Survey of Research-focused Engineering Programs and Modern Technical Communication Learning Outcomes

Dr. Alyson Grace Eggleston, Pennsylvania State University

Alyson Eggleston is an Associate Professor in the Penn State Hershey College of Medicine and Director of Evaluation for the Penn State Clinical and Translational Science Institute. Her research and teaching background focus on program assessment, STEM technical communication, industry-informed curricula, and educational outcomes veteran and active duty students.

Dr. Robert J. Rabb P.E., The Pennsylvania State University

Robert Rabb is the associate dean for education in the College of Engineering at Penn State. He previously served as a professor and the Mechanical Engineering Department Chair at The Citadel. He previously taught mechanical engineering at the United States Military Academy at West Point. He received his B.S. in Mechanical Engineering from the United Military Academy and his M.S. and PhD in Mechanical Engineering from the University of Texas at Austin. His research and teaching interests are in mechatronics, regenerative power, and multidisciplinary engineering.

Glen Coates, Pennsylvania State University

Glen R Coates received his B. S. degree in Environmental Engineering from Penn State University. He then went on to receive an M. S. degree in Mechanical Engineering at Penn State and a second M. S. degree in Management of Technology from Rensselaer Polytechnical Institute. Working in the Aerospace industry as a Senior Analytical Engineer for the past 45 years, he also has taught undergraduate mathematics and physics at several institutions as an adjunct professor. These experiences fueled his passion to bring real world engineering into the classroom. Mr. Coates is currently teaching at Penn State for the Aerospace Engineering Department.

Survey of Research-focused Engineering Programs and Modern Technical Communication Learning Outcomes

Abstract: This paper examines current methods for integrating modern technical communication skills—such as data visualization and collaborative writing platforms—into U.S. bachelor-level engineering programs within research-focused institutions. Emerging trends in course design and content integration are analyzed, alongside broader recommendations for modernizing technical communication curricula. These recommendations include incorporating data visualizations and infographics, fostering collaboration through digital platforms, practicing agile reporting, and anchoring coursework in real-world projects.

Equipping engineering students with technical communication skills is crucial for both academic success and future employment. ABET underscores the importance of effective communication, a priority shared by industry, government, and other employers. Although technical communication has been formally introduced in teaching-focused engineering programs in the last decade, the field itself has rapidly evolved. Modern technical communication now leverages digital tools to engage diverse audiences—from subject matter experts to the general public—requiring not only mastery of technical writing but also visual communication skills. This evolution presents two key challenges for engineering curricula: (1) where should these skills be taught, and in what format? and (2) which instructors are best suited and qualified to deliver this instruction? With limited space in the curriculum for standalone technical communication courses, many programs embed communication training within project-based courses, hoping that this exposure will suffice. However, most engineering instructors do not have a current background in technical communication that includes the integration of digital tools. As a result, there is a growing need for instructors with technical expertise who can effectively teach these evolving communication skills with digital tools.

This paper provides a survey of current curricular pathways that are used by research-intensive (R1) institutions to deliver modern technical communication content. It also provides a natural language processing analysis of technical communication content across R1 institutions, with a focus on common trends and gaps. Best practices for sustainable curricular innovation are proposed, along with strategies to support instructors in upskilling and adapting to these new demands.

Introduction

Today's engineer must be competent in technical skills relevant to a discipline, demonstrate effective data gathering and analysis acumen, and communicate with a wide variety of audiences. Engineering professional societies and accrediting bodies emphasize the need for ethical and precise communication to inform decision-making on the part of leadership, management and clients [1].

Meanwhile, the need for improved verbal, written, and visual communication is well documented in engineering education [2] - [4] with calls for reform emphasizing benefits for deeper student learning, enhanced internship and employment preparation, and overall expansion of a new engineer's influence in their employment organization.

To illustrate the need for an expansion of a new engineer's influence, in the wake of the Exxon Valdez oil tanker crash in Alaska, numerous scientists and engineers were asked by lawyers and policy analysts to "gather evidence, not data" [5]. Josh Schimel was one of those scientists gathering evidence and he subsequently spearheaded a STEM communication call to action, arguing that STEM communication:

(1) is part of our social commitment to the public;
(2) it makes us more critical thinkers;
(3) STEM communication is an essential professional and disciplinary skill as fields become more interdisciplinary and integrated [5].

A 2017 review of the undergraduate STEM curricular gap notes "While a few science communication courses are slowly being layered into the curriculum as electives at universities and colleges across the country, a gaping hole in the curriculum remains that needs renewed attention, particularly at the undergraduate level" [5].

The purpose of this report is to illustrate the examples of how modern technical communication skills, including data visualization, multimodal storytelling, and collaborative online writing, are being embedded in bachelor-level engineering curricula among the top 50 engineering schools. By understanding the terrain of technical communication pedagogy, recommendations for scaling and adapting these approaches can be developed for new institutional contexts. Using publicly available engineering degree completion materials, this report addresses the following research questions:

RQ 1: Where in the undergraduate engineering curriculum (stand-alone course vs. embedded modules) is instruction in modern technical communication happening and where is it most effective for long-term skill retention?

RQ 2: What disciplinary backgrounds (engineering faculty, communication specialists, hybrid appointments) most strongly represent current practices in teaching engineering technical communication?

The term Technical Writing and Communication (TWC) is used throughout this work to signal the technical and professional communication forms specific to STEM that are characterized by accuracy, precision, conciseness, and visual and data-based evidence where appropriate. With that said, TWC is taught in a variety of programmatic, departmental, and institutional contexts and the term is defined differently across text books. Table 1 below summarizes these varying approaches to teaching TWC with three main themes identified:

(1) focusing on broad, conceptual views of technical communication [6] - [7];
(2) the craft of scientific writing [8] - [10];
(3) technical writing in workplace contexts [11] - [12].

With this spectrum of emphasis, it is not surprising that we would also see varying curricular integration approaches. From TABLE 1, it is clear that there is a variety of approaches for teaching TWC.

TABLE 1: Nuance and Semantic Mismatch in Technical Writing and Communication as Field Term

Theme	Authors	Features
(1) Broad, Conceptual Views of Technical Communication	Markel & Selber (2021)	Includes proposals, emails, tweets, and even videoconferences. TWC is framed as a multifaceted process of discovering, shaping, and transmitting information.
	Johnson-Sheehan (2018)	Dynamic nature of genre: mobile, interactive, reader-centered, team oriented, and influenced by global and transcultural factors.
(2) Craft of Scientific Writing	Alley (2018)	Offers advice on best practices, what to do, what to avoid, without trying to define scientific or engineering communication outright.
	Schimel 2012	Stresses that scientists must embrace their role as professional writers who transform raw data into clear, understandable insights. (professional responsibility).
	Berger (2014)	Takes a "scientific approach" to writing, arguing for the importance of understanding syntactic rules and progressively building towards more complex sentence structures, especially for engineers and scientists.
(3) Technical Writing in Professional/Workplace Contexts	Beer & McMurrey (2019)	Provide guidelines on crafting documents (reports, emails, memos, etc.) that are clear, well-organized, and appropriately formatted for an engineering context.
	Tebeaux & Dragga (2021)	Discuss technical writing (or business/work writing) by contrasting it with academic writing, stressing the importance of factors such as security, legality, accuracy, and conciseness in professional communications.

Prior Work

In a 2021 study, investigators reported on current modes of integrating technical writing courses and content in 98 US Bachelor-degree granting engineering programs and some trends in curricular adoption [13]. Further, the study used the Accreditation Board for Engineering and Technology (ABET) student learning outcomes as a starting point to show the need for and importance of technical communications in the engineering profession. This investigation found that instructor selection can also be an issue, as many engineering faculty reported either a reluctance for integrating technical writing instruction, or a concern that engineering faculty are not appropriately trained to teach technical writing and communication (TWC). Finally, the investigation identified the program structure in the surveyed colleges and universities and determined the degree of interdisciplinary work present (which schools collaborated to reinforce the student learning experience). In the initial review of 98 engineering programs, only 28% included a separate course on technical writing in their respective curriculums, with 10% of programs opting to embed aspects of technical writing in their programs. Most of the remaining institutions did not overtly emphasize technical writing in their stated curricula. A range of institutions from research to teaching universities were included in the survey. To summarize, this brief study revealed some opportunities and suggestions for many engineering programs to improve their emphasis in TWC.

In 2004, Reave conducted a survey of 73 top-ranked U.S. and Canadian engineering schools revealed that 50% of the U.S. schools and 80% of the Canadian schools required a course in technical communication [14]. Only 33% of the schools used some form of integrated communication instruction, and another third offered elective courses in communication. The most comprehensive preparation that engineering schools provide is a communication-across-the-curriculum approach that combined these instructional methods to offer concentrated instruction, continual practice, situated learning, and individualized feedback.

Courses in first-year composition, writing-intensive courses in the humanities and social sciences, and reports and presentations in regular engineering courses did not fulfill the students' need for instruction in business and technical communication. The report recommended that a well-designed program begins with a good foundation delivered through a separate course or through integrated instruction. This recommendation is reinforced with further instruction throughout the curriculum. Specifically, a series of courses, or integrated modules delivered through team-teaching, delivered consistent instruction that emphasized skill building and the practiced needs of the profession.

Reave's study showed that the engineering schools that have the most extensive communication programs are among the highest rated programs in North America. Those that developed strong communication programs in their engineering curricula differentiated themselves as providers of top-quality engineering education. Engineering schools with strong communication programs provide a competitive advantage not only to students but also to themselves and their universities.

Methods

Conducting a survey of US News and World Report's Top 50 Engineering Programs (2024) from doctorate-granting institutions (R1, research focused) yielded complex curricular profiles for accomplishing engineering communication. For example, eschewing an overt TWC course, some programs opt for a writing-intensive course that occurs mid to late in the four-year pathway. This writing-intensive course simultaneously meets the general education requirements of the institution for critical thinking, communication, teamwork, and personal ethics, while also is flagged as 'writing intensive' in some way, likely allowing the course to be substituted for traditional or literature-based academic writing courses. Comparing and coding degree maps for Mechanical Engineering (ME) across institutions yielded four discrete pathways for teaching engineering communication.

(1) *General Education*, English, or (rarely) Communication courses were found to be a common 2-course sequence with varying titles like First-year Seminar; College Writing, Composition, or Rhetoric. All schools with some form external-to-

engineering writing requirement common to most or all undergraduates were counted for this category.

(2) *Technical Writing and Communication* (TWC) as a category refers to those degree maps where TWC was either mandated or offered overtly as an option in an institution's degree map. Institutions that offered TWC as an upper-division course in English or Communication departments—but were not listed in the Engineering degree map—are not included in this count. The rationale for excluding these courses was because the target student audience is likely English or Communication majors.

(3) *Engineering Mid-Program* second- and third- year design courses with a specific focus on reporting were counted as a discrete category also. +

(4) Finally, degree maps that included more than two *senior design courses* and where design and reporting were emphasized formed the final pathway category for teaching engineering communication. A total of 50 research-focused institutions were surveyed.

Results

The survey concludes that nearly all institutions require some General Education, first-year writing component (96%), while fewer than half (39%) reinforce writing and communication with design or lab-report heavy courses at the end of the curriculum beyond mandatory senior design / capstone courses. Engineering schools with mid-curriculum writing-intensive or communication-intensive courses represent a minority of 31% of schools surveyed. Finally, only 15.7% of degree maps specifically invite or require students to training in technical writing or technical communication. Table 2 below summarizes these percentages and program counts.

TABLE 2: Comparison of the Top 50 Research-focused Engineering Programs and Engineering Communication
Pathways

	Count		**Percentages**	
Engineering Communication Pathway	*Yes*	*No*	*Yes*	*No*
Gen Ed ENGL / Comm	48	2	96%	4%
TWC	8	42	16%	84%
Engr Mid-Program 200-300 level design courses	16	34	32%	68%
Taught in other 400 courses	19	31	38%	62%

Requirement for Technical Writing and Communications

Addressing research questions (RQ1 and RQ2), Table 2 summarizes where in the curricular progression technical communication is taught and which department's faculty teach the course. Following a review of the top 50 research intensive Mechanical Engineering (ME) programs in the US (all but one are ABET accredited), exactly 25 (50%) programs do not have an explicit TWC requirement in their program requirements or shown in their curriculum maps, as shown in

Figure 1. While the TWC programs are not listed as a requirement, they might be included as other curricular requirements (such as specific math or sciences).

Of the 50% of programs that do specify a TWC requirement, 6 (12%) of these indicate a separate course taught in another department or college such as English or Communications, respectively. Eleven (22%) of the total of the programs have a separate TWC course in the mechanical engineering program or one in the engineering college. Fig. 1 gives a visual for the relative magnitude of the vehicles for TWC instruction.

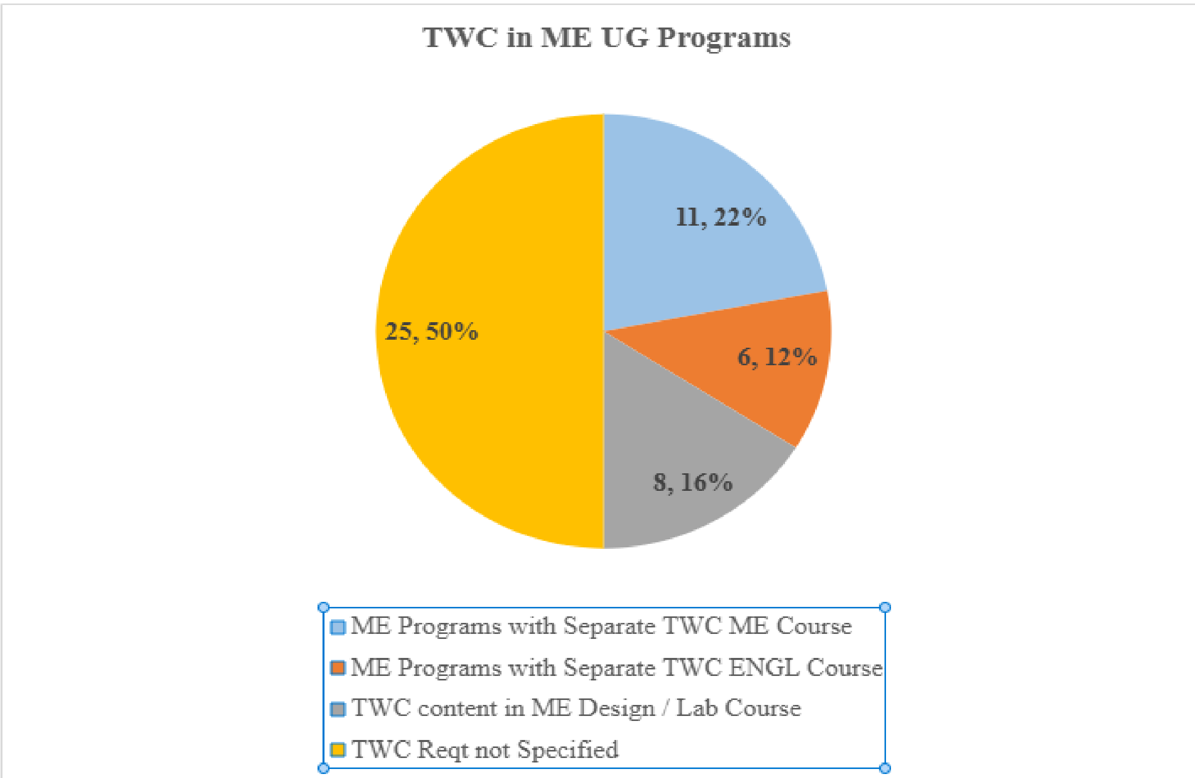

Fig. 1: TWC in the top 50 ME Undergraduate Programs (R1 Institutions)

Some of the programs had neither of these but had lab or design courses that had substantial writing requirements, as defined by the institution. In this category, 8 (16%) of the mechanical engineering programs met their advanced communications requirements through one of these third- or fourth-year scheduled writing intensive ME courses.

Content and Purpose of Technical Writing Courses

Drilling down into the specific course objectives of the 25 ME programs requiring a TWC course, course descriptions were collected from ME departmental websites and compiled in a spreadsheet. These syllabi were then coded for probably key words and reduced to a discrete set of semantic themes. Using natural language processing approaches in Python, the following themes were used as frequency targets across syllabi (given in order of frequency, from most frequent to least): Reports; Presentations; Visual Communication; Teamwork; Writing;

Correspondence; Ethics; Oral Communication; Research. Related lexemes were pr-grouped in Python; e.g., “presentation” includes ‘present,’ ‘presenting,’ ‘presented,’ ‘presentations,’

In TWC course descriptions, the top six themes accounted for 80% of the courses. These themes included: Reports, Presentations, Visual Communications, Teamwork, Writing, Correspondence. Fig. 2 below shows the frequency of these themes in the course descriptions of separate TWC courses. It is apparent that 80% of the courses explicitly called the top six themes.

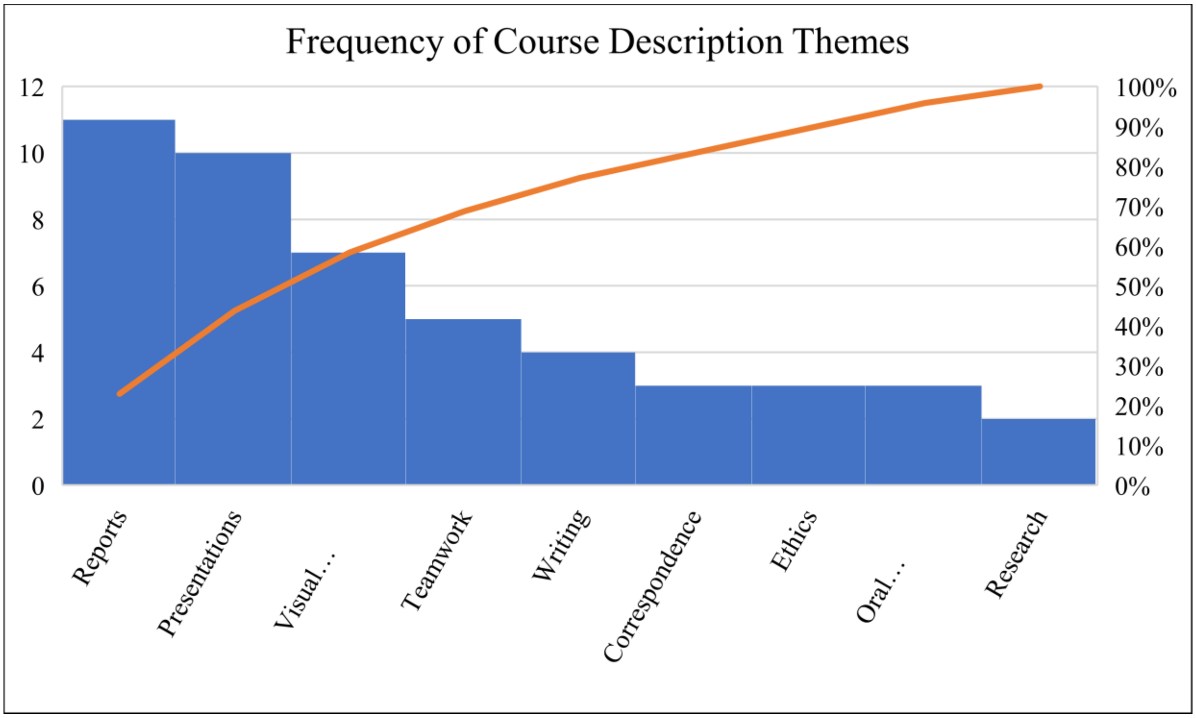

Fig. 2: Most Common Themes and Requirements in Specified TWC Courses Ranked by Frequency of Occurrence

Horizon Challenges

Engineering-focused communication

Visual communication strategies are not observably emphasized in general education writing courses as that is not the focus— but it should be expected that a strong focus should exist in an overt TWC course, writing intensive lab, and design and capstone courses. Engineers and other STEM disciplines communicate differently than other non-technical disciplines with regard to data-supported assertions and this gap continues to widen as engineers need to interoperate with large data sets. Engineering communication in industry is visual-focused, requiring engineers to create and explain datasets and test results to a variety of audiences—and often in dynamic and transparent ways, which requires them to also ‘think on their feet’ [15].

Student Disconnection
Engineering students are accustomed to taking courses that apply principles, instrumentation, laboratory processes, modeling approaches to some problem and derive answers. While general college writing courses are crucial to their development as well-rounded, educated individuals, engineering students can struggle to see the connection between some Platonic concepts in classical disciplines like Rhetoric and their audience focus for a proposal. While this connection is likely obvious for an instructor in the Classics, it might not be obvious to engineering students. Pivoting toward more applied communication courses or content can help reinforce students' integrative understanding of engineering communication and their responsibilities for clarity, accuracy, and conciseness [16] - [17]. It should be noted that if the aim is to teach applied communication, then that effort entails hiring instructors with recent industry-aligned backgrounds, rather than predominantly academicians.

Employment preparation
As engineering programs seek more industry input and voice on their advisory boards and within their internship partner networks, programs may need to refine engineering communication preparation for their students. Industry feedback in the literature repeatedly requests stronger so-called professional skills that can determine success of team-based collaborations, customer interaction, regulatory reporting, and internal SOP management [18] - [20]. Additionally, ABET, or the Accreditation Board for Engineering and Technology, emphasizes communication as a key student outcome. Specifically, Student Outcome 3 of ABET Criterion 3 requires students to be able to communicate effectively with various audiences. This requirement encompasses both written and oral communication skills, allowing graduates to convey technical information clearly and concisely to diverse audiences [21]. Attainment of these outcomes better prepares graduates to enter the professional practice of engineering.

Machine Learning-assisted Writing (Chat-GPT and others)
As the Large Language Models (LLMs) continue to become more robust in their capacities for summary, outlining, and organizing text, they have been operationalized by technical writing professionals as well. These tools are largely unknown by academicians in liberal arts or STEM and point to the benefits of industry-sourced hires. While the humanities approach to integrating LLMs as operational TWC tools has largely being one of 'cautious surveillance' [22] with more recent examples of critical integration, both approaches ignore the ethical responsibility for preparing engineering students for a technical workforce where these tools will absolutely be used. Industry-aligned instructors may better understand the mechanics of LLMs, their limitations, and security risks than academicians whose chief interaction with LLMs may occur during technology and pedagogy workshops in an academic context.

Discussion

This survey offers no concrete recommendations for engineering course map changes, but some opportunities exist to improve emphasis of selected TWC concepts. Certainly, each institution will have specific contexts that drive their choice of engineering communication pedagogy pathways. That said, some trends in the data emerged that suggest that for some institutions (n=19), a first year or general education writing component was sufficient to meet the needs of their program. With increased industry requests for professional, visual, and technical communicative capacity, these skills likely need to be scaffolded and reinforced throughout the curriculum, extending through the capstone year.

To enhance student learning and adaptability, we recommend increasing the emphasis on visual communication and AI-focused courses. Self-reported data from students at the authors' institution indicate that AI tools are more readily applied when these subjects are taught outside the college setting. However, when coursework requires high-context, technical content, such as project-based learning or lab reports, students face greater challenges in generating text that is both technically accurate and appropriate for specialized audiences. Strengthening instruction in these areas will better prepare graduates to produce a wider range of high-quality, discipline-specific work while effectively practicing when and how to use AI in preparation for their engineering careers.

Future work will broaden this study to include engineering curricula from other disciplines (Civil, Electrical, Computer Science), and triangulate perspectives from students, faculty, and employers in order to (1) better identify emergent curricular model trends in technical communication pedagogy; (2) identify gaps between academic focus and workplace needs; (3) promote evidence-based recommendations for discipline-appropriate integration of modern technical communication instruction throughout the undergraduate engineering experience.

As more collaborators join this work, we expect to surface important differences between teaching- and research-focused schools in terms of their approach to teaching modern technical communication. When considering the best instructional approach for lab courses, there are distinct benefits to hiring industry professionals versus traditional engineering professors. While ME professors possess deep theoretical knowledge, their time may be better spent on research and core academic instruction rather than teaching highly applied courses. Some institutions have found success in hiring industry retirees or industry professionals as adjunct instructors or full-time faculty who bring valuable real-world experience and examples into the classroom. Both industry professionals and engineering professors may require additional training in TWC, data visualization strategies, and other tools commonly used by technical writers to effectively convey complex information. Planning for these strengths and gaps can help programs optimize for the best TWC instruction, curricular 'timing', and student learning outcomes.

References

[1] National Society of Professional Engineers. (2013). Professional Engineering Body of Knowledge. NSPE.

[2] C. Prusty, A.K. Dwivedy, and J. Khuntia, J. Why and How Do Engineers Communicate? *IUP Journal of Soft Skills*, 9(1), 45, 2015.

[3] A.G. Eggleston and R.J. Rabb, "Technical Communication for Engineers: Improving Professional and Technical Skills Paper presented at *2018 ASEE Annual Conference & Exposition*, Salt Lake City, Utah, June 23-27, 2018 10.18260/1-2—31068.

[4] A. Andreou, "Teaching a Technical Writing and Research Course to Engineering Students: Recommendations for Curriculum Reform," In Ktoridou, D. (Eds.), *Cases on Engineering Management Education in Practice* (pp. 22-38), 2021. IGI Global. http://doi:10.4018/978-1-7998-4063-3.ch002

[5] A. Fulton, “Expanding the Job of a Scientist: A Call for Explicit Writing Instruction in Undergraduate STEM Education,” *The Synapse: Intercollegiate science magazine*, 12(1), 16, 2017.
[6] M. Markel S. Stuart, *Technical Communication*, 13th ed. Bedford St. Martin’s, 2021.
[7] R. Johnson-Sheehan, *Technical Communication Today,* 6th e*d*. Boston, MA: Pearson, 2018.
[8] M. Alley, “Connecting Your Ideas,” The Craft of Scientific Writing, 69-92, 2018.
[9] J. Schimel, “Writing science: how to write papers that get cited and proposals that get funded,” OUP USA, 2012.
[10] R.E. Berger, *A scientific approach to writing for engineers and scientists*, John Wiley & Sons, 2014.
[11] D.F. Beer and D.A. McMurrey, *A Guide to Writing as an Engineer*, John Wiley & Sons, 2019.
[12] E. Tebeaux, and S. Dragga, *The Essentials of Technical Communication*, 5th ed. Oxford University Press, 2021.
[13] A. Eggleston and R. Rabb, “Survey of and Best Practice Identification for Course Development and Integration of Technical Communications for Engineers,” technology Interface International Journal, 22(1), pp. 37-43, Fall/Winter 2021.
[14] L. Reave, “Technical Communication Instruction in Engineering Schools: A Survey of Top-Ranked U.S. and Canadian Programs,” *Journal of Business and Technical* Communication, vol. 18, no. 4, pp. 452–490, Oct. 2004, doi: 10.1177/1050651904267068
[15] K. Zhao, C. Peng, and Y. Wu, "Exploring the Teaching Path of Visual Communication in the Digital Era,” *International Journal of Web-Based Learning and Teaching Technologies (IJWLTT)*, 19(1), pp. 1-17, 2024.
[16] B. Coulter, R. Petelin, J. Gannon, K. O'Brien, and C. Macdonald, "Enhancing technical writing skills for undergraduate engineering students," in *Annual Conference of the Australasian Association for Engineering Education (*28th: 2017: Sydney), Australasian Association for Engineering Education Sydney, pp. 160-169, 2017.
[17] L. R. Cox and K. G. Lough, "The importance of writing skill to the engineering students," University of Arkansas-Fort Smith/University of Missouri-Rolla, 2007.
[18] A. Çal, T. Mearns, and W. Admiraal, "Two worlds apart? Engineering students’ perceptions of workplace English," *Business and Professional Communication Quarterly*, p. 23294906231182613, 2023.
[19] C. DuPre and K. Williams, "Undergraduates' Perceptions of Employer Expectations," *Journal of Career and Technical Education*, vol. 26, no. 1, pp. 8-19, 2011.
[20] M. Hirudayaraj, R. Baker, F. Baker, and M. Eastman, "Soft skills for entry-level engineers: What employers want," *Education Sciences*, vol. 11, no. 10, p. 641, 2021.
[21] (2025) ABET Criteria for Accrediting Engineering Programs, 2025 – 2026. [Online]. Available: https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2025-2026/
[22] E.H. Pflugfelder and J. Reeves, J. (2024). Surveillance Work in (and) Teaching Technical Writing with AI. *Journal of Technical Writing and Communication*, 2024, 00472816241260028.