Implementing Writing-as-Process in Engineering Education

Bruce Kovanen, University of Illinois at Urbana-Champaign

Bruce Kovanen is a PhD candidate in the Department of English and the Center for Writing Studies. He works with faculty and teaching assistants across disciplines to help hone their writing pedagogy. His research and teaching focus on sociocultural perspectives of literacy and learning.

Ryan Ware, University of Illinois at Urbana-Champaign

Ryan Ware is a doctoral candidate in Writing Studies primarily interested in cultural-historical theories of writing and learning to write. He is part of an interdisciplinary team that focuses on helping STEM instructors integrate writing into their courses, and that helps departments integrate writing across undergraduate curricula.

Megan Mericle, University of Illinois at Urbana-Champaign

Megan Mericle is a PhD student in Writing Studies. She is a member of a research team focused on writing in STEM, where she works with faculty to develop and implement learning objectives for writing in undergraduate science and engineering courses. In her own work, she focuses on disciplinary identity as well as communication practices in citizen science.

Nicole Turnipseed, University of Illinois at Urbana Champaign

Nicole Turnipseed is a PhD candidate in the Department of English and the Center for Writing Studies. She teaches a range of writing courses and helps teachers across disciplines hone their writing pedagogy. Her research and teaching focus on developing robust learning environments to support holistic literate development.

J. Patrick Coleman, University of Illinois at Urbana-Champaign

Patrick Coleman is a doctoral candidate in the Department of Physics at the University of Illinois at Urbana-Champaign. He researches synchronization in non-linear dynamical systems. He is also part of an interdisciplinary team that studies and improves the way writing is incorporated in STEM curriculum.

Celia Mathews Elliott, University of Illinois at Urbana - Champaign

Celia Mathews Elliott is a science writer and technical editor in the Department of Physics at the University of Illinois at Urbana-Champaign. She has been teaching technical communications to upper-level undergraduate physics majors since 2000, and recently developed, with S. Lance Cooper, a graduate technical writing course.

Prof. John S Popovics, University of Illinois at Urbana - Champaign

John Popovics is a Professor in the Civil and Environmental Engineering Department at the University of Illinois at Urbana-Champaign. He earned his B.S. and M.S. in Civil Engineering from Drexel University and his Ph.D. in Engineering Science and Mechanics from Penn State. His research interests include testing, sensing and imaging of infrastructure and geologic materials. He is also involved in efforts to improve writing skills in engineering students.

Prof. S. Lance Cooper, Department of Physics, University of Illinois at Urbana-Champaign

S. Lance Cooper is Professor and Associate Head for Graduate Programs in the Department of Physics at the University of Illinois at Urbana-Champaign. He received his B.S. in Physics from the University of Virginia in 1982, his Ph.D. in Physics from the University of Illinois in 1988, and he was a postdoctoral research associate at AT&T Bell Laboratories from 1988-1990. Cooper's research interests include optical spectroscopic studies of novel magnetic and superconducting materials at high pressures, high magnetic fields, and low temperatures. Since 2013, Cooper has co-taught (with Celia Elliott) a graduate-level technical writing course each spring to physics and engineering graduate students.

Dr. John R Gallagher, University of Illinois at Urbana - Champaign

I am an assistant professor of English at The University of Illinois, Urbana-Champaign

Prof. Paul Prior

Paul Prior is the Director of the Center for Writing Studies and Professor of the Department of English at the University of Illinois at Urbana-Champaign.

Julie L Zilles, University of Illinois at Urbana - Champaign

Dr. Zilles is a Research Assistant Professor in the Department of Crop Sciences at the University of Illinois Urbana Champaign. She received her B.S. in biology from the Massachusetts Institute of Technology and her Ph.D. in Bacteriology from the University of Wisconsin Madison. In addition to research at the intersection of microbiology, agriculture, and environmental engineering, she leads a transdisciplinary team focused on integrating best practices from writing studies in STEM classes and curricula.

Implementing Writing-as-Process in Engineering Education

Abstract:

Although professional boards and engineering employers have emphasized written communication as a key feature of engineering education and practice, a range of challenges—from lack of pedagogical training in writing to large class sizes and heavy content requirements—often prevent science, technology, engineering, and math (STEM) faculty from incorporating writing instruction into classes. This paper focuses on a key theoretical concept from the field of writing studies, writing-as-process, and explores how it has been included by STEM faculty in their teaching. We first review theoretical and empirical work that supports writing-as-process as an effective tool for facilitating student learning. We then illustrate how writing-as-process has been incorporated into varied types of courses, drawing on a multi-year intervention project designed to enhance writing in engineering and STEM. The examples describe reflective, writing-to-learn activities for first-year orientation courses; scaffolded approaches for laboratory and problem-based-learning classes; and directed peer review and response to reviewer comments in middle- and upper-level courses. The paper concludes by addressing the vital role STEM faculty play in socializing their students into ways of thinking, being, and writing in their disciplines and demonstrates how a process orientation to writing instruction can help faculty achieve that goal.

Section I: Introduction

The Accreditation Board for Engineering and Technology (ABET) has identified effective communication as a key criterion of engineering competency, and engineering schools across

North America have noted the specific importance of writing instruction [1], [2]. However, STEM faculty have faced persistent obstacles in designing and delivering writing instruction. Common challenges include the time constraints of grading and responding to student writing, particularly for large enrollment classes, and lack of training in writing instruction, response, and assessment for teaching assistants (TAs) [3], [4]. Many STEM classes also have heavy demands to cover technical content that leave little pedagogical time for writing instruction. Additional challenges can arise from a lack of student motivation or engagement [5] and from discrepancies between faculty's and student's perception of the purposes for writing assignments [6].

Reflecting these challenges, writing in STEM classes is often used primarily to demonstrate content knowledge. Rather than offering opportunities for students to learn about writing practices and disciplinary genres, typical writing assignments are effectively treated as tests of course content. In contrast, STEM workplaces display quite varied kinds of writing and communicative practices [7]–[10]. Thus, STEM graduates will be required to write in a wide and evolving array of genres; however, the types of writing assignments students are asked to do in engineering often do not resemble the forms, functions, or practices of workplace genres [4]. Students often receive only summative feedback to their final texts. Given the emphasis on formal features (grammar, organization, style, editing, content) of finished products, writing studies would categorize these practices as emblematic of a traditional product orientation to writing [5]. Product-oriented approaches often ignore writing processes entirely or depict simple, linear processes of both writing (plan→write→edit) and writing instruction (assign→submit→grade). However, the field of writing studies has largely rejected the product approach in favor of writing-as-process models for writing instruction since the 1970s [11].

Writing-as-process shifts attention from the final products to the complex, cyclical processes through which writing is developed. Writing-as-process approaches attempt to account for and acknowledge the often uncertain and nonlinear processes of production. As writers produce texts, a wide range of *literate activities* are involved, including reading, conversations with colleagues, varied types of inquiry and experimentation, and informal and formal presentations [12], [13]. From this perspective, what we typically call "writing" is better described as complex "chains of reading and inscribing, talking and observing, acting and making involving a temporally and spatially dispersed set of scenes and cast of characters" [13]. These writing-as-process models have led to longstanding and empirically-grounded lines of writing research that have informed a variety of effective classroom practices, such as using scaffolded assignments [14]–[16]; providing formative feedback and guiding revision [17], [18], including peer review [19], [20]; and developing evaluation schemes that emphasize process and communicating those evaluation schemes to students [21].

Despite this long history of process models in writing studies, the philosophy appears to be rare in the engineering education literature. Although a search of the American Society for Engineering Education's repository of conference papers for "writing" and "process" finds numerous articles mentioning a writing process, very few papers offer accounts that are grounded in writing studies research and pedagogy. Early glimmers of a process orientation appear in Wheeler and McDonald's 2000 article [22], where they highlight similarities between writing and design, namely their recursive nature and lack of a unique correct solution, but their pedagogical and curricular recommendations do not include a process orientation. Two studies

focused on introducing writing in large engineering classrooms proposed or "accidentally" implemented revisions [23], [24] suggesting again some recognition of the importance of process. Examples where a process orientation was named and emphasized typically arise from a close collaboration with experts from writing studies or technical communication (e.g., [4], [25]–[27]). It is difficult to conduct a comprehensive search for examples that do not use this terminology directly; elements of a process orientation are likely more widespread than is documented here. However, the limited attention to this core concept from writing studies and technical communication in engineering education supports the need for this review of how the field of writing studies understands a process orientation and what its implementation might look like in STEM classrooms.

To assist STEM educators in implementing writing-as-process approaches in their curriculum, we review some key research from writing studies and science and technology studies that points to the tangible pedagogical benefits (Section II). We then offer examples from a faculty development program called Writing Across Engineering [4], [28]–[30] to show how STEM faculty have incorporated writing-as-process into their courses (Section III). We conclude by discussing the critical role that STEM faculty play in socializing their students into their disciplines and how a process orientation to writing instruction can help faculty achieve that goal (Section IV).

Section II: Review

Writing-as-process is a central disciplinary value in writing studies. For example, the Council of Writing Program Administrators (CWPA) identifies it as a core outcome of first-year writing

courses [31]. Specifically, CWPA states that college students should develop an understanding of writing as a nonlinear process that unfolds across multiple stages, and that students should develop the ability to adapt their processes to "different contexts and occasions." The CWPA highlights multiple dimensions of writing processes, including moving between multiple drafts of a text, developing "flexible strategies" for revising and editing, managing multiple genres and modes, collaborating with others throughout the process, and using writing to discover and inquire.

The recognition of writing-as-process as central to writing theory, research, practice, and pedagogy was a central motivation for the emerging discipline of writing studies in the 1970s. Prior to the process model, writing was typically taught from a product-oriented perspective that was not grounded in research on writing and that focused on form rather than ideas, particularly stressing organizational schemes (like five-paragraph essays and cause-effect paragraphs) and adherence to conventions for grammar, style, and layout [11], [32]. However, as Douglas pointed out, there was from the start a disconnect between writing instruction and writing instructors' descriptions of their own processes [33]. Likewise, in our project we have observed a similar discrepancy between what STEM faculty describe as their values around writing and the characteristics that are most often assessed on grading rubrics.

Writing-as-process shifted instructors' goals from assessing students' one-shot written texts toward improving students' writing processes as a whole. In a 1972 essay, Donald Murray argued that students should "write as many drafts as are necessary to discover what there is to say" and instructors should allow time for this practice [34]. To increase awareness of invention

(e.g., brainstorming) and revision, pedagogical attention began to focus on providing feedback on drafts [35] and asking students to reflect on their texts and writing practices [36]. Research quickly rejected models that portrayed writing as a linear progression of stages (prewriting, drafting, revising, and editing): laboratory and situated studies alike found recursive, cyclical, non-linear processes of writers struggling with ideas, texts, and audiences as they produced particular texts [37]–[41].

By the early 1990s, writing process research was increasingly adopting a sociocultural approach to writing which highlighted the notion that writing tools, practices, and contexts are highly situated and heterogeneous [37], [41]–[43]. As people participate in specific activities, they tacitly develop practices, stances, and identities around inquiry, communication, knowledge, social interaction, and identity, all of which come into play in writing. In short, as writers engage in activities, they are not just learning the skills of writing but are being socialized into specific ways of thinking, acting, and being in relation to their disciplines and professions. A sociocultural approach then provides a ready explanation for the difficulty students have applying knowledge from first-year composition courses into their STEM courses. It also makes clear the limits to outsourcing writing instruction to professionals from other disciplines. To navigate disciplinary writing values, genres, contexts and practices, novices need engagement with, and guidance from, instructors most familiar with their disciplines.

In situated studies of scientific practices, researchers have highlighted that socialization into writing processes involves blends of curricular and extracurricular experiences mediated by materials and tools in the writer's environment [44]. For example, Roozen's study of an

engineering student revealed how her inscriptional practices for making, understanding, and using tables were not only developed in, or confined to, her school or disciplinary experiences, but were instead entangled with her wider experiences as she composed and used tables to schedule events in her life, to play computer games, to do logic puzzles, and to write fan fiction [45]. Using methodologies such as process-tracing (the observation of writing practices alongside analysis of writers' changing texts), researchers have argued that process research should not focus on identifying the "right" practices and replicating them but on studying existing practices and their ongoing evolution in order to better understand and help students [12], [13], [46]. Studies of scientific and technical writing, both from writing studies and parallel work in science studies, have varied in methods and theory but have converged on some core findings: writing processes are always collaborative and situated, and developing the practices is as recursive as producing the texts.

First, situated studies of writing in science demonstrate that the social and collaborative character of writing processes is spread throughout scientific activity and involves multiple settings and forms of communication. For example, Amann and Knorr Cetina's study of molecular geneticists found that talk was "the machinery of seeing" in the lab [47]. As the scientists moved from reading and interpreting laboratory data to creating visuals and crafting text that illustrated "what was seen," the geneticists employed particular practices of talk (e.g., questioning and offering alternatives) and embodied activity (e.g., positioning x-rays in front of lights). Latour has highlighted the ways that writing happens in shifting networks, where securing research funding and building professional allies cannot be fully separated from collecting data or writing up results [48]. Building on Latour's work, Winsor showed how even when engineers in the field

used formulaic and repetitive documentation practices like meeting notes and memos, they were working to assemble and maintain networks of collaborators and investors [49]. In classroom contexts, peer review is one practice that highlights the social nature of writing. In a study of peer review in an engineering communication course, Artemeva and Logie found that, over the course of the semester, students moved from making comments on format and local contexts to crafting overarching evaluative feedback, indicating increased confidence and comfort with "intellectual teamwork" [19]. Timmerman and Strickland argue that peer review increases scientific reasoning, finding that paper scores increased when students incorporated suggestions from peer review [50].

Second, research has highlighted the complexly situated nature of writing. Writing processes are linked to broad social and disciplinary contexts as well as to features in writers' immediate environment [51]. In Kent's observation, "writers always write from some position or some place; writers are never nowhere" [52]. For instance, Prior and Shipka show that writers use a wide variety of "environment-selecting and -structuring practices," organizing time, people, materials, and practices to assemble environments that will support and shape their processes [12]. Similarly, Durst illustrates how an engineer drew on her industry experience to fashion disciplinary practices, shaping the way she structured her physical space, did note-taking, and adapted planning processes to maintain research confidentiality while organizing and motivating the students in her lab group [46]. In practice, researchers and instructors have found that reflective assignments, like the writer's memos we will discuss later on, help students better understand the situated nature of their writing processes, and allow them to take steps to select and structure their process environments more consciously [53]–[55].

Finally, writing studies research regularly points to the recursive nature of both writing practices and writing development. Early studies of writing processes found that writers repeatedly (recursively) engage in reading, planning, writing, and revising throughout the process whether in short research tasks [38] or the extensive document cycling among writers, managers, and others typical of many workplace writing projects [40]. Likewise, people build complex trajectories across contexts as they learn and relearn how to write: refining, altering, abandoning, and recombining past and present processes as they encounter ever-changing situations [12], [44], [46]. Given the recursive nature of both writing processes and learning to write, we recommend scaffolding practices that invite students to re-engage with, and reflect on, their writing from multiple perspectives across cycles of peer and instructor feedback.

When incorporating process pedagogy within STEM education, it is important to structure and support a diverse set of pathways toward developing disciplinary and professional writing practices. Process pedagogy supports flexibility by emphasizing student reflection and cyclical engagements with central concepts. This approach invites students to discover and enact their own best writing practices [56]. As Bloom argued, process pedagogy and research teaches us that "the act of writing can be a means of learning and discovery" and that effective writing instruction works to "intervene in each student's writing process" at "appropriate occasions," giving students time to develop their practices [57].

Section III: Examples

The examples in this section are drawn from our work with STEM faculty in Writing Across Engineering, a faculty development program our team developed [29]. In the paragraphs below, we first offer generic examples that can be implemented across a wide variety of courses. These changes include incorporating short writing-to-learn assignments in large classes and providing scaffolding—that is, breaking a writing assignment into smaller pieces—for a writing assignment in a graduate-level environmental engineering course. Then, we move to discuss specific examples drawn from our mentoring work with faculty across STEM, demonstrating the effectiveness of a variety of writing-as-process elements including peer review, writer's memos, and scaffolding.

Recognizing that time constraints are one of the major challenges limiting incorporation of writing in engineering classes, we want to particularly highlight low-investment, easy-entry examples of how a process orientation to writing can be implemented in STEM classes. For example, in large, minimal-credit orientation courses for first-year students, we have designed several short writing assignments. When introducing these assignments to the students, instructors talk about how writing is integral to their discipline and can serve a wide range of purposes. Most of these assignments are reflective, prompting students to capture their thoughts about a reading or presentation. Other assignments are more structured and oriented to developing professional communication practices, such as drafting an email to a professor asking for advice after missing class because of an illness. The assignments are designed as writing-to-learn opportunities [58], [59] and typically receive minimal individual feedback, perhaps an encouraging phrase or a compliment on a particularly well-supported argument. Evaluation is also fairly quick, such as evaluating assignments with three categories: satisfactory, not fully

satisfactory, or unsatisfactory. Incorporating low-stakes writing into these early courses helps combat STEM students' perceptions that writing is not needed for STEM disciplines and gets them in the habit of writing and using writing to work out ideas even in low-credit-hour courses.

Scaffolding a writing assignment can be accomplished with relatively low effort and can benefit many types of assignments. If information is available about what stages of the assignment frequently present difficulties to students, those are generally the most beneficial to scaffold. For example, in an upper level undergraduate/graduate class where students submit a summary of a primary journal article, a recurring problem was that students often unknowingly selected a review article. Having students obtain approval for their chosen article before they continue with the assignment avoids wasted effort by the student. For an instructor, adding this single stage is not burdensome and may even save time when compared to communicating the mistake and allowing students to redo the assignment. Another possibility is to add stages where students submit bullet points or a key data figure for feedback before writing a full report; these stages can improve the quality of their submissions, and having clearer texts also facilitates quality feedback and assessment. For classes assigning repeated genres, such as lab reports, focused scaffolding can be implemented over multiple assignments, for example by giving feedback and instruction on specific sections at a time in early reports (e.g., focusing on methods one week; on graphs and accompanying text another week, then on discussion, and so on), gradually building up to assessment of full report later in the course.

Conceptually, scaffolding provides an important opportunity to help students develop good habits around their writing processes, such as seeking out feedback along the way and revising in

response to that feedback. Many scaffolding interventions also require students to start working on a writing assignment earlier, which again can improve the quality of submissions and therefore make responding and assessing easier and more productive. The impact of these changes can be amplified by being explicit with students about why the changes are important and sharing stories that show the connection between an iterative or recursive writing process and the way writing occurs in their discipline. We turn now to three specific examples of implementing writing-as-process in STEM classes that our project team has supported.

Example 1: Peer Review

This example focuses on the addition of peer review into the ongoing flow of a single assignment in a natural resources and environmental sciences course. The course was a mix of graduate and upper-level undergraduate students taught by Dr. Angela Kent. The course included a product-oriented writing assignment, a literature review of eight to ten pages. Originally the assignment had also included student presentations to the class, but that aspect had been absent for several years as the instructor had found it difficult to ensure the accuracy of the information presented. In a previous paper, we briefly discussed overall changes to the assignment that emerged from a semester-long mentorship by project team members Ryan Ware, a PhD student in writing studies, and Dr. Julie Zilles, a research assistant professor in crop sciences [29]. In short, Dr. Kent redesigned the entire assignment, beginning by articulating and sharing learning objectives with the students. Other writing process elements were also added as Dr. Kent re-incorporated the objective of sharing information with classmates. Students were asked to research a topic and present it as a blog post within the course. She also scaffolded the writing process, breaking it up into various parts on which she provided feedback and asking students to provide peer feedback

to their classmates on the first full draft of the blog post. Here we will focus only on one specific writing-as-process change she made, the way she organized that peer review.

The practice of peer review is adaptable and implementable across courses in which students produce writing. When designing peer review, a framework must be created for the students to follow, one that provides transparent objectives for assessment and focuses on elements that the students have the background to assess [60]. When this framework is not provided, students are likely to revert to more traditional product approaches of marking texts for error rather than engaging with content, purpose, and other more meaningful objectives. In this case, students in the course were provided with a peer review form for their blog post on their research topic that focused on the following topics: i) evaluating for audience appropriateness; ii) clarity; iii) gaps in content; and, iv) connections made to class topics or missed opportunities for such connections. Dr. Kent also required that students formulate questions that arose about information the blog post did not cover. Importantly, all of these topics were ones students in the class were well-qualified to raise and evaluate, especially since they were the target audience and had at this point taken part in about three-quarters of the class sessions.

Submission and peer review were implemented in a campus-supported course management system, which was already routinely used in the course and had a built-in peer review feature. Thus, the primary additional work for the instructor was the one-time investment of designing the peer review form and entering it into the system. With the scaffolding providing for multiple drafts and feedback, Dr. Kent reported that the overall quality of the submissions improved noticeably, which in turn decreased her grading time.

Peer review can be a valuable strategy for STEM instructors aiming to implement process approaches to writing in their courses. It can be implemented in a range of fashions (from informal, on-the-fly peer response in a class session to carefully designed and scaffolded peer response), and it can scale to larger class sizes and more challenging instructional resources (e.g., by using it simply to support writing rather than going on to document and evaluate the review). Reading other students' work can help students learn about writing, writing conventions, and content, particularly if faculty are explicit with students that these are goals of the peer review. Getting feedback on their own work can also raise students' consciousness about audience awareness, alert them to elements of the task they had missed, and challenge them to develop effective ways to communicate their ideas and content for others in a text.

Example 2: Writer's Memos

Our second example comes from a multi-pronged, large-scale mentoring project in an undergraduate physics course on nuclear weapons and arms control that we have also described elsewhere [4], [29], [30]. The course, *Physics 280: Nuclear Weapons and Arms Control*, was led by Matthias Grosse Perdekamp and a group of graduate and undergraduate teaching assistants. It already required students to write a series of short essays in various technical and popular genres and a longer-format research paper. Dr. Perdekamp consulted regularly with two mentors from our team, Nicole Turnipseed, a PhD student in writing studies, and John Yoritomo, a PhD student in physics who simultaneously served as a TA for the course, and invited Paul Prior, as Director of the Center for Writing Studies, to lead an early workshop with the teaching staff on response and assessment. Physics department technical research writer Kelly Searsmith also

provided instructional support. Through an extended series of mentoring interactions centered on the weekly meetings of the instructors, the course enhanced and added several process elements related to assignment design, feedback and assessment mechanisms, and scaffolding of writing in TA discussion sections [4], [29], [30].

One change focused on how peer reviews were motivated and guided. Students originally received written responses from their TA for each essay, participated in peer reviews once during the semester, and were required to revise some texts. However, the teaching staff (graduate and undergraduate teaching assistants working closely with the professor) felt the peer reviews were only minimally effective: students' revisions typically only involved surface-level issues (editing rather than revising for content or organization). In consultation with our team, Dr. Perdekamp added a short writer's memo to each assignment [36]. Writer's memos generally aim to help students be more reflective about their writing processes. The memos in this course particularly encouraged students to take greater responsibility for how they sought and took up feedback between drafts. To open lines of communication between writer and responder, the instructions for the first writer's memo asked students to: "...submit a brief statement (8-15 sentences) that includes: A paragraph describing your revision process for this essay and explaining how you went beyond proofreading; and a paragraph that briefly answers the following questions: What is your previous experience in technical writing? In non-technical writing? And what do you consider your strengths in writing? Which writing skills would you like to improve?" Later writer's memo prompts for first drafts of other assignments simply asked students to compose three to five questions for their peer reviewer, while prompts for revised drafts asked them to

describe how and why they chose to incorporate (or not) their TA or peer reviewer's feedback, much as in professional review processes.

As in each of our examples, an important component of this intervention was communicating its purpose and importance directly to the students. As described on the course website, "In general, a writer's memo gives the writer the opportunity to reflect on the challenges of a given writing situation and the rhetorical strategies and content knowledge required to address it, assess his or her own effectiveness in addressing these challenges, and request specific feedback." The course website also addresses the specific purpose of the writer's memo in opening up instructional relationships: "Your writer's memo will help your writing lab TA to improve their response to your writing."

Writer's memos can serve an important function in STEM classrooms as a space for students to seriously reflect on their writing. They can be included in a variety of ways (from paragraph-length letters to multi-page rationales) and have well-established benefits for both students and instructors [61], [62]. For students, writer's memos provide an opportunity to discuss how they made decisions and to articulate their approach to the assignment. For instructors, writer's memos can inform their reading and assessing practices. Providing spaces for students to reflect on their writing decisions pushes students to think critically about how they approached the assignment and can deepen their engagement and understanding of their writing process.

Example 3: Scaffolding the processes of writing a literature review

Our third example describes how atmospheric sciences faculty member Nicole Riemer taught writing for the first time. When she began working with our project team, Dr. Riemer had been a faculty member for over ten years but had not explicitly taught writing in her courses. She did not have any training in the teaching of writing prior to enrolling in Writing Across Engineering. After completing the workshop series, she requested and received mentoring for an advanced graduate course in atmospheric sciences enrolled with eleven students. Mentoring for Dr. Riemer ran for nine months. She requested assistance with teaching graduate students how to write a literature review, something that she had tacit knowledge of but little pedagogical experience with. In response to Dr. Riemer's request, our team provided her with two mentors, John Gallagher and John Popovics. Dr. Gallagher is an assistant professor in Writing Studies and Dr. Popovics is a professor of Civil Engineering.

Dr. Popovics provided Dr. Riemer with an assignment he had been using in his courses for a few years. This assignment, developed in consultations with the Center for Writing Studies (our campus writing-across-the-curriculum program), scaffolded the processes required to write a literature review, attempting to break down and articulate the complex activity required to write these sections of scientific papers. Dr. Popovics's approach was thus a writing-as-process approach, but did not match any single school or professional genre. In her uptake of this model, Dr. Riemer designed the literature review assignment to help train graduate students how to write a review and perform the actual research.

The assignment from Dr. Popovics contained five parts that scaffolded the research writing process. We helped adapt this intervention to simply task students with writing about their

research processes, including documenting how they approach searching for sources. Dr. Riemer's stated purpose was for students to learn the history of an important research paper. Writing studies faculty often refer to this process as joining a scholarly or research-oriented conversation. Dr. Gallagher immediately saw this connection and was able to advise Dr. Riemer using writing-as-process concepts for what she was teaching.

The ongoing consultations were part of a broader range of pedagogical suggestions discussed throughout the spring and summer (the summer consultations were designed to help Dr. Riemer make the transition to teaching writing to undergraduate students rather than graduate students). Dr. Riemer and the mentors met in order to adapt Dr. Popovics's assignment to her purposes and her initial inexperience with *teaching* writing. As the consultations progressed, Dr. Gallagher realized Dr. Riemer did not necessarily want a point-based classroom assignment (as was the original from Dr. Popovics); rather, she wanted graduate students to internalize the research process as she does *in her research*. In other words, she was aiming to train graduate students to perform a literature review in a way that matched the practices she tacitly employed but was not initially able to fully and explicitly articulate. Thus, as Dr. Riemer's class progressed throughout the assignment, she also developed a tighter connection between research-as-process (something faculty practice but often have little training in teaching or mentoring to students/advisees) and writing-as-process.

Section IV: Conclusion

Writing-as-process approaches highlight the complex social, situated, and recursive processes through which disciplinary writing and writers are shaped. These approaches are grounded in

evidence-based practices that foster student learning and professionalization in ways that product-based approaches do not. While some instructors already include process-based practices and pedagogies in STEM courses, we argue that raising STEM instructors' consciousness about writing-as-process and working to have these models integrated into a range of STEM courses can enhance the effectiveness not only of STEM writing instruction, but also of socializing students in their disciplines and professions.

STEM instructors play a crucial role in socializing their students into ways of thinking, being, and writing in their disciplines. Sociocultural research on writing has shown that writing is not bounded in single contexts but is dispersed across students' lives in and out of their disciplines. From this perspective, STEM students must learn to write by participating in the authentic activities of their disciplines. For all the examples discussed here, a critical part of implementing process approaches was working with instructors to carefully articulate the intended goals of the assignments and then to communicate those goals explicitly to the students. While it may sound simple, articulating the goals of writing tasks and disciplinary activities can be surprisingly challenging because much of the knowledge around writing that even prolific STEM faculty have is tacit.

Finally, we encourage STEM faculty to consider a broad range of activities as relevant to the writing process and to experiment with and communicate about those activities in their classes. Writing-to-learn activities may already be present in a student-centered classroom and can be further leveraged to focus attention and discussion on writing. Scaffolding assignments and building in time for feedback from peers and instructors followed by revision can model for

students both the values and practices of a process orientation. In our experience, multiple revisions of shorter pieces of writing often benefit students more than a single submission of a longer piece, so we also advocate for considering carefully how long a piece of writing needs to be to meet targeted learning objectives. Our experience with faculty suggests that devoting more attention to writing processes often improves the instructor's experience, creating greater common ground with students, resulting in less frustration with student work, and even reducing time spent giving feedback. Even when time constraints and class sizes make focused scaffolding and revision impractical, peer review and writing-to-learn activities can offer a scalable mechanism for feedback and the deeper classroom dialogues central to teaching and learning.

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