lab report for the tissues lab. Each lab section is written as a draft, peer reviewed, discussed in class, and then assessed by the TCM instructor using a checklist-style rubric. The TCM course does not meet on the weeks that the BME students review for an exam on the lecture material.

The Junior-level Paired Courses: BME 38300 (Implantable Materials Lab) and TCM 35900 (Technical Data Reporting and Presentation)

The second integration of technical communication and biomedical engineering courses involves the pairing of the junior-level implantable materials lab course with a course on technical data reporting and presentation. The implantable materials lab focuses on the fabrication and testing of materials that are commonly used in biomedical applications, and it incorporates both traditional lab activities with lab reports and more open-ended and inquiry-based projects. Students are expected to draw upon their technical communication knowledge and skills from the sophomore year as they write lab and project reports in the class. Particular emphasis is placed on the presentation of data, as students work with both their technical communication and engineering instructors on best practices for making graphs, tables, and other data representations.

The signature assignment in BME 38300 that pairs with TCM 35900 is one of the main course projects, in which student teams design and perform experiments to answer research questions related to either controlled drug delivery or material cytotoxicity. Unlike traditional lab assignments, students working on the project must draft their own methods for performing the experiment, collecting results, and analyzing the data. For this reason, the project generally involves more troubleshooting than the more conventional lab assignments in the course, and students are given a total of four weeks to complete the project. The project was designed to resemble biomedical research as it occurs in practice, and the project deliverables were chosen with this in mind. Student teams submit a one-page abstract (a genre of technical communication that is commonly used for submissions for biomedical research conferences) in lieu of a longer project write-up, and they also deliver a 10 minute oral/platform presentation to the class, Teaching Assistants, and instructors.

The assessment strategy used for the project deliverables highlights the impact of the BME-TCM partnership. Students receive feedback on these common assignments from both their engineering and technical communication instructors. The engineering instructor provides feedback on the technical content of the one-page abstract and platform presentation, drawing context from the contemporary landscape of biomedical research publications and presentations. The technical communication instructor lends their expertise as they provide feedback on writing style, narrative quality, and oral presentation skills.

Table 3: BME 38300/TCM 35900 Topics Spanning the Courses

BME 38300 Topic	**TCM 35900 Topic**
Introduction, safety	Intro to the course, learning goals, how the lecture+lab+writing works
Prepare Calcium Phosphate Ceramics	Advanced audiences, writing for different audiences, peer review best practices
Test Calcium Phosphate Ceramics	NO CLASS
Prepare PEGDA Hydrogels	TCM 21800 Review, teamwork and collaboration, digital tools for collaboration, genres in general, genre and the team contract
Evaluate PEGDA Hydrogel Swelling Prepare Porous Composite Scaffolds	Analyzing writing in the industry, reader-centered research, BME journals, genre and the academic article, how to read research articles
Evaluate Scaffold Porosity Beer's Law & Spectrophotometry	Genre and the technical presentation, storyboarding, telling the story of your research
Evaluate Scaffold Degradation Spectrophotometer Design Project	PPTX—guidelines, adapting from storyboard, examples (this should help with your Friday presentation)
Drug Delivery Design Project	Research in the industry, importance of critical reading and thinking in BME, finding articles, using Google Scholar with the IU library, tie back to advanced audiences
Project work time	No class
Project work time	Genre and the research abstract--why do we write it and what is it for? Exploration of BME research abstracts in the wild

Project work time	NO CLASS Plan your final writing and communication projects—presentation, PPTX, research abstract
Project work time	APPLYING WHAT WAS LEARNED Project worktime—work on both your presentation AND the research abstract
Project work time	Rehearsal and peer feedback on PPTX—I know it is due Friday and you may not have a lot done. Bring what you have as a draft. We will rehearse and practice presentation style in class
Presentations	It's showtime! I will see you in the BME 383 lab classroom where your team will report on your design project
Review	Review (to help you write the reflection) and discuss reflection assignment

As can be seen in Table 3 above, the material for the TCM 35900 course is complementary to (i.e. supports) the BME 38300 work. For example, when students are placed in teams for the semester-long project in BME, they begin learning about teamwork and team communication in TCM 35900.

Using the shared schedule for the BME courses and the TCM courses allowed us to deconstruct boundaries between disciplinary content and effective communication by emphasizing the relevance of the technical communication genres the students were learning in TCM. Students learned about a specific technical communication genre in TCM, then they applied the knowledge to produce the relevant report in BME. Students learned writing skills, teamwork skills, and presentation skills in TCM, then they applied the knowledge to the BME projects.

Community of Practice

A community of practice is a "group of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly" [4]. A community of practice has the following attributes: a domain—a shared interest; a community—a network of members who interact and learn; and a practice—a shared repertoire of resources (vocabulary, stories, knowledge, strategies, and/or tools). Communities of practice can be deliberate or emergent. They are about problem-solving, sharing knowledge/experience, re-using assets, synergy, maintaining a shared history, documenting issues, and sharing space—virtual and/or physical. Communities of practice are common in education, where both instructors and students engage in knowledge-sharing community practices [10].

A BME/TCM CoP was integral to the deliberate and intentional integration of the BME and TCM courses. Monthly CoP meetings were held where resources were shared and issues with assignments or students

were addressed immediately instead of waiting for the end of the semester. BME/TCM instructors shared classroom space and participated in overlapping classroom activities, which offered further opportunities to interact, learn from each other, and model a collegial and positive relationship.

The CoP supported a cohort teaching model where students worked with the same instructors in both the sophomore- and junior-level courses, adding continuity [11]. Both the BME and TCM instructors adopted a TILT framework in presenting assignments [12]. This standardization of assignment presentation ensured pedagogical choices were transparent and reduced the boundaries between the courses. It was our intention that students experienced the courses as one entity, further reducing the boundary between disciplinary content and effective communication.

Signature Assignments

The TCM courses culminate in signature assignments, which are comprehensive; in other words, they are meant to assess the full complement of skills and knowledge learned in the course--they are summative assessments of student learning across the semester. They integrate technical knowledge learned in the BME lab with the communication knowledge learned in the TCM course. In the TCM courses, signature assignments are graded against rubrics developed by the AAC&U to ensure standardized reporting of student progress. The rubrics used are *Written Communication Value Rubric* and *Oral Communication Value Rubric*.

The writing and presentation assignments are drafted or practiced in the TCM courses. They are peer reviewed, and the instructor provides feedback. When the final assignment is submitted to the BME course instructor, it will have been thoroughly reviewed and students are highly likely to achieve a high level of success in their work.

Lessons Learned

Upon reflection, a multitude of evidence-based practices contributed to the success of this partnership. This is a summary list of successful practices mentioned in the document.

- Communities of practice are key
    - Opportunity to develop a shared vocabulary, which may provide continuity and a seamless connection among lecture, lab, and communication.
    - A forum to discuss student issues with curriculum instead of waiting until the end of the semester
    - Ensure clear delivery and unified content across each semester
- Openly collegial instructor relationships across the disciplines are valuable in multiple ways
    - They make our work easier
    - They set an example for boundary-spanning for all BME students
    - They offer a rich opportunity to explore how evidence-based instruction methods can enhance the student experience
- Integrated, ongoing, and consistent assessment of written and oral communication is key (using checklists or AAC&U rubrics)

- Students respond to the consistency of assessment—if they know they will be held accountable for the TCM skills and knowledge across the writing and speaking projects they do in BME, they will apply the learning continually (rather than just applying it the semester they are taking a paired course).
- Students respond positively to the split assessment. They appreciate being able to correct their TCM errors before submitting their work to the BME instructor
- Students grow in their ability to review peers over the course of the 200-level and 300-level TCM courses. Students gradually move from school rubrics to workplace review (narrative—no rubric).

Conclusion

The pairing of BME and TCM courses is meant to be an ongoing partnership enhanced by collegial relationships between the departments and the continued active participation in the monthly CoP. We look forward to building this student-centered practice and continuing to deconstruct boundaries between disciplinary content proficiency and effective communication.

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