STEM Writing as Disruption: Views from First Year Writing

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Sociopolitical conditions have distinctly influenced the development of scientific disciplines in the United States. These histories have promoted traditionally white, male knowledge producers as objective and reliable while sidelining others who have been deemed less neutral, objective, and authoritative in society (Kozlowski et al., 2022). Imagined hierarchies of knowledge and knowledge producers in the sciences have come at the expense of robust explanations of the world and its humans, which could otherwise impact society positively. Recent public health crises continue to highlight the disparate ways in which science and technology fall short in addressing underlying social inequities in this modern, pluralistic society. Moreover, the COVID-19 pandemic revealed widespread, keen interest in, and the need for, the critical analysis of science and its applied impact on human behavior, decision-making, and medical interactions.

This chapter is a call for STEM and STEM writing faculty to critically examine and center multiple perspectives on the roots of scientific knowledge production in our classrooms. Our objective is to explain the implications of historical and social realities within knowledge production—and their attendant epistemic injustices (Prescod-Weinstein, 2020)—within our first-year undergraduate science writing classrooms. We explain how Black Feminist, Indigenous Feminist, and other anti-colonial approaches to writing in STEM are not only the lenses of our own pedagogies, but also how these approaches can be parlayed into many kinds of STEM writing classrooms. Our theory and practice (i.e., praxis) of teaching citation are explained here as a site for making these pedagogical goals reality.

Historical and Present Challenges of STEM Knowledge Production

We approach this work by centering the tenets of Black Feminist, Indigenous Feminist, and other anti-colonial and decolonizing paradigms. Black Feminist and Womanist approaches entail collective struggles to address systemic inequities in the present and past, and the outcomes of centuries of exclusion and oppression. Following the lead of thinkers such as bell hooks and her critique of the imperialist

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white supremacist capitalist patriarchy (1984/2000), Black Feminism acknowledges the importance of intersectional approaches to the array of oppressions made possible by the multiple dimensions of marginalized identities (e.g., A. J. Cooper, 1892; B. Cooper, 2015, 2016; Crenshaw, 1994; Hill Collins, 1989). Black Feminist thought centers the experiences of Black women as essential to understanding the ways that multiple, interlocking oppressions operate in society. Since at least the 19th century, voices, such as Anna Julia Cooper (1892), have called for resistance to overly simplified explanations of how social inequality works. Cooper's work has been followed by a long line of Black Feminist theorists urging ways to end all oppressions by attending to the exclusions and marginalizations experienced by Black women (e.g., the Combahee River Collective Statement, 1978) and by understanding the ways systems including racism, sexism, patriarchy, capitalism, and more operate to uphold each other. More recently, theorizing these interlocking systems is referred to as "intersectionality theory" (Crenshaw, 1994).

Indigenous Feminist ways of knowing and doing prioritize Indigenous sovereignty for Indigenous lands and people. Similar to other critical feminisms, Indigenous Feminist thought emphasizes an intersectional approach to disrupting current and historical harms perpetuated on groups excluded from dominant society. Through Indigenous Feminism, decolonization is not merely a metaphor but rather demands the re-positioning of resources in just ways, with material change toward honoring self-determination (Tuck & Yang, 2012). Indigenous Feminist thinkers challenge the ways that scientists have violated Indigenous sovereignty and have unduly dismissed and sidelined Indigenous ways of knowing as non-scientific and inferior or subjective (Kolopenuk, 2020; Steeves, 2021; TallBear, 2014, 2016). Like Black Feminism, Indigenous Feminist theory similarly requires that the experiences of Native and Indigenous women be considered legitimate and be included as credible sources. Indigenous Feminist approaches require us to consider that not all women's lives are the same and do not need to be, and that our ways of knowing the world may be heterogeneous, which is a strength rather than a deficit. Indigenous Feminist thought rejects assumptions about the superiority of science and "Western" ideologies of normalcy and nature. Indigenous Feminism also centers decolonization as a process of letting go of unearned material dominance (Tuck & Yang, 2012) and calls attention to the specific forms of violence experienced by Native women (Green, 2017).

These anti-colonial ways of knowing are leveraged to overturn the outcomes of racialized and gendered oppressions (and gendered oppressions, as well as other forms of marginalization) and how they influenced dominant Western thought. In the sciences, ample research demonstrates systemic exclusion and delegitimization of Black and Indigenous women and others who did not fit an expected and purportedly normative EuroAmerican, male, middle-class identity (e.g., Bolnick et al., 2019; Mills, 2020; Rifkin, 2016; Shelton, 2020; White & Draycott, 2020).

In other words, simply existing, for Black and Brown individuals, as well as other marginalized groups, is a disruption.

Intersectional and decolonizing approaches to teaching and researching are not merely exercises in adding "diverse scholars" to one's syllabus reading list; they are not a matter of acknowledging the existence of Black women or other people historically removed from powerful institutions of knowledge production. Rather, these approaches require that teacher-scholars re-orient and re-center (Barlow & Dill, 2018) inequitable forms of knowledge production through and with STEM writing. Physicist and Black Feminist theorist, Chanda Prescod-Weinstein, points to epistemic injustices in STEM: devaluing and undermining a writer's knowledge due to their identity (2020). When epistemic injustice plays out in our STEM disciplines, it is fueled by white empiricism, which is the belief that white people are objective, neutral observers while others are biased and incapable of neutrality (Prescod-Weinstein, 2020). In a related vein, archaeologist Paulette Steeves draws upon Indigenous Feminist science and the sacred practice of burning for radical renewal to coin her original concept of pyroepistemology (2021). Steeves explains that "a practice of pyroepistemology is a ceremony that cleanses the academic landscape of discussions that misinform worldviews and fuel racism. Such literary renewal clears the way for healthy growth in academic fields of thought and centers of knowledge production" (2021, p. 20). Steeves' pyroepistemology may provide the cleansing needed to overcome white empiricisms, which may further the goal of intervening in harmful and exclusionary scientific knowledge production. This chapter offers a practice of pyroepistemology with its focus on ontologies, epistemologies, methodologies, and pedagogies that enable teacher-scholars to engage in cleansing academic practices rather than perpetuating the status quo of epistemic inequities.

The point of intervention is to decolonize methodologies by transforming the production of scientific knowledge. In fact, interrogating ontologies (i.e., What can we know? What's out there to know?) and epistemologies (i.e., How can we know? How do we know what we know?) of historical and contemporary approaches toward scientific knowledge production is how we disrupt STEM writing. As Linda Tuhiwai Smith has argued with regard to decolonizing methodologies, research is an institution marked by "its claims, its values and practices, and its relationships to power" (Smith, 1999/2021, p. 286). Smith further posits that research is "a set of ideas, practices and privileges that [are] embedded in imperial expansionism and colonization and institutionalized in academic disciplines, schools, curricula, universities and power" (Smith, 1999/2021, p. 287). As a result, re-framing and re-centering the curriculum move scientific knowledge production into the light, making the social, political, and historical contexts around research more transparent and thus closer to the scientific method's promise of empiricism and truth. As STEM knowledge has been written into existence in ways that perpetuate social inequities, so too can STEM knowledges be burnt to the ground and re-composed to overcome epistemic injustices.

Creating Inclusive Pathways Through Critical Writing Pedagogies

Writing is the primary tool by which STEM knowledge is communicated to other scholars and to the broader public. However, writing has also played an active role in reifying exclusionary ways of knowing. Teacher-scholars must be aware of and account for the historical and present challenges of STEM epistemologies discussed above and should seek out examples from their own disciplines. Knowledge in STEM fields is not neutral, though these disciplines have masqueraded as such in the Western world for at least the last five centuries. We, humans, are the ones who actually produce scientific knowledge and technological innovation: we introduce our biases, agendas, and imperfections (Marks, 2017; Smith, 1999/2021) into how we know the world and how we use writing as a technology to intervene in the world around us. An uncritical approach that treats science and technology as if they operate in a void—divorced from their cultural and social milieus—is an approach that deprives students as writers and researchers of a full picture of the human condition and what is at stake for justice and fairness in human societies.

Moreover, this does not benefit science. Scientific knowledge and technologies can, and have, improved our lives, but one need look no further than racist, sexist robots (Alaieri & Vellino, 2016; Caliskan et al., 2017) to see that social problems are only reproduced and exacerbated rather than eased or erased by scientific and technological progress. Medical algorithms and metrics (Braun, 2015; Vyas et al., 2020) are the residues of the dehumanizing histories that produced knowledge of human health (Braun & Saunders, 2017; Owens, 2017), while the technology industry can trace a throughline from legalized discrimination to de facto racism made possible through automation and apps (Benjamin, 2019). Studies of human genetic diversity have been leveraged to solidify myths about racial and ethnic inferiority, upholding white supremacy (Larsen et al., 2020; Panofsky et al., 2020). These examples from across fields taught in STEM writing courses merely scratch the surface of the wide-ranging, long-standing role of STEM disciplines and discourses that create material harm.

From the fields in which each of us was originally trained in the sciences prior to becoming writing faculty, we offer a range of case studies to students to demonstrate the harmful effects of science writing over the centuries and into the present. In anthropological archaeology and biological anthropology, for example, researchers write about the harms done to particular populations due to enduring preservation and celebration of white supremacist pasts (Carter, 2018; Mullins, 2017), some of which originates from anthropology itself (e.g., Geller, 2020; Mitchell, 2018) or through nonconsensual field research methods (Atalay, 2006; Blakey, 2020). In forensic anthropology, writers are sounding the alarm about use of the

euphemism "ancestry" as a stand-in for "race," which served to uphold mythologies about biological race that cannot be supported by the sciences (DiGangi & Bethard, 2020; Tallman et al., 2021). Anthropologists are re-orienting these harmful ways of producing knowledge about the past with analysis of the language and rhetoric of anthropology (Allen & Jobson, 2016) but also by using composition itself as an instrument to disrupt (Reid, 2021).

In another disciplinary example from our courses, epistemological concerns are rarely discussed in public health and psychological science research. When they are discussed in these fields (Barlow & Dill, 2018; Bowleg, 2017; Bowleg et al., 2017), they are particularly immersed in women's and gender studies interventions (Meyer, 2007). Writing studies, in concert with the critical theories that interrogate epistemologies, offers a bridge for applied intervention by engaging philosophies of science. Community psychology (Boyd & Bright, 2007; Campbell & Murray, 2004) and community writing (Ryder, 2012) explicitly leverage agency and rhetoric to create sustainable change in communities. Research on writing as healing (Baker & Mazza, 2004; DeSalvo, 1999; Pennebaker, 1990), drawing upon the humanities and writing studies (Barlow, 2016, 2018), thus become tools for sustainable community change around healing, harm, and trauma. Public health, psychology, and composition theory are already in conversation with each other in the scholarly landscape, forging connections between knowledge production and structural inequities, and need only be explicitly presented as such in our courses.

Incorporating an equally wide range of perspectives from various disciplines, including from people of different backgrounds and positionalities, is an essential component to addressing these inequities. Anti-colonial and decolonized theoretical frameworks position teachers and learners to value multi-vocality, consent, sovereignty, differently-abled bodies, lived experience as evidence, collaboration, and a rejection of unquestioned normative categories and classifications. Including these diverse (and often excluded) scholarly and community perspectives models these values for students in the process of disrupting the standard ways of knowing in STEM disciplines.

Writing as Teaching Tool and Technology for Disrupting Inequities

In a decade in which the enduring intergenerational effects of inequity have never been clearer to more people in the US, we channel the power of writing to disrupt our pedagogies. Writing is both a tool with which to teach and a technology for disseminating scientific knowledge about the world, which can intervene in currently imperfect realizations of a pluralistic and inclusive society. Teaching STEM writing

to undergraduates with anti-colonial approaches represents an ethical and more appropriate mode for this disruption to take root because students can more directly observe the impact and influence of colonialism in science as this uncovering process occurs (see Blomstedt, this volume, on the ways that White English emerged as legitimate scientific language; see Bitler and Oraby, this volume, on exclusion of non-European ways of knowing, for examples beyond our scope).

Because scientific inquiry is misunderstood as a neutral, value-free way of knowing the world (Smith, 1999/2021), instructors can use case studies showing genealogies of knowledge over time (see the models for this in more detail in Callow and Shelton, this volume) to turn that assumption on its head; tracing knowledge production reveals inconsistencies, inadequacies, and contradictions in the actual practice of science, especially as related to narrow representation of perspectives (the very problems elaborated upon by Prescod-Weinstein and Steeves, as described above). However, the lesson we ought to be extending to students is not that science is fundamentally, irredeemably flawed, but rather that the sciences are brought to life by humans working within social and individual contexts. For example, RetractionWatch.org (e.g., Marcus, 2020, 2021) offers a range of examples of the sciences failing to live up to their promise of reporting what is more true and less false about the universe. Whether studies are retracted or challenged due to the undue influence of ideology over empiricism (Larsen et al., 2020) or due to a lack of care in challenging white empiricism, the result is the same: unchecked exclusionary ideas continue to circulate under the guise of science's perceived superiority and neutrality (Nature, 2022). Intellectual and institutional barriers to marrying Black Feminist and Indigenous Feminist thought with STEM disciplines remain rigidly in place, and writing instruction can be positioned to break those barriers down. Common rhetoric poses science in opposition with these ways of knowing, but we practice pedagogies that put them into contact with each other. Our work aims to be the bridge between rhetorical writing and scientific inquiry, anchored by decolonial practices.

In our classrooms, we position students as knowledge producers themselves and empower them to use research and composition to disrupt harmful ways of knowing. Western traditions in the sciences have been forwarded in limiting and exclusionary ways, but returning to openness about what can exist (ontologies) and how we know it (epistemologies) allows us all to open up to more exhaustive ways of seeing and explaining the world. We position students to produce and to intervene in two principal ways:

1. As readers and consumers of knowledge, they learn to identify what is left unsaid and whose perspectives are overwritten in the scientific disciplines they are reading or in the selection of sources available to them (see above examples, as well as Bitler and Oraby, this volume).

2. As writers, they practice reflexive examination of their citation praxis: the ways they define sources as expert and reliable, and the ways they weigh evidence in their writing. They also learn to question how their teachers define credibility and expertise, and to seek to make those concepts more inclusive for themselves and their peers.

Our Situated Context

The authors teach in an undergraduate writing program at a historically white higher education institution in the United States. Undergraduates across the university, which is a large, private, high research activity university, are required to complete one semester in a writing and research course, and these courses emphasize disciplinary forms of writing and transfer between writing genres. About one-third of the dozens of faculty in the writing program were not trained in rhetoric and composition or related fields, but rather have come to writing instruction from other home disciplines, including STEM and the humanities. We authors are from humanistic STEM backgrounds and bring those disciplinary frames into first-year writing. Our standpoints, methodologies, praxis, and approaches are encouraged by program administration as a decolonizing practice, which we see as rooted in Steeves' pyroepistemology concept of replacing old ways of knowing and doing for more equitable futures.

Both authors are faculty in the first year writing program, considered a central component of the university's general education curriculum and a place where undergraduates are required to complete a 4.0 credit-hour introductory research and writing course. The program uses multiple disciplines and genres to prepare first year students for an academic career in writing. Both authors focus on writing in the sciences and/or health.

Course Reflection: Jameta Nicole Barlow, Ph.D., MPH

The first co-author is an unapologetic Southern Black woman and community psychologist, public health scientist, and women's health scholar teaching science and health writing. She brings her full self into the classroom—which enables her students to do the same. Her research utilizes decolonizing methodologies to disrupt cardiometabolic syndrome and structural policies adversely affecting Black girls' and women's health, intergenerational trauma, and perinatal mental health. She has spent 25 years in transdisciplinary collaborations with physicians, public health practitioners, researchers, policy administrators, activists, political appointees, and community members in diverse settings throughout the world. An alumna of the university, Barlow is deeply committed to preparing future scientists and health professionals

for a future world of scientific thought and praxis, using writing as a tool of critical thought and intervention. She teaches a research-intensive first year course on writing science and health, using women's health as a point of inquiry.

This course meets any student, STEM major or not, at the door of discovery. Recent socio-political moments have attempted to sanitize science in a way that can inhibit such discovery. I aim to describe the discovery process, using STEM as our lens, in such a way that any audience could possibly replicate the experience. This method offers students space to consider multiple standpoints, interrogate their philosophy of science, and consider alternate ways of knowing—all skills critical to introducing students to university academic writing. Students practice weekly reflective responses to prompts, which may include reference reviews, current news in science, conference proceedings, non-governmental reports, and peer-reviewed manuscripts. Through this process, students also practice peer review with opinion-editorials, abstracts, elevator pitches, and academic STEM/health research mini-mock grants they will develop over the semester. Teaching students how to deconstruct research, as well as think critically about current events in STEM, encourages ongoing critical thought and practice beyond the end of the course. Moreover, I teach students to consider alternate approaches of knowledge production; thereby, introducing them to the process of interrogating both their ontologies and epistemologies and the philosophies of science in literature. This is reinforced by what I call "healthy citation practices."

Two course learning objectives central to this process are (a) critically evaluate others' research and conduct scientific research; and (b) become a thoughtful producer of research and develop a discipline of writing, editing, proofreading and "healthy citation practices." My students learn how to weave history and science to synthesize and situate a scientific topic. Through this process, students deconstruct the topic, using traditional tools Audre Lorde (1984) references as the "master's tools" (Bowleg, 2021) and develop an understanding of alternative tools, approaches, practices, and methodologies to address their scientific topic. As a result, students not only embrace critical perspectives (Bowleg, 2021), but also learn the essentiality of developing a research paradigm (Bowleg, 2021). This dynamic process involves two major steps:

1. The first week of the semester, students are tasked with writing a philosophy of science, where they engage texts (Harding, 2011; Popper, 1934/2005) and respond to prompts assessing the nature of their knowledge production (see prompts in the Appendix). Throughout the semester, students return to their philosophy of science, which inevitably expands, as their knowledge production increases through course readings, discussion, and writing exercises. Students' ability to interrogate their philosophy of science represents a necessary step in understanding science.

2. Students are tasked with placing their science/health topic within the context of history. This requires an engagement with various types of references, each offering different slices of the historical narrative. At this point in the semester, we are also deep in the engagement of critical perspectives that offer the foundation of their emerging research paradigm, which is developed through their science/health topic. This contextualization of the literature—implemented by the multiple references and critical perspectives—is augmented by healthy citation practices, where students cite the relevant primary source(s), multiple perspectives, and specifically center marginalized authors, as modeled by the hashtag movements to #CiteBlackWomen (Smith et al., 2021) and #CiteASista (Nicole & Williams, 2018). This rebalancing of the historical narratives serves to counter tunnel vision views of a science/health topic.

Course Reflection: Kylie Quave, Ph.D.

The second co-author is a white EuroAmerican woman raised in the rural south and an anthropological archaeologist teaching science writing. Her research in the South American Andes investigates how Indigenous communities prior to and during European colonization responded with resistance and persistence in the face of imperialism. Quave teaches a first-year writing and research course focused on the themes of scientific racism and racism as a public health crisis. The course brings together texts and ways of knowing from biology, anthropology, political science, economics, science, technology, and society (STS), sociology, psychology, and public health. Assignments focus on writing in different scientific genres and translating research between genres for different types of audiences.

In this science writing course, critical approaches to citation are centered in order to correct the landscape of whose research is elevated and whose research is overwritten or ignored. Citation practices—including choices about who we read, who we assign, whose ideas we deem credible, and whose work we write about—often mirror the existing inequities and exclusionary forces of the societies in which we live (Itchuaqiyaq et al., 2020). Knowledge production tends to follow the same skewed patterns of marginalization of people already pushed to the edges of societies: what this manifests as is an outsize representation of white middle-class men from EuroAmerican and European backgrounds on our bookshelves, syllabuses, and bibliographies (Craven, 2021; Edmonds, 2020; Itchuaqiyaq & Frith, 2022; Tuck et al., 2015). Ample studies across disciplines have shown this pattern to be persistent (e.g., Chakravartty et al., 2018; Hutson, 2002; Itchuaqiyaq, 2022; Mott & Cockayne, 2017).

The course on scientific racism is designed to alter attitudes and practices about citation on several overt and covert fronts. Overcoming the white empiricism that

marks the status quo in many science bibliographies, I strive to channel Steeves' decolonizing method of pyroepistemology in teaching citation (2021). In Steeves' research on how deep histories of Indigenous Americans have been obscured in favor of anti-scientific denialism, she puts it as such: "Decolonizing Indigenous histories rebuilds bridges to ancestral places and times, which American archaeology burned in political fires of power and control" (2021, p. 181). Many scientific disciplines have endured such erasures, also called agnotology, which is the purposeful production of ignorance. Expertise has been ignored or cast aside to privilege the views of those already dominant in society, even when it has to do with experiences and knowledge that is not their own. Thus, in my courses, I promote a kind of anti-agnotologist way of choosing readings and citing research in our writing.

I begin my courses with critical examination of how we know what we know using the scientific method. I find that students need to be reminded of the tenets of science and the ways in which science is designed to be self-correcting. It is not a failure for scientists to err but rather is a failure when scientists do not ask about whether past knowledge production has been erroneous. For example, when Charles Darwin promoted myriad false and harmful assumptions about the nature of human races (Fuentes, 2021) while also providing researchers with the enduring theory of evolution by natural selection. Or how the "slavery hypertension hypothesis" has continued to promote the myth of an African American gene for high blood pressure, absent any evidence of such a deterministic feature (Lujan & DiCarlo, 2018).

At the heart of these and other examples is citational praxis. Students must deconstruct scientific studies and focus on writers' citational habits and how writers construct knowledge based on assumptions from their fields and elsewhere. I ask them to locate the writers' positionality as they assess the authors' epistemology (Takacs, 2003), and they work together in class to ask and answer questions that they report they have never or rarely asked about sources:

1. What is the author's background and worldview? What discipline are they from?
2. What kind of evidence is used? What is missing? What is not measured? What is excluded? How are some kinds of evidence weighted more heavily than others?
3. What kind of sources do the writers cite? What kinds of expertise have the writers prioritized and deemed credible in this study?

When students learn about citation in research writing, I steer them away from thinking of it as a legalistic matter of giving credit and instead ask them to see citation as opening up their worlds; citation creates new conversations, and I want them to see that both when they read and when they compose their own research. I urge them to view citation as a series of choices we writers are able to make and not

as inevitable. Furthermore, I ask them to reconsider their assumptions about who is credible and authoritative and to question preconceptions about objectivity and bias. Instead, students are required to incorporate citations from writers of varied positionalities and backgrounds and are encouraged to think critically about what counts as "scholarship." I do not ask students to make checklists of identities or fill quotas; rather, I merely ask them to reflect on who is there in the citations, who is not, and what we might miss without greater multivocality.

Furthermore, I do not restrict student writers to a definition of scholarship that only includes peer-reviewed works but rather ask them to consider the role of peer review and what other forms of review could provide comparable outcomes beyond academic publishing. We look into examples of how peer review sometimes fails, particularly by reading cases from RetractionWatch.org and reflecting on shortcomings in our own shared process as peer reviewers in our course. When students are restricted to only citing that which has undergone peer review, they miss out on a whole universe of expertise that is excluded from academic knowledge-making.

The learning outcome in this science writing course that is informed by Black Feminist, Indigenous Feminist, and decolonizing approaches is to have a critical understanding of expertise, credibility, evidence, and authority that is demonstrated through a reflexive and inclusive citation practice. The scaffolding to support this kind of learning outcome in any STEM writing course ought to include the following:

1. A syllabus that models prioritization of voices from historically and systemically excluded experts on the course material. Those sources should be scholarly in the broadest sense of the term, in which scholarship is work that is supported by evidence, embedded in prior research, and which is produced by someone with experience or training in the research area.
2. Lessons on bibliometric inequalities in the STEM discipline one is teaching. In archaeology, for example, there are many studies demonstrating an overall underrepresentation of researchers from minoritized backgrounds (e.g., Goldstein et al., 2018; White & Draycott, 2020), and there is also a strong tradition of tracking publication and citation statistics (e.g., Heath-Stout, 2020; Hutson, 2002) to understand who is given a platform to produce knowledge in the field.
3. Scaffolding increasingly complex lessons throughout the semester that introduce citation as a practice shaped by our social and political values. Citation choices are presented as not inevitable but rather as a series of decisions we make as writers, even as our choices may be limited by previous bottlenecks in the publication pipeline that result in outsize influence from certain kinds of researchers and writers. Students encounter this problem first as readers of chosen texts, then as researchers making their own choices, and then as

writers tasked with presenting cited sources with evaluative context. In other words, students learn to offer sources not as self-evident but rather as products of knowledge production processes occurring before the student writer encounters them.

4. Citation styles are taught as functional, and alternative forms are explored to reveal what is missing in traditional scholarly citation practice. It is insufficient to teach students the formal moves of citations without helping them see the construction of citation norms. Personal communications, including oral knowledge like that used to pass on Indigenous ways of knowing in some cases, are often excluded from reference lists and thus devalued, as outlined in Lorisia MacLeod's guide to citing Indigenous oral knowledge (Kornei, 2021). Helping students to find ways to add to or defy normative structures, such as MacLeod's creation of new templates for oral knowledge, puts marginalized epistemologies on even ground with easily cited scientific journal articles.
5. Students are required to reflect on the choices they make in selecting and evaluating sources to include in STEM writing, and they take responsibility for understanding how the epistemologies of the authors they cite are shaped by their positionalities. They are moreover responsible for identifying gaps in understanding that may be introduced by privileging a limited scope of worldviews in their research. Evaluation of their research paper is partly based on how accountable they are to these values, as realistic and truthful explanations of our world through science writing are only possible when we read and cite capaciously.

Broader Contexts for Promoting More Just and Inclusive Ways of Teaching and Learning

Cultivating the next generation of STEM scholars and writers who are well positioned to contribute to innovation is the collective goal we share in our pedagogies. As scientists who teach writing, we are committed to creating a formula for this journey of decolonizing science and democratizing knowledge. Because scientific disciplines have historically sidelined the research of those already marginalized in scientists' broader societies, knowledge is and has been a structural inequity. Addressing the exclusionary ways our disciplines were formed and currently operate requires altering the fabric of how we teach; this must be enacted at multiple levels. We cannot stop at making our reading lists more inclusive; we must also hold students accountable for understanding what is at stake and how to disrupt these structures as they participate in knowledge production.

These teaching methods do not go unquestioned in our experiences. Students have usually been taught prior to their first year in college that the sciences are a place of certainty, single answers, and exactitude. They often have the sense that multiple ways of knowing must not be valid, and that questioning of established paradigms is undesirable. Some struggle to accept decolonizing ways of thinking about research, expertise, and knowledge production. However, helping them to examine case studies such as those cited here from various disciplines, and then asking them to practice citation in the ways we've outlined helps many to re-assess their relationships to the sciences.

Teaching STEM writing in a way that promotes transparency about the intellectual histories (including the successes and the failures in those histories) of STEM disciplines in order to instill sound research and communication methods harnesses the power of teaching to transform society. Doing so through critical analysis of how writers know what they know, disrupts the myth of neutral scientific ways of knowing, while composition offers a site of liberation for those marginalized and excluded by the sciences.

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Appendix: Philosophy of Science Writing Prompt:

What is truth? And, how do we seek it? Is there only one truth? Are there multiple truths? Is truth necessary in science? Why or why not? How did your gender, sexuality, race, class, religion, neighborhood, nationality, personality contribute to your understanding of your world and what is meaningful? How do you begin research? What is important to you? Why do scientists rely on models and theories which are at least partially inaccurate? How is this related to implicit or unconscious bias? Explicit bias? What role does ethical research play in your approach to or thoughts about science? What is your goal in science?