Introduction

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In early 2021, LaKeisha McClary (co-editor of this collection and Assistant Professor of Chemistry at The George Washington University) and I found ourselves in a conversation about writing instruction in science, technology, engineering, and mathematics (STEM) disciplines, as well as the persistent, pernicious inequities that continue in these spaces. It was a casual conversation in the midst of a global pandemic where everyone seemed to be "pivoting" left, right, and center. Across academia, instructors were still sorting out how to move their large, in-person lectures into online modalities while simultaneously deciding if and how the social unrest being experienced nationally in the US[1] should find its way into classroom conversations. In our conversation, LaKeisha and I shared some of our own approaches toward creating inclusive spaces in our classrooms and the challenges we faced in doing so. It also involved a significant airing of grievances about our conditions of operation (e.g., institutional barriers, resistant faculty, resistant students), but much of it focused on steps toward improvement. What would a socially just future in STEM look like? What role might writing play in that future, and how could inclusive instruction be enacted in STEM spaces? How can we help STEM instructors be more equitable in their writing assessments and explicit in their instruction? What can be done, short of blowing the whole system up and starting all over again?

That conversation was the impetus for this book. We set out to highlight the ways in which this work can be done both in writing *and* disciplinary courses, providing a firsthand look at the types of interdisciplinary conversations we would love to see more of on campuses across the US. We also aimed for a bottom-up approach, one where the underlying assumption from day one was that equity should simply be part of the new normal. Making our classroom spaces accessible and welcoming to *all students* is just how operating in the 21st century should be. Part of that equity and accessibility is making explicit the ways in which the writing and meaning-making we do in our disciplines is unique and specific to our fields, and as such the *teaching* of those practices falls on anyone who is invested in language education and writing in STEM spaces. Hence, this book is both for those whose primary academic home is STEM as well as those who are focused on writing instruction.

1 I am referring, here, to the 2020 Presidential election, the storming of the U.S. Capitol Building, the very public murders of Black Americans at the hands of the police, and the marches around gender and LGBTQIA+ rights. All of these are tensions that continue to persist.

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To be clear, this book is not arguing for the teaching of STEM through an interdisciplinary lens. We are not attempting to bridge the divide, for example, between STEM and the arts and humanities (i.e., a STEAM approach) or STEM and the public. There are already excellent collections taking up this work (see Kao & Kiernan, 2022 and Yu & Northcut, 2017, respectively, as recent examples). Similarly, we knew that another text arguing for the importance of disciplinary writing instruction itself was unnecessary. Effective communication skills have been recognized for some time as a critical aspect of being a STEM practitioner. Research has shown that explicitly teaching the ways in which language and forms of writing (i.e., genres) are representative of the various procedural and communicative tasks scientists and engineers regularly perform has positive impacts not only on persistence but on the development of disciplinary identity and agency—particularly for those from historically marginalized groups within those fields (Falconer, 2019a, 2019b; Hyland, 2012; Paretti et al., 2019; Poe et al., 2010). Accreditation boards and national STEM organizations have also recognized the necessary role of communication instruction in higher education: ABET Criterion 3 (2022-23) identifies the need for students in engineering, as well as applied and natural science programs, to develop an ability to communicate effectively with a range of audiences; the 2011 American Association for the Advancement of Science (AAAS) Vision and Change report identified the "ability to communicate and collaborate with other disciplines" (p. 15) as a core competency for biology undergraduates; the National Research Council (2012) has explicitly called out the need for further research into the ways educational conditions and strategies like writing across the curriculum (WAC) can "limit or promote metacognition" (p. 175) and have an impact on retention and persistence in STEM disciplines.

Compiling another text drawing attention to inequities in STEM was also not our goal. Concerns of equity, retention, and persistence for minoritized groups in STEM have been a topic of discussion for a considerable amount of time, with initiatives supported through the U.S. government (e.g., the National Science Foundation, President Obama's "STEM for All") as well as programs designed to offer high-impact practices like undergraduate research experiences. Scholars such as Ebony O. McGee (2020a, 2020b) have well-documented structural racism in U.S. STEM higher education and its impact on retention and persistence of Black students and scholars, particularly as it relates to performativity expectations (McGee & Martin, 2011). McGee and William H. Robinson (2020) have published compelling research into the ways in which inequity (both structural as well as social—i.e., microaggressions) impacts racial minorities in STEM, offering suggestions for remediation. Both Kathi N. Miner and colleagues (2018) and Mary Blair-Loy and Erin A. Cech (2022) have similarly examined the ways in which STEM inequity is structured as it relates to historically marginalized communities, highlighting the fact that epistemological and cultural beliefs perpetuate unequal

and unfair outcomes. Remediating discrepancies must begin with a shift in lens in how the problems are viewed—from the individual's challenge to the group's responsibility. These conversations have been circulating for long enough that in a 2017 letter published in the journal *Science,* Amanda J. Zelmer and Aleksandra Sherman noted that "the failure of long-standing efforts to effect substantial change [in STEM diversity] reflects a deeper issue: the widespread cultural belief that science is neutral, objective, and apolitical" (p. 312-313). In their explicit call for STEM instructors to use culturally relevant teaching practices and materials in their classrooms to dismantle barriers, the authors asserted that "the idea that science is separate from social and cultural issues is flawed and alienates women and underrepresented minorities" (p. 313).

Yet, we found ourselves wondering to what degree instructors feel comfortable *doing* this work. How does engaging with these questions of ontology and epistemology force educators to confront what Mark Skopec and co-authors (2021) refer to as "epistemic fragility:" "an effortful reinstatement of an epistemic status quo, as a reaction against introducing ideas, narratives and research associated with decolonizing the higher education curriculum" (p. 3)? And what about resistances to writing instruction? Despite significant research related to writing and writing instruction in STEM and the recognized need for direct instruction, gaps continue to persist between WAC scholarship and its implementation in STEM education. Reynolds et al. (2012) have attributed this siloing of knowledge to a "lack of awareness of the research on the effectiveness of [WAC pedagogy], since most published findings are in journals not regularly read by STEM faculty and the majority of studies use methods unfamiliar to most scientists" (p. 18). More recently, research into STEM faculty beliefs related to writing illustrated reluctance due to understandings of what constitutes writing in their courses (Bathgate et al., 2019; Hora et al., 2019; Lund & Stains, 2015), whether writing is of benefit to students within these contexts (Thompson et al., 2021), and whether writing is even part of the knowledge-making process in their field (Gere et al., 2019; Moon et al., 2018). The humanistic aspect of writing—that it is a process of thinking and creating knowledge, not just a skill to document information, and is rooted in culture—often gets lost.

These are heavy challenges, to be sure. They don't have easy solutions, and they don't fall onto STEM instructors alone to resolve. Those who work with STEM students in writing courses and initiatives also bear some of this burden. From a writing studies perspective, we have known for some time that writing plays an important role in how knowledge is constructed and disseminated in STEM disciplines. For decades, scholars have examined the role of stases and topoi in scholarly arguments (e.g., Fahnestock & Secor, 1988; Wolfe et al., 2014), the ways in which language shapes how scientific knowledge is constructed and communicated (e.g., Bazerman, 2000, 1981; Myers, 1990, 1985), and various approaches to the incorporation of writing into STEM disciplinary spaces (e.g., Finkenstaedt-Quinn et al., 2021; Gallagher et

al., 2020; Gere et al., 2019; Venters et al., 2018). In short, we have a good idea of how STEM researchers write and how those practices reify particular ways of knowing and doing. In writing studies, we also have a rich body of scholarship related to inequity (e.g., Condon & Young, 2016; Inoue, 2019; Poe et al., 2018), though that has not quite yet merged with the scholarship related to STEM from writing in the disciplines—and neither seems to have effectively crossed the disciplinary divide to reach STEM practitioners directly. Topics of writing in STEM journals, particularly as they relate to Discipline-Based Education Research (DBER), tend to focus on the use of inquiry-based writing in laboratories to improve students' critical thinking skills and knowledge acquisition (e.g., Badenhorst et al., 2020; Jeon et al., 2021; Larsen & Gärdebo, 2017), not explicitly to increase access.

It is with all of these questions and challenges in mind that we began cultivating the chapters that appear in this collection, as well as the vignettes that offer important insights into the lived experiences of students in STEM. We sought contributions that moved beyond typical disciplinary writing and content instruction and instead focused on work that was intentionally, sometimes subtly, disrupting the assumptions of STEM writing, communication, and knowledge-making. In our call for submissions, we asked contributors to think critically about how we create a sense of belonging for students from groups that have historically been kept out of these disciplines, how faculty can consciously create space for student voices to be heard, and specifically how we can do this with an eye toward discursive practices of STEM disciplines. Contributors were asked to offer us specific cases—classroom- or research-based contexts—that described their intents and goals, the interventions they enacted, how students responded, and the unexpected elements that presented themselves. We asked contributors to be self-reflective in ways that were transparent and showed the ugly bits; to share the lessons they learned and the errors they made.

In selecting chapters for this collection, we intentionally chose contributions that worked to disrupt the status quo, challenge assumptions, and embrace inclusive writing pedagogies. To be sure, these are not quick-fix solutions to appease the diversity, equity, and inclusion committees on campus, nor are they a one-off to allow instructors to check a box and feel that they have done their part. Rather, these chapters serve as entry points; they are the *beginning* of a conversation and set of practices that we hope educators and scholars will take up, expand on, and incorporate into programs so that, together, we can materialize a vision of a socially just future in STEM. We aim to create, as Rebecca Walton, Kristen R. Moore, and Natasha N. Jones (2019) have argued, spaces that "value ways of learning and knowing beyond [our] own and challenge complicity in oppressive intellectual practices" (p. 95).

Once chapters were accepted, we also circulated a request for vignettes from STEM students (either current or former) who had experiences that invoked a sense of belonging in their fields. This request, which was circulated via our authors as well as through social networks, resulted in short reflections about what helped

make these students feel welcome in STEM spaces. These vignettes are included so that readers can see the power of microinclusions – subtle practices that tell our students that they are valued, that their perspective matters, and that they belong. The vignettes illustrate the ways that small changes and the creation of space can have lasting impacts on students from historically marginalized groups in STEM.

With this book, our goal is to create a "way in" for instructors in a wide range of disciplines to incorporate inclusive practices into STEM spaces—whether that is in a disciplinary writing classroom, teacher preparation program, traditional classroom, or undergraduate research. We seek to inspire, while also providing useful resources that can immediately be incorporated into existing courses and programs. This collection aims to show how meaningful change does not need to be drastic or involve tension or massive curricular reform. Simply modifying an assignment or replacing an assessment practice can create microinclusion opportunities. While we cannot change the system as a whole all at once, we *can* make efforts in the places we control (our classrooms and laboratories) to help counteract the negative messages students encounter elsewhere. Small efforts by individuals lead to larger, collective change.

Our Guiding Principles

As faculty who actively engage in interdisciplinary work, we began this project with certain assumptions about what instructors need—assumptions based specifically on U.S. educational contexts. We recognize that many of the inequities we experience in the US regarding STEM education are present in other countries, but we also recognize that different contexts and systems require different solutions and that some of our assumptions may not apply. We offer our assumptions here so that readers outside of the US can determine what applies and what does not, and those within can see how we are oriented.

Despite coming from very different fields (Heather from writing studies; LaKeisha from chemistry), we recognize some important considerations that impact this work:

- Faculty in STEM rarely have access to courses in pedagogy and, outside of WAC programs, typically do not receive instruction on how to teach disciplinary writing.
- Faculty in writing programs may have a firm grasp of writing pedagogy but not the disciplinary orientations or discourse knowledge to effectively teach STEM writing.
- There is often tension surrounding who has the authority—who is *allowed*—to teach disciplinary writing (the people who do it versus the people who study it).

- Equity and inclusion work is new to most instructors, and though interest is often there, a "way in" can be very hard to find.
- Balancing the course content for a traditional STEM class with writing instruction *and* inclusion work is a big lift.

In this collection, readers will find detailed information about the practices our authors have tested within their classroom spaces, as well as the relevant resources (reading lists, assignment prompts, etc.) that were used to effectively conduct the course. Importantly, we have asked authors to speak to the challenges they experienced in teaching the material, what they might change, and other frictions encountered or anticipated for the future. Our goal with these inclusions is to highlight the often-messy, imperfect ways in which inclusion *and* writing work gets done. We wish to destigmatize who is able to do this work, as well as offer some guidance in avoiding pitfalls. This collection is about action, not only theoretical orientations. We wish to offer actionable steps faculty can enact to make their STEM writing spaces more inclusive and challenge assumptions about disciplinary writing. We want readers to read a chapter, be inspired and empowered to modify the materials to fit their local context and try something new. That isn't to say that conscious, careful consideration of students and disciplinarity are not at the forefront. Rather, these considerations are already built into the chapters so that readers start at a place of accessibility and positive action.

At the same time that we strive for accessibility and positivity, we don't shy away from the hard truths. As Ann Fink notes in her chapter (this collection), "Practitioners must decide how and when they will resist oppressive practices around them, knowing that this also, inevitably, involves risk." Throughout this book, readers will encounter theoretical orientations and frameworks from a wide variety of disciplines. Some of these may be familiar (such as feminism or colonialism); others may be new or have connotations from the public sphere that need to be disentangled from political rhetoric (critical race theory, for example, or linguistic justice). Our authors present the scholarly definitions of these terms, as they were introduced in their original formulation, to help readers separate evidence-based frameworks from speculation or misinterpretation. In the end, though, the agency is with the reader as to whether these approaches work within their specific institutional contexts and needs, as well as if they feel prepared to enact these evidence-based theories effectively.

The chapters in this collection are organized around the themes of disruption to epistemic beliefs and challenge to traditional pedagogical practice. We believe these themes will resonate with instructors broadly rather than arranging chapters by disciplinary area. This is because the authors have worked hard to present their approaches in ways that transcend disciplinary boundaries. An instructor who works with engineering students, for example, can learn as much from chapters

that discuss technical communication and mathematics as they do from those chapters that focus on engineering contexts. Likewise, instructors who primarily teach writing will be able to find and use concepts and assignments presented in distinctly disciplinary courses. We believe that the interdisciplinarity of this collection is one of its strengths. For readers who are interested in specific topics or disciplines, however, we offer a matrix at the end of this introduction that identifies common elements addressed in the chapters. This allows for more of a "pick-your-own" journey through the collection.

In *Section 1. Disrupting the Status Quo*, contributing authors share stories of building critical awareness of inequity throughout the curriculum. Jameta Barlow and Kylie Quave open the section with an exploration of what this work might look like within the context of a first-year writing course. They offer us ways to use decolonial, Black Feminist, and queer theoretical frameworks both as a way to teach writing and communicate scientific information about the world. This is followed by Blomstedt, who advocates for STEM writing instruction to begin with teaching students the history of how English became "the language of science" (this collection). Responding to calls from those in writing studies to resist linguistic imperialism and white language supremacy in our teaching (Canagarajah, 1996; Baker-Bell, 2020) and instead teach writing from a translingual approach, the series of lessons described by Blomstedt teaches students the precise means by which English became and has remained "dominant" in STEM writing.

Megan Callow and Holly Shelton continue this theme of challenging historical accounts of STEM knowledge with a discussion of a novel partnership between writing scholars and STEM faculty at the University of Washington. In this chapter, the authors describe how they designed and implemented a Critical Science Literacy course to help students think critically about the nature of science through the analysis and production of texts and about the ways that scientific knowledge shifts as it traverses platforms and audiences. The course emphasizes an understanding of the nature of science as contingent, contested, and situated; engages a diversity of ways of knowing and doing in science across cultures and nations; and traces the genealogies of ideas in circulation as information moves through pipelines and networks.

Laura Callis expands on this topic of knowledge-in-circulation with a discussion of the roles mathematics and statistics have historically played as tools of oppression, as well as how they can be leveraged to highlight and address injustice. Her chapter describes two assignments used in introductory statistics courses at a neurodiverse college that welcomes learners with a range of educational backgrounds. The assignments use real data about social justice topics and low-stakes, scaffolded writing prompts to support students in working through the statistical inquiry process, developing conceptual understanding and technological fluency, and improving their precision of language both mathematically and contextually.

Callis uses this chapter to show how using data sets that address injustice can be a solution for statistics faculty who feel the tensions of covering an ambitious syllabus, developing students' conceptual understanding, and recruiting interest in the quantitative fields.

This is followed by a chapter by Alicia Bitler and Ebtissam Oraby that discusses a course meant to destabilize and challenge the prevailing view of science as Western, male, and white. The authors of this chapter created a course that allows students to explore a non-Western epistemology of science and think of science as diverse and inclusive. Throughout the course, students explore Muslim and Arab science history and culture as part of a globally shared human heritage to open a space for other ways of thinking about and doing science. Muslim and Arab scholars have contributed to science in meaningful and often unacknowledged ways, founding disciplines like chemistry, algebra, modern surgery, and optics, shaping science as we know it. The course highlights the achievements and ways of knowing in science of prominent Arab and Muslim scientists.

The section concludes with a chapter by Justiss Burry, Carolyn Gubala, Jessica Griffith, Tanya Zarlengo, and Lisa Melonçon, who take up similar considerations of justice and ask: "What happens in a large [Technical and Professional Communication] program when it creates a programmatic inclusion vision and then sets out to enact it?" (this collection) In this chapter, the authors discuss the answer to this question as a way to address this collection's emphasis on actionable steps faculty can enact to make their STEM writing spaces more inclusive and challenge assumptions about disciplinary writing.

Section 2. Challenging Orientations to Instruction and Assessments moves from an exploration of ontology and epistemology into one of application. Contributors in this section present ways to enact elements of disruption into considerations of genre and disciplinary practice, while also asking STEM educators to turn the lens back onto themselves and what they value. In the opening chapter to this section, Rachel Riedner, Royce Francis, and Marie Paretti ask questions of common classroom practices by looking specifically at the intersection of writing and identity in engineering in the context of engineering judgment. Their goal is to consider how one might design assignments and create group work practices that help students to actively position themselves as engineers. This chapter discusses the theoretical framework and praxis implications from an instrumental case study that explores how writing in the disciplines (WID) assignments do and do not support students' engineering identities in an existing capstone course.

Continuing with a consideration of writing in engineering, Jennifer Mallette's chapter examines the situated learning and integrated approaches that facilitated one engineering communication course's success, with a focus on the ways the course was planned and designed and the approaches built into that design that were aimed at supporting student success, particularly in a year where more students

struggled because of remote classes and various pandemic challenges. The first part of the chapter examines the impacts of designing a course in collaboration with the College of Engineering and the specific department, implementing a backward planning approach that also incorporated inclusive excellence pedagogical strategies and equitable assessment. The second part of the chapter explores the course's preliminary impact on student learning, given the course's built-in flexibility and use of contract grading in an online environment. The chapter concludes with key takeaways for designing a course with inclusion and equity as a core value, as well as approaches to implement in a course to support student success.

Sally B. Seraphin continues the theme of supporting student success by presenting a framework for creating relevant, meaningful writing assignments that leave space for students to perform at their best and grow in their learning. Her "non-disposable assignments" engage students at a variety of tiers of engagement in a manner that leads to sharing of resources and materials in a multitude of ways. These assignments, Seraphin argues, provide entry points for students to thrive—to capitalize on their skills and knowledge in a way that moves beyond completing activities for assessment and toward having an impact in the world.

Similarly pushing traditional notions of writing instruction and assessment, Jennifer Newell-Caito discusses what it looks like to incorporate "ungrading" (Kohn & Blum, 2020) strategies into an upper-level analytical biochemistry course. Newell-Caito explains how her use of flexible deadlines, authentic assessment, contract grading, and process letters support student learning and aids in building metacognition for students.

Continuing with the theme of meaningful writing, Janelle Johnson et al. present a strategy for engaging students with questions of their own positionality within STEM education. Explicitly focusing on disability, the authors (which include participants in the course) present an assignment sequence that asks students to choose an educational inequity they are passionate about and combine a synthesis of the policy context with a sharp focus on a particular community. They learn to create a series of concrete actions they can take to address the inequity, and those actions are captured in a public service announcement. The project concludes with an exposition where students publicly share their call to action.

In the final chapter of this section, Ann Fink offers educators an example of how to enact liberatory pedagogy in STEM content courses. By focusing on a course in neuroethics, Fink discusses the way she has built an inclusive curriculum that disrupts traditional ways of thinking about neuroethics as well as the pedagogical approaches used to make the classroom more equitable.

The collection concludes with a discussion of the kinds of questions we anticipate readers will have regarding the practical realities of implementing these practices. We offer individual perspectives from our respective fields as well as additional resources for those who wish to continue their social justice journey.

Our Call to Action

As noted earlier, this collection is not about convincing STEM instructors that writing is important; nor is it about convincing anyone that diversity and inclusion are paramount concerns for their fields. Rather, this book is for the educator who wishes to do something about it. As editors, we recognize that there are important conversations missing from this collection and equity conversations more broadly. Though we actively sought scholars and educators doing work specifically around neurodiversity in STEM, for example, our outreach yielded very little response (Johnson et al. being the exception). Similarly, finding scholars exploring the residual effect of this work—tracking what sticks and what fades away—proved elusive. We sought contributions from scholars doing work and practices that pushed the boundaries of what typically gets addressed in equity and inclusion (looking toward disability and socioeconomics, for example, or experimenting with language use) but encountered similar challenges.

To be sure, there are individuals doing this work, and we have made strong efforts to provide direction to that scholarship in the Conclusion. Finding unpublished work related to STEM writing (and not education broadly), however, turned out to be more difficult than expected—particularly in interdisciplinary spaces and international contexts. What that highlighted, though, was that inclusive writing instruction in STEM spaces is an area of scholarly and practical interest, and with many lines of inquiry still left to be explored and amplified. We are hopeful that the approaches presented in this collection will empower educators to start (or continue) equity and inclusion work in their STEM-relevant classrooms and inspire researchers to consider new lines of inquiry aimed at the long-term impacts of this work and how it transfers to spaces outside of the classroom. To that end, the collection's Conclusion provides some reflections by each of us (including a final, powerful call to action from LaKeisha), a series of questions and considerations for educators and resources to continue learning and contributing.

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Appendix: Topic Matrix for Collection

Topic area	1. Barlow & Quave	2. Blomstedt	3. Callow & Shelton	4. Callis	5. Bitler & Oraby	6. Burry et al.	7. Riedner, Francis, & Paretti	8. Mallette	9. Seraphin	10. Newell-Caito	11. Johnson et al.	12. Fink
Ableism/Disability	x		x						x	x	x	
Critical Inquiry		x	x	x	x		x	x			x	
Critical Literacy		x	x	x					x			
Cultural Diversity		x	x	x	x			x		x	x	
Decolonial Approaches	x	x		x		x					x	
Disciplinary Identity		x	x			x			x	x	x	
Feminist Theory	x			x							x	
History of Science	x	x		x							x	
Indigenous Cultures	x	x		x								
Interdisciplinarity	x			x						x	x	x
Meaningful Writing			x		x			x	x	x		
Reflective Assignments	x	x						x	x	x	x	
Translingualism		x						x				
White Language Supremacy		x				x		x				
Community Engagement								x				
Course Level												
First-Year	x		x	x				x			x	x
Second and Third Year		x	x	x	x		x	x			x	x
Capstone						x		x				x
Graduate								x			x	x
Assessment and Evaluation												
Ungrading & Labor-based Contracts			x				x		x			x
Instructor Feedback			x			x		x				
Transparent Assignment Frameworks					x		x	x				
Self-Assessment	x						x		x	x		