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A WINning Approach: Teaching Science Communication Skills Through Small-Group Workshops

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Abstract

Objectives: Research almost always culminates in the communication of findings. Despite the necessity of grant and manuscript writing throughout academic careers, scientific trainees often receive little guided practice in written communication. To fill this gap, we designed, implemented, and evaluated a voluntary writing initiative for biomedical students at a research-intensive (R1) university in the midwestern United States called Writing Initiative in Neuroscience (WIN).

Method: WIN consisted of didactic and workshop components. The didactic component included discussions with topic-specific experts on writing grants and manuscripts for the public and for non-academic scientific careers. The workshop component consisted of small group-based peer review of participant writing samples. Student self-enrollment consistently filled all available seats over three separate cohorts, including those formed during the COVID-19 pandemic. Student self-assessments were implemented to determine improvements quantitatively and qualitatively in writing and peer-review across 3 years of WIN programming.

Results: Student self-assessment of writing skills before and after programming revealed improved scientific writing competency with medium or large effect sizes. Qualitative self-assessments indicated perceived improvements in writing competency and confidence. Collectively, students who participated in WIN improved their writing and communication skills and gained experience in providing and receiving feedback.

Conclusions: Ultimately, peer-led writing initiatives, such as WIN, may enhance scholarly training and lay a foundation for future trainee writing success across scientific disciplines.

Implications for Theory or Practice: These results support the utility of a student-centered writing workshop for biomedical students. Our study combined aspects of multiple existing resources, including peer

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feedback, interdisciplinary student backgrounds, and professional editing guidance. Together, these features formed a flexible and practical writing workshop, which can be used as a template for biomedical training programs.

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Introduction

Academic success and career advancement depend on communicating findings. Yet, in the natural sciences, students at all levels of training are often left to navigate the writing process on their own, without much formal instruction. This can result in inadequate training and long-lasting consequences on future success. An emphasis on coursework and productivity, particularly early in training, often results in students neglecting scholarly writing until frenzied deadlines. While elective writing courses exist, students and mentors are often hesitant to invest in communication skills until they are imminently needed. Furthermore, courses often require that students write with minimal guidance or iterative feedback and therefore learn very little about successful techniques and strategies. The need to pivot to virtual instruction during the COVID-19 pandemic has emphasized these limitations.

Literature Review

Many students in the biomedical and natural sciences learn technical writing skills through informal or observational interactions with academic advisors (Cameron et al., 2013). However, mentors are commonly plagued by time constraints and deadlines, leading to a hands-off approach or, conversely, a complete takeover of mentee work (Cameron et al., 2013; Kranov, 2009). The academic "publish or perish" dogma, combined with insufficient training in academic writing, make it unsurprising that novice scientists self-report significant stress over starting and completing writing projects (Jatin et al., 2009; Rawat & Meena, 2014). These cognitive barriers include inexperience or previous negative experiences, writing anxiety and self-doubt, resistance to feedback, and fear of failure (Huerta et al., 2017; Pololi et al., 2004; Witt, 1995). These factors deplete writing confidence and promote writer's block and anxiety (Huerta et al., 2017).

Interactive writing interventions, such as group-review and writing workshops, are a strategy to improve writing confidence and facilitate student success. Writing instruction is the target of significant resources and attention at many tertiary institutions (Simpson, 2012), and dynamic models for instruction (such as writing workshops) have gained some popularity. Workshops for pre- and post-doctoral trainees range from those that take place across 1 or 2 days (Fernandez et al., 2018; Goyal et al., 2020) to those that take place over the course of several sessions or semesters (Wortman-Wunder & Wefes, 2020). In many cases, trainees find that these workshops—regardless of format—improved their writing skills, increased their confidence in their writing abilities, and better prepared them for future academic writing projects (Cameron et al., 2009; Wajekar et al., 2018).

Workshop programs have been applied previously in the context of science, technology, engineering, and mathematics (STEM) education. For example, interactive oral and written communication workshops for STEM students, which feature both didactic and informal, hands-on components, have been shown previously

to improve student confidence (O'Keeffe & Bain, 2018) and productivity (Guydish et al., 2016). Among behavioral science trainees, similar workshop-style writing interventions improve writing skills and productivity (Gianaros, 2006). Even in an abbreviated format only 6 hours long, a similar workshop-style science communication teaching intervention yields improved student writing confidence, more consistent writing routines, and increased willingness to review written work (Druschke et al., 2022).

In designing an effective program to provide applied, real-time instruction in writing for biomedical students, we critically appraised the available evidence on similar initiatives. The literature revealed that attributes of a successful workshop program may include increased student interest, motivation, attention, and self-efficacy; inquiry-based learning; peer tutoring; and incorporation of applied learning from experts in the field. We review the literature on these attributes of a learning paradigm, as well as their relevance to the workshop evaluated in the present study.

A student's level of interest and involvement in their own learning often correlates with motivational aspects of learning, which are significant predictors of learner success (Chen et al., 2022). For example, self-efficacy and optimism promote adaptive learning and increase learner satisfaction (Usan et al., 2022). Workshop-based learning involving peers and social support is one method by which to increase self-efficacy and cultivate positive learner attitudes and interest. For example, a managed learning space that facilitates social interaction may contribute to improved student success (Black & Roberts, 2006). Social motivation and obligation, for example to provide peer feedback, has long been noted as a driver of effective learning and positive student experience, with attention and memory significantly improved in social learning contexts versus nonsocial ones (DiMenichi & Tricomi, 2015).

In addition to capitalizing on social motivation, an additional advantage of a peer-workshop model is that it blends a variety of teaching formats and styles, including interactive peer tutoring and an emphasis on inquiry-based learning. Peer tutoring encourages student autonomy and intellectual development (Hayward et al., 2016). Cooperating and working with others across varied interest and experience levels can enhance student skills and productivity (Johnson et al., 1994). Frequent check-ins with peers around ongoing work, particularly in a small group setting, also increase productivity (Edwards, 2002). At the university and post-graduate levels, inquiry-based learning in a workshop setting has been shown to significantly improve self-efficacy and learning outcomes (Hayward et al., 2016; Werner, 2007). This premise—that varied interests and an emphasis on cooperation and peer tutoring enhance learning—was one that was capitalized on in the program described in this report.

In addition to incorporating opportunities for student-led inquiry and peer tutoring, didactics from a variety of experts in varying biomedical fields promoted applied learning in the workshop we developed. Incorporation of field-specific experts who share career or research interests with students offers opportunities for real-world learning and skill building. This may be particularly true in the context of biomedical education, where trainees vary greatly in career goals and in the relevance of written communication to those goals. Prior work has shown improved learner outcomes and satisfaction when guest lectures and applied didactics are incorporated into science education (Crockett, 2014; Markowitz & DuPre, 2007).

Hart (2008) described the preferences of learners, which include a preference for experiential learning through discovery; social or collaborative learning within a learning community; immediate feedback; independence and autonomy within a structured or guided learning framework; and involvement in scaffolding their own learning (Hart, 2008). The workshop-based writing intervention we describe and evaluate here incorporated many of these preferences with the goal of providing practical guidance in scholarly communication for trainees in the biomedical sciences.

Purpose of the Study and Hypotheses

Writing interventions, such as group-review, are a strategy to improve writing confidence and facilitate student success. Given this, we developed a workshop-based program for graduate-level students, modeled after the world-renowned Iowa Writers' Workshop. We coined this initiative the Writing Initiative in Neuroscience (WIN). WIN sessions consisted of both didactic and workshop components. Our research questions were as follows:

1. Would WIN improve student confidence and writing skills?
2. Would WIN enrollees report high levels of satisfaction with the program?
3. Would satisfaction with WIN programming be consistent across sessions?
4. Would the COVID-19 pandemic and a pivot to virtual instruction alter satisfaction with WIN programming?

We hypothesized that WIN would consistently and significantly improve student self-confidence and writing skills, which we determined by assessing student satisfaction over 3 years of WIN programming (2018–2021), including during the COVID-19 pandemic, which involved a shift to virtual programming.

Method

Population and Sample

Participants were post-comprehensive exam (at least 2nd-year) students in a U.S. research-intensive (R1) university interdisciplinary neuroscience graduate program (Table 1). To be enrolled as "WIN fellows," participants agreed to good attendance (80%) and to actively participate in peer review.

Table 1. *Summary of Participants by Year and Sex*

Academic year	Participants		Total Participants/Eligible
	Men	Women	
2018–2019	3	11	14/26
2019–2020*	4	12	16/32
2020–2021*	5	10	15/36

Note. *Some or all programming held virtually due to COVID-19 pandemic

Procedures

WIN was promoted through weekly announcements and program-wide emails. Meals were provided during in-person workshops. Professional medical college editing staff (one to two per meeting) were hired from the College of Medicine Scientific Editing and Research Communication Core to moderate the peer workshop component, engage in discussion, and provide feedback.

Eight or nine sessions were held monthly during the academic year (August–April/May). Each was 2 hours long—the first hour involved didactics and the second was a peer workshop. The first cohort of WIN fellows attended all sessions in person; the second cohort attended some sessions in person (seven) and some virtually (two); and the third attended all session in a virtual format. The study was approved by the institution.

Didactic Component

During the didactic component (~45 minutes), speakers presented and led short discussions on pre-selected topics (see Appendix A). These topics changed annually based on student interests. Some speakers distributed reading materials ahead of time (e.g., exemplary science writing; science writing or communication articles; their own work).

2018–2019 Academic Year. The debut year of WIN featured didactic presentations from clinical and biomedical neuroscience faculty on broad scientific writing topics, such as grantsmanship, manuscripts, and popular science. Speakers from outside of the Department of Neuroscience were also invited to discuss pedagogy. Finally, professional editing staff from the university led a session on practices to achieve clarity in writing. This topic was selected by popular demand from a selection of the editing staff's areas of expertise.

2019–2020 Academic Year. The didactic content of WIN in the 2nd year began with a primer on the workshop's structure, particularly focusing on how to receive and deliver peer review (see Appendix B and Appendix C). This session was led by professional editing staff at the university. While most topics and speakers were like the previous year, student feedback guided some changes. For example, one speaker was invited from a local biotechnology company and spoke on writing in industry. Additionally, one workshop offered more fundamental advice on how to write a curriculum vitae and a National Institutes of Health biosketch.

2020–2021 Academic Year. The 3rd year of WIN featured more fundamental writing topics based on positive feedback from students. These topics included sentence and paragraph structure, writing a good introduction, the scientific review process (specifically for predoctoral fellowships), and broader impacts statements. As a complement to written science communication, publication figures were also a topic discussed.

Workshop Component

To maximize student engagement and discussion, students were divided into two subgroups comprised of approximately six students each during the workshop. In each subgroup, one student was designated as "author," and provided the group with a writing submission of less than 500 words. One week prior to the workshop, submissions were circulated with a brief statement outlining the context and goals of the writing project and concepts to focus on (Appendix B). Authors were encouraged to submit works-in-progress so feedback would be directly applicable.

In each workshop subgroup, all students provided oral and written feedback on overall themes and line-by-line edits, respectively. At the first session, professional editing staff provided instruction on peer feedback (Appendix B and Appendix C). To initiate discussion, one student was designated the lead reviewer. They provided in-depth review and others contributed on a more ad-hoc basis. Professional editing staff moderated each subgroup.

Analysis

Students reported their perceived writing abilities before and after workshop intervention. These scaled self-evaluations were used for their ease of application and their ability to inform student writing confidence, a key component of writing success (Huerta et al., 2017; Pololi et al., 2004; Witt, 1995). During the workshop's first year (2018–2019), participants were surveyed prior to starting the workshop and again after four sessions. The second cohort (2019–2020) was surveyed at the outset and again after 1 year of programming. Using a scale of 1–7 (1 = strongly disagree; 4 = neutral; and 7 = strongly agree), participants rated their perceived ability to write concisely and effectively; plan a written document; write stylishly and creatively; and edit and

peer review proficiently. Before and after scores were compared using a paired, two-tailed *t*-test. A value of $p < 0.05$ was considered statistically significant. Effect sizes were calculated as Cohen's *d* (difference in means divided by pooled standard deviation), with a small effect defined as *d* less than or equal to 0.2, medium as between 0.2 and 0.8, and large as greater than 0.8.

To assess the efficacy of the workshops design, qualitative feedback was also solicited from students. We specifically requested feedback on what went well or poorly about the didactic and workshop components, along with any additional comments. These qualitative data were collected from all three cohorts and incorporated in an iterative way across the years of programming. The third cohort (2020–2021) was only surveyed for qualitative feedback due to the remote (Zoom-based) structure of that year's programming and disruptions caused by the COVID-19 pandemic.

To determine student overall satisfaction with the workshop, participants were asked yes/no questions about gained fluency in different scientific writing styles and whether they would enroll again. These assessments were completed during the 2nd and 3rd years (2019–2020; 2020–2021) of the workshop and were assessed via a one-sample binomial test (versus chance, 50% "yes").

Results

Scaled Assessment

Assessments were taken before and after the first four sessions of the 1st year of programming and before and after all eight sessions of the 2nd year of WIN. Due to the COVID-19 pandemic, the final two sessions of the 2nd year of WIN were held online, potentially limiting the number of completed before and after self-assessments from the year. Pandemic disruptions also prevented before and after assessments in the 3rd year of WIN (2020–2021). Overall, self-assessments indicate that the writing abilities of WIN participants improved after the course of the workshop. Scaled self-assessments were used to gauge student self-perceived writing competency before and after this writing workshop intervention across four domains. Table 2 provides a summary of the results.

Writing Concisely and Effectively. Across the 1st year of WIN, participant ratings for "write concisely and effectively" improved modestly (by 6.5%) and non-significantly with a medium effect size. Participant ratings for this domain in the 2nd year of WIN showed a significant improvement and large effect size [22.7% increase; $t(4) = 3.2$, $p = 0.03$; Table 3].

Planning a Written Document. In the 1st year of WIN, participant ratings improved significantly by 44.1% for self-perceived ability to "plan a written document" [$t(7) = 3.8$, $p = 0.01$; Table 3]. The size of this effect was large. This score increased over the 2nd year of programming (by 19.0%), though not significantly. The magnitude of the effect size for this measure in the 2nd year of programming was medium.

Writing Stylishly and Creatively. In the 1st year of WIN, participant ratings improved significantly by 27.8% for "write stylishly and creatively" [$t(7) = 3.7$, $p = 0.01$; Table 3]. This change corresponded to a large effect size. This score non-significantly increased (by 11.8%) over the 2nd year of WIN programming, which corresponded to a medium effect size.

Editing and Peer Review. Although average scores for "editing and peer review" increased during the 1st year (by 22.5%) and 2nd year (by 16.7%) of WIN, these changes were not statistically significant (Table 3). The magnitude of this change had a medium effect size over both the 1st and 2nd years of WIN.

Writing Across Styles. During the 2nd and 3rd years (2019–2020; 2020–2021) of WIN programming, participants reported whether they gained greater fluency in different scientific writing styles (yes/no). During 2019–2020, 5/7 respondents answered "yes" to gaining greater fluency across writing styles (binomial p-value = 0.23). During 2020–2021, 8/9 respondents answered "yes" to the same question (binomial p-value = 0.02).

Would They Enroll Again. After the 2nd and 3rd years of programming, participants reported whether they would enroll again if given the option. Of 2019–2020 participants, 5/7 answered "yes," that they would repeat (binomial p-value = 0.23), while of the 2020–2021 participants, 6/9 (binomial p-value = 0.25) answered "yes" to the same question.

Table 2. *Self-Assessment Ratings for Workshop Participants*

	Mean Before Score (± *SD*)	Mean After Score (± *SD*)	Mean Difference	Percent Improvement	Effect Size (Cohen's *d*)
2018–2019 Academic year; 4 sessions					
Write concisely and effectively.	4.6 (± 0.5)	4.9 (± 1.0)	0.3	6.5 %	0.4
Plan a written document.	3.8 (± 1.0)	4.9 (± 1.1)	1.1	*44.1 %	1.0
Write stylishly and creatively.	3.6 (± 1.1)	4.6 (± 0.7)	1.0	*27.8 %	1.1
Edit and peer review proficiently.	4.0 (± 1.6)	4.9 (± 1.4)	0.9	22.5 %	0.6
2019–2020 Academic year; 8 sessions					
Write concisely and effectively.	4.4 (± 0.5)	5.4 (± 0.5)	1.0	*22.7 %	2.0
Plan a written document.	4.2 (± 1.6)	5.0 (± 1.4)	0.8	19.0 %	0.5
Write stylishly and creatively.	3.4 (± 1.3)	3.8 (± 1.3)	0.4	11.8 %	0.3
Edit and peer review proficiently.	4.8 (± 1.1)	5.6 (± 0.9)	0.8	16.7 %	0.8

Note: *$p < 0.05$ by paired two-tailed t-test

Qualitative Assessment

Qualitative feedback from WIN participants after all 3 years of programming (2018–2019; 2019–2020; 2020–2021) included positive, negative, and constructive comments on both didactic and workshop components. Feedback clustered around several themes: WIN structure; content; delivering and receiving feedback; and use of a virtual format during the COVID-19 pandemic.

WIN Structure

Participant feedback across all 3 years of WIN programming consistently highlighted the benefits of a flexible structure. Students enjoyed the open-ended structure of the didactic component: "Leaving it open for the speakers to present how they wish to present is good," and "I think the structure of the most constructive [didactic] presentations was a mix between prepared content (~10 minutes' worth) and open discussion."

Similarly, participants enjoyed a flexible format for the workshop component: "It was good to have a rough structure that left enough flexibility for each session to be tailored to the individual submitter;" "I think it is important to leave flexibility in the structure to allow individuals to be able to contribute their ideas fully and not feel restricted by time or structure;" and "each group takes the discussion in the direction they want it to go, so any added structure would just be ignored."

In contrast, some participant comments during the 1st year (2018–2019) of WIN demonstrated a need for more guidance in the workshop component: "The lead reviewer should have a bit more guidance of how to drive/lead the conversation," and "the discussion could be more structured." These comments highlighted the need for additional instruction in providing helpful, constructive, and useful feedback. Later iterations of WIN (2019 and on) emphasized this point with an initial session, taught by professional scientific editing staff, on delivering and receiving feedback. Subsequent participant feedback reflected the benefits of increased structure around feedback and a clarified understanding of the role of the lead reviewer: "the lead reviewers helped guide discussion well and everyone was engaged in the conversation." Some maintained, however, that sessions were "sometimes a little too unstructured feeling." Overall, these remarks supported the open discussion design and informed us on providing more guidance on peer-review expectations on the program onset.

Session Content

There was a strong preference for the workshop component of each session, which was echoed across all WIN cohorts: "The second-half [of the] workshop is the most valuable part. I learned more from workshopping others' pieces and having a group of people workshop my piece than I learned in the whole year of first-half speakers"; "I definitely got the most out of the second part of each meeting and learned a lot about writing simply from hearing from others, rather than learning about writing through the invited speaker"; and "The greatest strength was the second part of the meeting where we discussed the submitted sample. I thought the structure of these discussions was great and it felt very natural and comfortable to critique other's work in this setting."

Participants provided more constructive feedback about the didactic component: "Sometimes I was just hoping they would finish up already so we could get to the small group discussion which I thought was very helpful." Feedback indicated that the didactic component could be improved: "a little more interaction [with the speaker]." Additionally, some students felt that additional materials provided by some speakers ahead of the workshop were unnecessary: "[Do not] have the speakers assign reading materials.... they very often went unread as people were focusing their energies on reading and editing." However, students appreciated instruction involving "very tangible ways to improve structure and organization" and discrete "strategies that I didn't have before." Strategies included, for example, "learning new ways to approach a document when editing." Some suggested that "more direction towards reading materials that can assist with writing" or "stylized exercise(s)" would have been helpful.

Participants also expressed an appreciation for exposure to new and emerging genres of science writing: "I did learn about different styles and learned a lot (especially about writing for non-scientists and.... writing [for industry]) that I would never.... have looked into without these sessions," and "Pulling guest speakers from a variety of backgrounds showed the diverse areas where writing well is essential." Others noted that this diversity sometimes meant that speakers weren't always relevant: "It was hard to be engaged in workshops/speakers that didn't necessarily apply to me (pop-sci writing, writing in industry), though at a later point in my life that info will be helpful." These comments highlighted the strength of the workshop's peer-review discussion for both reviewers and for students with their work being critiqued. Overall, these results are consistent with successfully employing peer review and feedback for biomedical trainees.

Delivering and Receiving Feedback

The effectiveness of each workshop component depended on a successful peer-feedback discussion. Overall, the small group peer-review process benefitted participants through "critiquing others' writing.... helps to see scientific styles outside of your own lab" and "pushing myself to offer constructive feedback for the writing samples." Participation balance amongst workshop subgroup participants (average five to eight per group) was perceived as critical, with participation imbalances being a notable weakness in some sessions: "[O]ccasional disproportional discussion [was] skewed towards one or two people"; "reviewer(s).... could be encouraged to get opinions from quieter members in the group"; and "there was a definite discrepancy in how much people contributed during discussion.... there were definitely people who did not contribute (perhaps due to shyness or not feeling like the ideas they had were worthwhile) which is a shame, as we probably missed out on some great insights." Participants found that having one student assigned as the lead reviewer, as well as the involvement of a professional scientific editor, enhanced group discussion: "[I]t is helpful to have both a lead reviewer and a.... staff member [i.e., professional editor] in each group to help guide conversation."

While there was near-universal appreciation for the peer-review process, perspectives from reviewers and reviewees noted that feedback was difficult to provide or that they would benefit from some additional instruction in preparing and delivering feedback, as noted above: "We need more structured/formal instruction on how to edit and review each other's writing. Not everyone has the same experience and skill when it comes to editing. I felt a little lost at times and was not always sure of what was appropriate, reasonable, or expected of me in terms of providing feedback on other people's work." And "I do wish we had more guidance regarding what we were supposed to be looking for (content, style, clarity, proofreading, etc.)." Also, "I am still trying to figure out what good feedback looks like and having some kind of workshop or feedback about my feedback would help me a lot—and make sure the feedback I'm delivering to others is better."

Feedback consistency was also an area of concern, with several participants noting that sessions "could benefit from consistency across all lead reviewers, with some sort of reviewer guide or a checklist of essential things to discuss" or "a general guide for things to additionally focus on for all samples." Finally, some logistical concerns were also reported: "I didn't have anything really important due at the time of my submission!" To help alleviate this concern, we allowed students to switch their writing sample submission times with peers if it was mutually agreed upon. These comments overall identified ways to improve the workshop component by encouraging all peer reviewers to provide their feedback and providing feedback to reviewers on the quality and comprehensiveness of their comments.

WIN During the COVID-19 Pandemic

During the 2020 and 2021 academic years, WIN was held via Zoom due to the COVID-19 pandemic. This posed significant challenges, given the highly interactive nature of the sessions. Several students disliked Zoom-based sessions: "The virtual format made discussions more difficult," and "greatest weakness: [Z]oom." In the 2020–2021 session, 3/9 students reported that their least favorite aspect of WIN was the virtual format. Others were more positive: "The transition to [Z]oom was flawless," and "Thank you for keeping this going through Covid, this was so valuable to me." Overall, the inevitable challenges of a virtual format were surmounted by the benefits of the workshop, as evidenced by our high program enrollment rate during the pandemic.

Discussion

The overall goal of WIN was to improve the writing repertoire and skills of biomedical students. The workshop was designed to accommodate a range of writing abilities, and, therefore, meet students at their level. The workshop thereby aimed to help students engage with audiences outside of their immediate area of

expertise and develop their skills in reviewing writing projects and providing feedback. Over 3 academic years of the workshop, participants expressed positive experiences with the workshop and self-reported an improved writing ability. Participants also expressed satisfaction with the structure and content of WIN, despite disruptions and a pivot to virtual programming during the COVID-19 pandemic. Overall, the WIN workshop described herein is a successful tool for improving scientific writing competency among science students, with positive long-term career implications.

A Workshop By the Student, For the Student

This workshop has the unique advantage that it was designed by students to meet the needs of their peers. While other writing interventions designed for students by mentors and instructors offer structured courses or informal resources (Gardner et al., 2018; Wortman-Wunder & Wefes, 2020), student organizers here designed WIN to focus on writing tasks encountered during scientific training at the tertiary level. Additionally, our workshop integrated inquiry-based learning and active learning goals to enhance student experience. Workshop attendees were charged with setting their own goals for progress and navigating learning topics at their own pace and according to their own interests and needs. This structure and design are translatable across different areas of study and could therefore be applicable to a wide range of scientific disciplines reliant on written communication of research findings. The iterative nature of this program and heavy student involvement also allowed for improvement across years of WIN programming. For example, course organizers noted only very modest increases in self-assessed "write concisely and effectively" scores over the 1st year of programming. Efforts were made in the 2nd year, therefore, to improve guidance on editing for clarity and conciseness and scores in this domain subsequently improved, such that participant ratings for this domain in the 2nd year of WIN showed a significant improvement.

Integration Into the Literature

Independently tackling a large dissertation project, including written comprehensive exams, prospectus plans, and thesis writing, is one of the greatest challenges to the successful pursuit of scientific training (D'Andrea, 2002). These nontrivial undertakings troublingly coincide with academic program attrition, as has been described previously (Belcher, 2009; Cassuto, 2015; Russell-Pinson & Harris, 2019). WIN participants benefited from learning how to plan large writing projects through organizational templates and suggestions on how to outline grant proposals and manuscripts that were provided by guest speakers (Carlson, 2007). Additionally, some speakers discussed concrete strategies for managing large writing projects (e.g., checklists, accountability partners, timeboxing).

Along with guiding students through large training milestones, workshops like WIN may improve the training experience and success of biomedical students due to a flexible and collegial design. The literature describes other types of writing interventions, including writing bootcamps (Fever, 2013), which are useful for academics preparing manuscripts on a deadline but have a narrower scope, stringent timelines, and more intense demands over a shorter period. Similarly, formal courses focused on writing intervention have been designed for graduate students (Glew, 2002). Such courses exist at our university, yet very few students in WIN's home program participate. This may be due to the larger time demands or lack of field-specific focus (highly cross-disciplinary), or simply because for-credit courses require mentor or programmatic funding. In contrast to many of the existing models, WIN had low time demands and was highly accessible and convenient. We removed attendance barriers by holding sessions immediately after mandatory seminars and provided catering with popular local food (for in-person sessions). WIN also differed by providing trainees with a wholistic view of school writing projects and allowing individual participants to receive feedback on materials they were actively preparing.

Given the recent COVID-19 pandemic, interactions between social settings and learning, particularly in the context of higher education or tertiary education, have received increased attention. Social isolation is a

significant barrier to student success (Ali & Kohun, 2006) and is particularly relevant given the COVID-19 pandemic. Thus, beyond gaining peer-review experience and writing expertise, the interactive workshop component of the WIN provided a casual social outlet for students. Our WIN enrollment numbers during the pandemic suggest that this workshop remained a safe place for students to come together and learn, even on a virtual platform. The literature supports pairing an accessible take on scientific writing with a social, peer-review element; this design may benefit student mental health and training success over alternative writing bootcamp models (Sowel et al., 2010).

Despite noted downsides of a pivot to virtual WIN programming, there may be some benefits of virtual or hybrid workshop models. As has been noted elsewhere, remote instruction, particularly at the higher education level, offers the benefit of accommodating student schedules and outside demands (Hartfield, 2013). In fact, a blended or hybrid model of education and learning delivery may be particularly effective in the context of biomedical science and education (Grob et al., 2007). Delivery of material via a flexible model allows for increased accessibility, particularly when technical materials, resources, or expertise are not widely available. Work in laboratory-based learning environments can be successfully leveraged via virtual formats, with students endorsing authentic and enriching learning (Hartfield, 2013). In fact, WIN hosted an extramural Manager of Scientific and Technical Communications at a large biotechnology company via Zoom during the COVID-19 pandemic. Use of a virtual platform increased expert speaker diversity since there was no longer a need to have speakers on campus. Additionally, virtual and hybrid learning frameworks often accommodate diverse learning styles and encourage student autonomy and self-paced learning (Herrington et al., 2014). This flexibility and emphasis on self-efficaciousness are attributes of a successful remote education program and might be highlighted in future virtual or hybrid iterations of the WIN program.

Success With Stylish Communication

Scientific training at all levels often lacks practical didactics in critical communication and writing skills. The disconnect between collecting evidence and communicating that evidence becomes problematic, as scientific writing success is often decided by those outside one's specific research niche, such as reviewers, funders, or even the public. Employing strategies to make results memorable, including stylish and creative writing, can make a lasting impact on the reader and be a deciding factor in acceptance or rejection (Heard, 2016). While many popular books have been written on effective writing communication (Strunk, 1918; Sword, 2012, 2016), creative and stylish writing is rarely discussed in biomedical training or courses.

One successful strategy to effectively communicate to a broad audience includes obtaining broad perspectives in interactive education (Hoffmann et al., 2021). Participants in the interdisciplinary WIN workshop reported an improved ability to write stylishly and creatively, which could be attributed to information relayed during didactic sessions and to the ideas generated from the workshop. Receiving feedback from peers who are outside of their immediate subject area encouraged participants to evaluate and adapt their writing to accommodate a broader audience. This peer feedback may be as simple as "what does this word mean?" to point out jargon, to "this has a different meaning in my field" to improve precision in the language. These reminders to write simply and clearly may reset automatic, niche-specific language and make students approach their writing in a more creative and thoughtful manner. Therefore, the WIN workshop provides evidence that engaging a diverse group of reviewers prior to submission may help them learn how to reach broader audiences using more relatable prose.

Limitations

Our workshop design and study have some limitations. This WIN workshop may have been successful due to the peer group studied. The positive impacts reported are based on findings from a small number of students from a single program and institution. The collegial nature of the WIN participants' home program may have made students more open to team-based learning, a predictor of learning outcomes in cooperative schooling

(Alvarez-Bell et al., 2017). Voluntary enrollment may have also been a self-selection feature for students who are most open to peer review and discussion.

The self-reported writing improvements may be influenced by higher participation of females in the workshop. Women reportedly have higher writing anxiety (Huerta et al., 2017), so it is possible that male participants with less writing anxiety would not report as much benefit. Further, participant personality profiles differ by student subject area and can also determine teaching and learning activity preferences (Fjelkner et al., 2019). Our group was too small to parse outcomes by gender or personality profile, but this would be an important future assessment to optimally address student needs across different demographic and academic settings. Finally, while limited by a small sample size and statistical power, we did find large effect sizes in change across several domains: document planning and writing stylishly and creatively. Other effect sizes were also appreciable despite a lack of statistical significance.

Implications for Research and Theory and/or Practice

As scholarship of teaching and learning efforts grow, institutional and program-level initiatives like WIN that offer an engaged learning experience will likely continue to gain traction (Hubball et al., 2013). However, our findings leave room for future inquiries into how these programs can be best structured and delivered. As perceived writing ability does not determine actual ability, it will be interesting to determine whether self-perceived writing competence in this cohort grows with time and experience. It is possible that a supportive and encouraging writing environment fostered early in academic training will technically and perceptually improve writing fitness. Future studies should objectively score participant writing proficiency changes and assess how participation influences stress encountered during writing projects and the number of submitted manuscripts and grants to address these limitations and improve future writing interventions. Nonetheless, the successes of our workshop can be leveraged by others. Future implementations of workshops like WIN should focus on our key identified strengths in peer-based feedback, interdisciplinary makeup, and student-tailored content.

One advantage of the WIN workshop over bootcamps or formal courses is that participants served as both reviewers and as authors. Thus, participants learned to identify useful and problematic writing habits, improve clarity to communicate with those outside their scientific niche, and deliver and receive constructive feedback. Learning to provide feedback is a critical component of peer review and is superior to receiving feedback from an individual peer or mentor (Cho & MacArthur, 2011; Nicol et al., 2014). This latter phenomenon is attributed to increased quantity, variety, and approachability of peer feedback (Cho & MacArthur, 2010; Cho et al., 2006). Participants here reported that the workshop and peer-review component was the most helpful aspect of WIN.

Another noted advantage of our WIN cohort comes from the highly interdisciplinary makeup of their home program, which spans cognitive, clinical, systems, molecular, and cellular neurosciences. Students found the most benefit from the workshop and peer-review component, making positive remarks on hearing about different perspectives of their peers. Thus, this WIN model might be most appropriate at the departmental level (for interdisciplinary departments) or for small groups of incoming students across related academic disciplines.

The qualitative feedback provided by participants was iteratively utilized to reform and improve WIN programming across years. For example, feedback that included requests for more structured peer-review parameters and expectations during the 2018–2019 academic year were integrated into subsequent years, with an initial session taught by professional scientific editors on how to receive and deliver feedback. The didactic component could be improved by encouraging speakers to discuss in more detail the outlines and templates that they use to plan and execute written documents. Feedback encouraging “more tangible” strategies, such as “stylized exercises” or “reading materials that can assist with writing,” instigated focused

session themes in 2019–2021 (e.g., the introduction, CVs, and biographical sketches). These discrete focuses are reflected in the session topics for subsequent years (Table 2). Although WIN enrollment was limited to post-comprehensive exam students, it could be extended to earlier-stage trainees, with an emphasis on planning techniques for large writing projects and the goal of increasing program retention.

Conclusions

Writing is essential to academic success across scientific disciplines. However, in the absence of adequate training, students can feel left alone to navigate this critical process, rendering them unprepared to communicate their findings and ideas. Gaining confidence in planning for writing projects and communicating findings through peer-led workshops lays a foundation for more pointed training, often from mentors, during later stages of training. The WIN peer-based writing workshop is a successful model that can be adopted broadly to help ensure that students across scientific disciplines are successful and confident in their academic writing skills.

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Appendix A

WIN Didactic Session Topics, Speaker Positions, and Affiliations

Session Topic	Speaker Position and Affiliation	Format
2018–2019 Academic Year		
Welcome, WIN structure	WIN organizers	In-person
Grant writing and review	Associate Professor, Neurology Department, College of Medicine and Professor, Neurology Department, College of Medicine	In-person
Writing for science engagement and advocacy	Clinical Associate Professor, Department of Internal Medicine, College of Medicine	In-person
Manuscript writing and editing	Professor, Department of Biochemistry, College of Medicine	In-person
Research communications	Associate Professor of Instruction, Department of Rhetoric, College of Liberal Arts and Sciences	In-person
Popular science writing	Chair and Professor of Psychological Brain Sciences, College of Liberal Arts and Sciences and book author	In-person
Writing for pedagogy	Associate Professor of Instruction, Rhetoric Department, College of Liberal Arts and Sciences	In-person
Practices to achieve clarity in writing (grants and manuscripts)	Scientific Editor and Writing Consultant, Scientific Editing and Research Communication Core, College of Medicine	In-person
2019–2020 Academic Year		
Welcome, WIN structure, and primer	WIN organizers; Scientific Editor and Writing Consultant, Scientific Editing and Research Communication Core, College of Medicine	In-person
Writing a CV and biosketch	Assistant Professor, Department of Psychiatry, College of Medicine	In-person
Writing for pedagogy	Associate Professor of Instruction, Rhetoric Department, College of Liberal Arts and Sciences	In-person
Popular science writing	Chair and Professor of Psychological Brain Sciences, College of Liberal Arts and Sciences and book author	In-person
Grant writing	Associate Professor, Psychological and Brain Sciences, College of Liberal Arts and Sciences	In-person

Journal article writing	Professor of Psychological Brain Sciences, College of Liberal Arts and Sciences	In-person
Practices to achieve clarity in writing (grants and manuscripts)	Scientific Editor and Writing Consultant, Scientific Editing and Research Communication Core, College of Medicine	In-person
Grant writing	Professor of Biology, College of Liberal Arts and Sciences	Virtual
Writing in industry	Manager of Scientific and Technical Communications, Large Biotechnology Company	Virtual
2020–2021 Academic Year		
Welcome, WIN structure, and primer	WIN organizers; Scientific Editor and Writing Consultant, Scientific Editing and Research Communication Core, College of Medicine	Virtual
Fundamentals: Sentence and paragraph structure	Scientific Editor and Writing Consultant, Scientific Editing and Research Communication Core, College of Medicine	Virtual
Fundamentals: How to write a good introduction section	Professor of Psychological Brain Sciences, College of Liberal Arts	Virtual
Journal article writing	Professor of Psychological Brain Sciences, College of Liberal Arts	Virtual
Grant writing	Assistant Professor, Department of Psychiatry, College of Medicine	Virtual
Creating figures and storyboarding	Chair and Professor of Psychological Brain Sciences, College of Liberal Arts and Sciences and book author	Virtual
NRSA: Grant writing and process	Professor of Biology, College of Liberal Arts and Sciences	Virtual
Writing a broader impacts statement for grants and applications	Assistant Professor, Department of Psychiatry, College of Medicine	Virtual
NIH review panels and how they deliberate	Assistant Professor, Pharmaceutical Sciences and Experimental Therapeutics, College of Pharmacy	Virtual

Appendix B

Guidelines for Writers and Reviewers in Workshop Component

Instructions for	Guidelines
Writers	Writing samples should be submitted with a cover message to readers in which you outline where you are with the project and where you need the most help in guiding your revision (this is not the same as a cover letter to an editor). Adjust the tone of the letter based on the level of feedback that is desired. In writing this, it may be useful to address some of the following: • The target audience/journal for your document • The preparation stage of your document (i.e., first draft, resubmission) • The main point of your document • The biggest problems you're having at this point in the writing process • Which idea or point do you feel you've made most successfully, and which you feel you've made least successfully • The main aspect of your document (i.e., thesis, structure, use of evidence, persuasiveness, etc.) that you'd specifically like comments on
Reviewers	Read the submitted project before the workshop and be prepared to provide feedback: • First state what you like about it. • Then, state what could/should be improved. • Be critical but friendly and constructive. Remember that constructive criticism is the only way to learn! • Feedback to the writer will be provided during the workshop. The writer will take these comments home and use as s/he sees fit.

Appendix C

Examples of Positive, Constructive Feedback for Peer Review

Topic	Example Feedback
Strengths	Example 1: • Sufficient background information • Logical progression from sentence to sentence • Pretty clear specific aims • Strong conclusion with a reinforcement of the importance of the research and its potential benefits Example 2: • This is a great draft of your SA page! You have included most of the main components that are needed. They are well written, just need some refining (as is always the case with SA pages). • The proposed studies address an important problem and would have broad implications for the trauma patient population. • I like that you include a rationale statement for your proposed studies in your second paragraph. It helps remind the reader of the importance of the study after having filtered through your preliminary data.
Areas for Improvement	Example 1: • Citations should be added. • Link sentence subjects more frequently to improve flow and clarity. • There are specific areas where concepts could be conveyed more concisely (annotated in document). • Introduction seems to be dominated by discussion of Aim 2, with far less attention paid to Aim 1. A more balanced approach might help the reader understand Aim 1 better. • Aim 2 results: Are these in mice or humans? Both? If you found promising results in mice, how would you examine their translation to humans? Example 2: • There was a lot of information in the first paragraph. I had trouble connecting the different pieces together. I made suggestions for re-ordering some of the information in the document. • Make sure to include an overall objective. What is the main goal that you are planning to achieve because of these studies? It is not sufficient to only have a hypothesis. This is because your hypothesis should be your best guess as to how

	you will achieve your objective. Having an objective leaves open the possibility that your hypothesis might be wrong but that doesn't mean you won't be able to achieve your objective (can come up with new hypotheses). • Your use of *underserved* in your central hypothesis is unclear to me. Is it necessary? • There were some vague statements that I don't totally understand their meaning. See the annotated text for details.
Other Comments	You don't need to indent paragraphs if you are including a space between them. It will save you a little space to not do this. In addition, I think it actually makes the page look a little busier when the paragraphs are indented.

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