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RESEARCH NOTE

A low-investment, high-impact approach for training stronger and more confident graduate student science writers

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Abstract

Scientists in applied fields, including conservation biology, face increasing expectations to communicate their research across multiple audiences. As environmental issues become more complex, the need for scientists to clearly communicate with other scientists, managers, stakeholders, tribes, the public, and policy makers becomes ever critical. Despite this need, students in graduate science programs receive limited direct instruction in writing and little training in writing for audiences outside of academia or in different genres. To that end, we developed an interdisciplinary program that incorporates rhetorical theory and writing intensive pedagogy to train graduate science students to write more effectively across genres. During the pilot testing in the first year of this broader, multiyear program, we evaluated changes in the writing practices and confidence of participants as writers and scientists who completed a low-investment, two-workshop sequence that highlighted habitual writing, peer review, and writing for multiple audiences and multiple genres. In just six contact hours, we documented significant increases in students' reporting maintaining a more consistent writing routine and writing environment, revising multiple drafts for writing projects, and being willing to have work reviewed by peers or mentors. Upon completion of both workshops, students reported an increase in their confidence as writers. The development of comprehensive graduate writing programs can be costly and time intensive, but our evaluation demonstrates that significant gains in writing capacity and confidence as writers were made by graduate science students with even a low level of investment. We urge graduate science faculty in all Science Technology Engineering Math disciplines to consider how they might offer this two-workshop sequence or similar low-investment interventions that will build writing capacity and confidence as writers and scientists in graduate students.

KEYWORDS
habitual writing, peer review, science communication, training workshops

1 | INTRODUCTION

Communicating science clearly and powerfully to colleagues and nonspecialist audiences is a challenging task for even the most experienced scientists and has become a growing preoccupation (Hundey et al., 2016; Kuehne & Olden, 2015; Pace et al., 2010). For the novice scientist, unarticulated conventions of both disciplinary scientific and public science writing present sizeable obstacles to professionalization and completion of degree, in part because of their differences (Andrews et al., 2005; deKoven & Trumbull, 2002; Fahnestock, 1998; Kuehne et al., 2014). This challenge has become so widespread that the National Academies of Sciences, Engineering, and Medicine recently published a comprehensive report to address the need for intervention (National Academies of Sciences, Engineering, and Medicine, Division of Behavioral and Social Sciences and Education, & Committee on the Science of Science Communication: A Research Agenda, 2017). The National Science Foundation (NSF) and Council of Graduate Schools, too, have called for Science Technology Engineering Math (STEM) graduate programs to incorporate more communication training (Linton, 2013), including a specific focus on writing for public audiences that can benefit both the public and the researcher (Kuehne & Olden, 2015).

But there is no consensus about what types of communication training are best for graduate students in applied science fields such as conservation biology where communicating with other scientists (Divan & Mason, 2016), the public (Hundey et al., 2016; Pace et al., 2010), and policy makers, typically in writing, is an important objective of the research. Inspired by the long-term, "high investment" approach to graduate science communication training described in this journal (Kuehne et al., 2014), the authors developed SciWrite@URI, an interdisciplinary model for training more effective science writers in graduate programs in the biological sciences (Druschke et al., 2018). Initiated with NSF funding, SciWrite@URI uniquely embeds rhetorical theory and writing intensive pedagogy into multiyear training for STEM graduate students at the University of Rhode Island. SciWrite@URI builds from the premise that complex science communication challenges require rhetorical knowledge and regular practice in multiple genres to move away from a deficit model of science communication (Gross, 1994) and advance critical public engagement with science (Druschke et al., 2018; Gigante, 2014).

While the full details of the 2-year, vertical curriculum developed through SciWrite@URI (a 4 year NSF-funded project) are useful for those wishing to create a robust structure for supporting graduate student science writing (Druschke et al., 2018), many faculty scientists interested in supporting graduate student writing do not have the institutional support, external funding, or disciplinary expertise to build a comprehensive, high-investment training program. To that end, we offer here an empirical evaluation of a stand-alone module of the larger program: a rhetorically based, scaffolded, two-workshop sequence from SciWrite@URIs pilot testing first year. We tested curricular materials, interactive workshops, and other activities intended to prompt quantifiable improvement in science graduate students' abilities to communicate with other scientists, managers, stakeholders, tribes, the public, and policy makers. We share this framework, details of its components and assessment (Appendices S1 and S2), and evidence of its impact on students to model how faculty in the biological sciences can support graduate student writing even with limited institutional resources.

2 | METHODS

2.1 | Study sample and recruitment

We recruited graduate students enrolled in the MSc and PhD in Biological & Environmental Sciences (BES) program through official university channels to participate in the two-workshop sequence (Table 1). The BES program includes about 90 faculties and about 130 students from fields in across all levels of biological organization (from molecules to ecosystems) and in this sense is representative of the biological sciences component of STEM graduate programs. The university's Institutional Review Board approved our study protocol (HU#1516-009), and all research participants provided signed consent prior to taking part in the study. We administered surveys informed by best practices in writing assessment at the beginning of the first and end of second workshop (Appendices S2 and S3) (Adler-Kassner & O'Neill, 2010; Huot & O'Neill, 2009).

2.2 | The two-workshop sequence

Participants attended two, 3-h workshop sessions held 2 weeks apart. The sessions were designed to build on

TABLE 1 Characteristics of participants in two workshops (n = 20, 19) designed to increase writing skills and confidence in graduate science

Characteristics	Workshop #1 *n* (%)	Workshop #2 *n* (%)
Sex		
Female	16 (75)	15 (83)
Male	4 (20)	3 (17)
Race[a]		
Caucasian	19 (95)	16 (84)
Asian	1 (5)	1 (5)
Degree		
Masters	13 (65)	13 (68)
PhD	7 (35)	6 (32)
College[b]		
College of the Environment and Life Sciences	16 (80)	14 (74)
College of Health Sciences	4 (20)	4 (21)
Years in graduate program		
1–2	15 (75)	15 (79)
3+	5 (25)	4 (21)

[a]Two of the graduate students in Workshop #2 (11% of participants) did not identify their race.
[b]One of the graduate students in Workshop #2 (5% of participants) did not identify their College.

each other via a writing assignment between the two sessions that could then be peer reviewed during the second session, to deploy SciWrite@URI's rhetorically informed tenets of habitual writing, frequent review, and multiple genres (Druschke et al., 2018). We divided both workshops into distinct units which each included mini-lectures on relevant topics, small-group writing activities related to the topics, and summary discussions that included all workshop attendees and facilitators (Appendix S1). Example topics and activities included addressing different genres by describing a research topic for a children's TV show and creating habitual writing practices via developing writing revision plans. This approach kept the workshop active and allowed student participants to become comfortable with a set of peers. Facilitators in both sessions included the five mixed-discipline faculty members who founded SciWrite@URI—representing natural resources science, nutrition, and writing and rhetoric—as well as a doctoral student specializing in rhetoric and composition. Some workshop components were previously developed for and applied in workshops focused on building writing capacity among science faculty at universities in Indonesia by the leadership team. Preworkshop and postworkshop assessments with Indonesian faculty helped us to identify workshop modules that yielded larger gains in writing confidence and capacity, thereby allowing us to incorporate feedback from these scientists into our SciWrite@URI workshops.

2.3 | Study measures and methods

Participants completed a preworkshop survey at the beginning of the first workshop and a postworkshop survey at the conclusion of the second workshop. The preworkshop survey included 22 items (Appendix S2). Questions focused on the three core rhetorical tenets: four questions focused on habitual writing practices, one on frequent review, and one question focused on writing for multiple genres and multiple audiences. Additional questions addressed general confidence as a writer and a scientist. The postworkshop survey included 17 items (Appendix S3) asking corresponding questions about the three tenets and confidence as a writer and a scientist as well as six more questions reflecting on students' overall workshop experience. While seven items asking about SciWrite@URI outcomes matched on the pre- and postworkshop questionnaires, the question about multiple genres and multiple audiences did not in terms of question content and answer form. The preworkshop question "As a graduate student, have you created a piece of writing related to your academic work that was intended for a nonspecialist or public audience?" required a Yes/No answer and the postworkshop question "As a result of attending the SciWrite@URI workshop, do you expect to share your scientific research with a public audience?" was answered on a Likert scale with a range of definitely not to definitely. As a result, we were not able to analyze this outcome.

2.4 | Data analysis

We report categorical variables as numbers (n) and percentages, and continuous variables as means ± standard deviation. We conducted paired sample t tests on seven pairs of survey items (habitual writing [three questions], frequent review [one question], multiple genres for multiple audiences [one question], and confidence [two questions]), comparing preworkshop scores from prior to the start of first workshop to postworkshop scores from the conclusion of the second workshop. Analyses were two-tailed and a p-value of $\leq .05$ was considered statistically significant. Cohen's d is also reported to provide effect size (point estimate, 95% confidence interval). The

following *d*-values were used to interpret Cohen's *d*: <0.2 is a small effect size, <0.5 is a moderate effect size, and <0.8 is a large effect size. We conducted analyses in SPSS Version 24 (IBM Corp., New York, NY).

3 | RESULTS

The preworkshop survey was completed by 20 respondents at the beginning of the first workshop. Eighteen of those respondents completed postworkshop surveys at the conclusion of Workshop 2. Participants were primarily female, white, and not Hispanic or Latino. Most were masters-level and in the first or second year of their programs. All participants were enrolled in masters or doctoral degree programs in biological and life sciences (Table 1).

3.1 | Best practices in writing

We found that students who completed both workshops self-reported adoption of best writing practices that included habitual writing, frequent revision, willingness to engage in peer review, and attention to organization. For students who attended the two-workshop sequence, we observed significant increases (Figure 1) in participants' self-report about maintaining a more consistent writing routine (pretest 2.6 ± 1.1, posttest 4.3 ± 0.7; $t(18) = 6.3$, $p < .05$; 1.46, Cohen's $d = 0.80$–2.1) and maintaining a more consistent writing environment (pretest 3.6 ± 1.0, posttest 4.3 ± 0.7; $t(18) = 2.6$, $p < .05$; Cohen's $d = 0.60$, 0.10–1.1) over the 2-week period. After attending both workshops, participants reported significant increases (Figure 1) in creating multiple drafts for a single project (pretest 4.3 ± 0.7, posttest 4.8 ± 0.6; $t(18) = 2.3$, $p < .05$; Cohen's $d = 0.52$, 0.0.3–1.0) and in their willingness to share work with a peer or mentor (pretest 4.0 ± 0.9, posttest scores 4.8 ± 0.4, $t(18) = 4.8$, $p < .05$; Cohen's $d = 1.12$, 0.52–1.67). Students also reported a significant increase (Figure 1) in their plans to use outlines or topic sentences for future projects (pretest 3.1 ± 1.2, posttest 4.8 ± 0.4; $t(18) = 6.1$, $p < .05$; Cohen's $d = 2.25$, 1.39–3.10).

3.2 | Confidence as a writer and scientist

Students who completed both workshops reported a significant increase (Figure 1) in their confidence as writers (pretest 3.2 ± 0.7, posttest 3.8 ± 0.6, $t(18) = 4.82$, $p < .01$; Cohen's $d = 0.84$, 0.30–1.35), but confidence as a scientist did not significantly increase after the intervention (pretest 3.4 ± 0.8, posttest 3.7 ± 0.8, $t(18) = 2.04$, $p = .056$; Cohen's $d = 0.47$, −0.12 to 0.94), though it did approach significance.

4 | DISCUSSION

Although graduate science students traditionally receive little to no training in writing or rhetoric (Kuehne et al., 2014), and the development of comprehensive writing programs can be costly, time intensive, and challenging, the outcomes of our workshop sequence indicate that significant gains in writing capacity and confidence can be made even with relatively little investment. Participants who completed this two-workshop sequence reported an increase in habitual writing practices, willingness to take part in review with a peer or mentor, and, notably, in their confidence as writers.

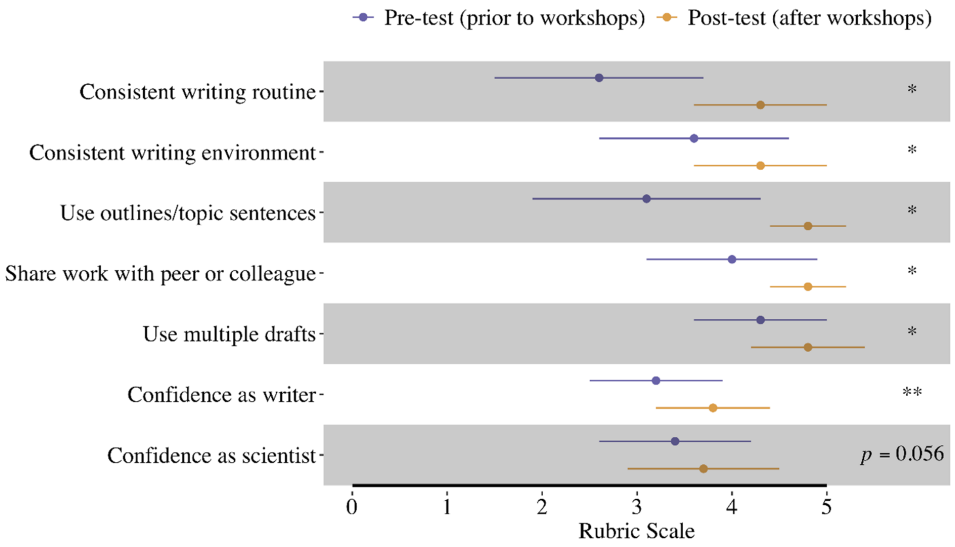

FIGURE 1 Changes in best writing practices and confidence for graduate students in biological and life sciences who completed a two-workshop sequence. Mean score and standard deviation are shown. Pretest measures were collected at the beginning of Workshop #1 and posttest measures were taken at the end of Workshop #2

After just six contact hours with graduate science students, we documented an increase in students reporting that they would incorporate more habitual practices in their writing—for example, maintaining a consistent writing routine, increasing the use of multiple drafts, and intentionally incorporating elements like topic sentences. Results indicated that many students already created multiple drafts and would continue to do so. Students reported that they were pleasantly surprised to realize that incorporating new habits into their writing routines led to more successful writing experiences, and that they could personalize these habits given that there was not one right or wrong way to establish a regular time, place, and environment for writing. Scientists are increasingly emphasizing the positive relationship between habitual writing and writing productivity, and the development of deliberate writing practices by students while in graduate school will yield career-long benefits for scientists (Petersen et al., 2020).

An increased number of students reported that they intended to participate in more frequent review with peers and mentors. While peer review in this workshop context leveraged guided participation in an online peer review tool, what students found more powerful was simply the experience of students setting aside their fears to share unfinished writing with supportive colleagues. In line with research that demonstrates graduate students who facilitate peer review strengthen their expertise in writing and improve their writing practices (Kumar & Aitchison, 2018), students expressed learning a great deal about their own writing by reading and commenting on others' work. They also reported through both workshops that sharing unfinished work could be helpful to their writing process, and that feedback from others helped solve problems in their work.

Students reported increased confidence in their writing—an exciting benefit and reflected our approach to writing as a process-centered practice built on habits such as peer review and preferred work environment rather than a product-centered mandate. The SciWrite@URI philosophy is based much less on offering students specific "tips and tricks" for effective scientific writing and communication, and much more on emphasizing the rhetorical tenets of the program—habitual writing, frequent review, multiple genres for multiples audiences—as flexible approaches to cultivating writing as a lifelong practice. This, we think, is the power of our approach: one that shifts students from thinking they need to finish memorizing a vast list of concrete rules before they can feel like confident experts, into thinking about developing the flexible capacities to engage with writing—and science—as ongoing, complex, flexible problems with a variety of solutions.

While we were not able to analyze the impact of the workshop series on multiple genres and multiple audiences, we have found in our experiences as graduate student advisers, many graduate science students have limited exposure prior to or within graduate school to the breadth of genres and audiences for which a career scientist might need to share their science and little practice in writing in different genres. This would be particularly true for our workshop participants who were predominantly first and second-year master's degree students who are still novices and may be more focused on content rather than genre. Engaging scientists, including student scientists, with expertise in subjects important to the public and with the desire and confidence to engage in sharing that science remains a key challenge in science communication (Fischhoff, 2013), and experience writing for the public is a critical, yet often lacking component of graduate science education (Hundey et al., 2016) that a program like SciWrite@URI can partially address. Future workshops might consider showcasing scientific Twitter accounts or blogs aimed at engaging the public to enrich students' understanding of the need for, and practice of, communicating across genres.

This need presents an opportunity to expand on workshop components that build students' writing flexibility for audience and genre. Such expansions may also address the situated and inherently biased nature of writing and peer review, including the potential for racial (Condon & Young, n.d.; Inoue, 2015) and gender (Pritlove et al., 2019) bias even at the highest levels of academic work. Other programs could incorporate the three rhetorical tenets tested and discussed here into STEM graduate courses rather than hold separate workshops. Other programs could also collaborate with institution-based writing centers who may be willing to offer workshops or course supplements on these topics. Students might reflect, for instance, on how their writing would change if they were explaining the same study to a nonspecialist or public audience or were presenting a study visually rather than in writing. Expanding on workshop elements would extend additional benefits as increasing science students' capacity to write for nonspecialist audiences has been associated with a more comprehensive understanding of science and implications of that science for the public by those students (Pelger, 2018; Pelger & Nilsson, 2018). These benefits support graduate science students beyond school and into their professions.

While we acknowledge the small sample size of our study, as well as the lack of racial diversity in our sample, we think the results of these pre- and postworkshop surveys show incredible promise for this low-investment, two-workshop sequence approach. We want to emphasize

that the precise content of the workshop presentations mattered less than engaging students in discussions and activities that emphasized the importance of, in this case, habitual writing, writing in multiple genres for multiple audiences, and frequent review. That said, some workshop elements, such as activities designed to build skill in developing strong topic sentences, appeared to be especially important in increasing capacity and confidence both in Indonesian scientists and our graduate students in the biological sciences. These elements would likely be useful for training graduate students in other fields. We encourage faculty or staff in other STEM disciplines to adapt our workshops to include discipline-specific activities and examples that would make them valuable for other graduate students.

We urge faculty in STEM disciplines at other institutions to consider how they might offer the two-workshop sequence or similar low-investment interventions that emphasize these rhetorical tenets of habitual writing, frequent review, and multiple genres for multiple audiences. We emphasize that these foundational tenets are the key to transforming graduate student scientists into more confident and effective writers and scientists.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Caroline Gottschalk Druschke—Made substantial contributions to conception and design, acquisition of data and interpretation of data; was involved in drafting and revising it critically for important intellectual content; gave final approval of the version to be published. Nancy Karraker—Made substantial contributions to conception and design, acquisition of data and interpretation of data; was involved in drafting and revising it critically for important intellectual content; gave final approval of the version to be published. Scott R. McWilliams—Made substantial contributions to conception and design, acquisition of data and interpretation of data; was involved in drafting and revising it critically for important intellectual content; gave final approval of the version to be published. Al Scott—Made substantial contributions to the analysis and interpretation of data; was involved in drafting and revising it critically for important intellectual content; gave final approval of the version to be published. Jenna Morton-Aiken—Made substantial contributions to conception and design, acquisition of data and interpretation of data; was involved in drafting and revising it critically for important intellectual content; gave final approval of the version to be published. Nedra Reynolds—Made substantial contributions to conception and design, acquisition of data and interpretation of data; was involved in drafting and revising it critically for important intellectual content; gave final approval of the version to be published. Elaine Finan—Made substantial contributions to conception and design and interpretation of data; was involved in drafting and revising it critically for important intellectual content; gave final approval of the version to be published. Ingrid E. Lofgren—Made substantial contributions to conception and design, acquisition of data and interpretation of data; was involved in drafting and revising it critically for important intellectual content; gave final approval of the version to be published.

DATA AVAILABILITY STATEMENT

The data in this study are from human subjects. Deidentified data can be requested from the corresponding author.

ETHICS STATEMENT

All of the authors have contributed to the manuscript and agree with the findings and conclusions. There is not any related work by the authors that might represent prior or duplicate publication in another journal. The authors have no conflict of interest to report.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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