New Idea

The benefits of workshopping graduate fellowships: a how-to guide for graduate students and early career scientists

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Abstract

Grant and fellowship proposal writing are key skills for professionals in scientific and research-driven fields, and early exposure and training in proposal writing substantially benefits early career scientists. Here, we present a framework for a student-led workshop for graduate fellowships that is built upon four years of implementation at the University of Washington's School of Aquatic and Fishery Sciences (Seattle, USA). This workshop was designed for applicants to the United States National Science Foundation Graduate Research Fellowship Program (NSF GRFP), but the format is flexible and easily tailored to other fellowships. We describe the primary components of the workshop, the implementation of the workshop, and the major benefits as reported by participants at the University of Washington. The core of the workshop framework is a small group structure that facilitates valuable in-depth interactions among student mentors and applicants. The primary outcomes of the workshop include improved writing and communication skills for graduate students and experience with peer review and critical feedback for both applicants and student mentors. These outcomes are achieved while maintaining a reasonable time commitment for student mentors. The workshop format is sustainable, promotes community-building within and

across departments, and facilitates equal access to mentorship and resources for all students.

Keywords: proposal writing; graduate research fellowship; workshop; student leadership; mentoring; peer review.

Introduction

Grant writing is crucial in academic careers in order to support research and provide opportunities for career advancement (Dumanis et al. 2013, Inouye and Fiellin 2005); as such, it is increasingly recognized as a critical component of professional development for early career scientists and individuals in research-driven fields (Leak, O'Donnell, and Surratt 2015, Wasby 2001, Weissmann et al. 1990). With grant and fellowship writing among the key skills required in both academic and non-academic career tracks (Blickley et al. 2012, Fleet et al. 2006), the training and experiential opportunities available to students are diverse and growing (e.g., Cole et al. 2013, Dumanis et al. 2013, Leak et al. 2015). Opportunities for structured interaction—including discussion of ideas as well as multiple iterations of feedback on writing—can lead to stronger research proposals (Dowse and van

Rensburg 2015), and increasing numbers of universities are implementing formal courses in grant writing (e.g., Delyser 2003, Leak et al. 2015). Additionally, training programs such as informal research proposal workshops (Dowse and van Rensburg 2015) and structured opportunities for students to pursue within-institution research funding earlier in their careers (Dumanis et al. 2013) are emerging. Workshops and short courses provide a promising framework for focusing on a specific grant or fellowship. For institutions, workshops provide flexibility and independence from the financial support, timeline, and teaching commitment required of a formal university course. For students, workshops provide a personal and effective framework for proposal writing skill development and peer review that is otherwise not available at many institutions.

Grant writing is only part of a broader suite of professional skills expected of early career scientists, including experimental design, expertise in a particular field, and giving and receiving critical feedback, including peer review (National Postdoctoral Association 2007–2009). One important skill is mentoring, which is often valued by prospective employers because good mentors are more likely to recruit and retain high-quality students and employees (Weigel 2015). Training opportunities that facilitate interactions and mentoring between and among graduate student cohorts and early career scientists also help build community and provide a critical support network for underrepresented groups in STEM fields (Kendricks, Nedunuri, and Arment 2013, Wilson et al. 2012).

We present the blueprint for a student-led, short-form workshop for graduate fellowship writing. The workshop design presented herein is based on four years of implementation at the University of Washington’s (UW) School of Aquatic and Fishery Sciences (Seattle, Washington, USA) for graduate and undergraduate students applying to the United States National Science Foundation Graduate Research Fellowship Program (NSF GRFP). The workshop design relies on student mentorship from senior graduate students and early career scientists (postdoctoral researchers, or “postdocs”) to provide general proposal writing training and fellowship-specific advice for current and prospective graduate students (e.g., undergraduates and post-baccalaureate researchers applying to graduate school). Unlike a formal course, this workshop design is flexible and requires no budget allocation for a formal instructor or teaching assistant. Thus, it can be implemented anywhere regardless of departmental budget constraints. This workshop also directly benefits academic advisors by providing additional guidance, structure, and support to their graduate students applying for fellowships.

We describe the key components of the workshop, including student mentors (senior graduate students and postdocs), applicants, and outside experts. We provide

two examples (Boxes 1 and 2) of fellowship-specific knowledge and highlight ways to provide unique insight and critical feedback for students applying for their first fellowship. We also outline the initial steps and investment required for implementation (Box 3). Finally, we present the results of a survey that evaluated the benefit of the workshop for both applicants and student mentors. The survey assessed: 1) the degree to which applicants felt the workshop improved their familiarity and comfort with proposal writing, and 2) whether participants felt the workshop provided additional benefits and professional skill development for both applicants and student mentors. The benefits, flexibility, and sustainability of the student-led workshop design presented here are applicable to many different fields, departments, and fellowship programs.

Components of the workshop

The workshop was designed by and for graduate students and is well-suited to fit within the constraints and demands of typical graduate departments. We designed the workshop for applicants to the United States National Science Foundation Graduate Research Fellowship Program (NSF GRFP). The NSF GRFP supports graduate students in science, technology, engineering, and mathematics disciplines at all accredited United States institutions, and the program received nearly 17,000 applications in 2016 with 2,000 fellowships awarded (National Science Foundation 2016). The workshop implemented at UW focuses on the NSF GRFP because it shares basic requirements (research proposal, personal statement) with several other graduate fellowships and later-career NSF grants, and because it is a fellowship open to diverse disciplines and student backgrounds.

The student-led workshop includes four key groups: workshop coordinators, student mentors, applicants, and guest experts (Figure 1). Workshop coordinators include one or two veteran student mentors who volunteer to coordinate the workshop logistics, including activities, guest experts, core group set-up, and deadlines. We encourage current workshop coordinator(s) to identify their successors one year in advance, to provide a useful opportunity for future coordinators to shadow current coordinators. Student mentors include senior graduate students and postdoctoral scholars with proposal writing and scientific writing experience; recruitment of current or former fellowship recipients can be very helpful but is not required. Applicants include eligible graduate students and in some cases senior undergraduates or other prospective graduate students (such as research technicians applying for graduate school). Workshop coordinators arrange applicants and student mentors into “core groups” of 2–3 mentors and 2–3 applicants (Figure 1). By facilitating personal interactions, community, and

Box 1. Collective knowledge and “Top Tips” from NSF Graduate Research Fellows

As an example of the collective knowledge compiled in a student-led workshop, we present some of the “Top Tips” from the NSF Graduate Research Fellows who served as mentors in our workshop. These tips are one example of the resources available via the workshop’s online platform.

- Use clear, concise language that indicates exactly how you have, are, and will achieve both Intellectual Merit and Broader Impacts criteria. Use direct statements such as, “The Intellectual Merit of my proposed research includes...”
- Show rather than tell. Be specific, and provide details regarding previous experience and proposed research, including collaborators, locations, and/or dates. For example, rather than simply stating that you are a strong leader, provide examples that illustrate this to the reviewer. These details help set you apart and will help the reviewer understand your story and your proposed research.
- Consider Broader Impacts as integral to the success of your proposal, and demonstrate that your proposed Broader Impacts are more than an afterthought. If you propose working with a group or organization, demonstrate that you have reached out to that group and highlight your common goals. Highlight how your proposed Broader Impacts connect with your previous efforts.
- If possible, relate your proposed research to your previous research experiences and/or first year in graduate school. Cite your own presentations, peer-reviewed publications, and/or technical reports wherever possible.
- If you do not have much previous research experience, highlight the transferability of skills and knowledge from other past experiences. Explain why these skills will help you succeed with your project and as a future leader of your field.
- Demonstrate your qualifications to carry out your proposed research, and make sure your advisor highlights your qualifications in her or his letter as well. If you need to learn new skills, briefly but clearly outline your plan to do so.
- Consider a conceptual figure to demonstrate your hypotheses and anticipated outcomes for your research proposal.
- Remember that this work is your own. Be true to your ideas and your voice, and do not feel obligated to address every comment made during the review process. Rather, try to parse comments into personal preferences and opinions versus true, fundamental issues. For example, if multiple reviewers flag the same problem, it is likely something that needs to be addressed or clarified.
- You have only a few pages to convince reviewers that you and your research are a good investment; thus, this is no time to be modest. Demonstrate your strengths with confidence, and show excitement for your planned contributions to your field.

mentorship, the core groups are the most important component of the workshop. Core groups meet during workshop sessions and exchange peer reviews and feedback. The small size of the core group is important as it allows for detailed feedback from student mentors and fellow applicants without creating a large workload or time commitment for any one individual. Finally, guest experts (faculty members with NSF funding and/or experience on an NSF review panel) are selected to provide advice on a range of topics, including scientific writing tips, obtaining high quality reference letters, and answering fellowship-specific questions.

Ensuring that applicants and student mentors have a common understanding of the specific fellowship requirements and, more broadly, an understanding of general scientific writing fundamentals is an important part of a successful workshop. We begin each workshop with general writing advice and fellowship-specific

advice. For example, faculty guest speakers provide their advice on best practices for clear scientific writing, avoiding common application pitfalls, and obtaining the best letters of recommendation possible. A guest visit from staff members of the university or college fellowship and awards office familiar with the specific fellowship program can be a very valuable experience for first-time applicants. We have also found that dedicating part of one workshop session to a panel of current or recently funded fellows for an open question-and-answer session has been useful for many applicants (see Box 1 for “top tips” collected from these panels). In short, providing a range of advice from seasoned proposal writers at all career stages—from faculty to graduate students—demystifies the application process and builds confidence for proposal writing generally (for a list of workshop materials, see Supplementary Materials, Box S1).

Box 2. Developing the Narrative: Using a CV to Guide the Personal Statement

The personal statement is an essential component of the NSF GRFP application. As part of our workshop series we focus on the personal statement early, using applicants' CVs to help them realize their strengths and selling points. NSF GRFP reviewers are looking for students who stand out on multiple fronts, and the personal statement is an opportunity for the reviewer to get to know the applicant. It is a chance to demonstrate how the applicant has engaged with their community and field of study – and how they are, or plan to be, an active participant and leader in the scientific community and society. It is also a chance to demonstrate that the applicant can achieve the Broader Impacts discussed in the research proposal. The personal statement should be used to demonstrate experience, abilities and commitment.

During the first workshop meeting, we ask all participants to bring copies of their CV for discussion within their core group. The CV should be a standard format, including at minimum: education, research experience, work experience, and community service. We prompt groups to use the CVs to brainstorm and identify application themes by asking the applicants and mentors to contemplate the following questions, as suggested by GRFP:

- Why are you fascinated by your research area?
- What examples of leadership skills and unique characteristics do you bring to your chosen field?
- What personal and individual strengths do you have that make you a qualified applicant?
- How will receiving the fellowship contribute to your career goals?
- What are all of your applicable experiences?
- For each research experience, what were the key questions, methodology, findings, and conclusions?
- Did you work in a team and/or independently?
- How did you assist in the analysis of results?
- How did your activities address the Intellectual Merit and Broader Impacts criteria?

The mentors and peers gain a unique “big picture” view of the applicant, and core group members can help applicants distill their experiences into a few fundamental themes. We find that it helps group members to consider the following questions:

- Which of this applicant's experiences are strong selling points?
- What parts of their history should they highlight, and what could be skipped?
- How can they use their experience to show their ability to accomplish the proposed Broader Impacts?

The NSF GRFP requires a statement of the applicant's personal background and future goals, and a strong personal narrative provides and communicates a well-developed foundation for an applicant's research proposal. Many graduate and early career fellowships require personal statements, but we have found that some applicants struggle to link past experiences, particularly non-academic experiences, with proposed research and future directions. To address this, we focus on the development of the personal narrative and the research ideas inspiring the proposal. We incorporate discussion of applicants' CVs or resumes into the initial introductions of the small groups (Box 2), allowing group members to become familiar with the experiences, strengths, and interests of applicants. This exercise can be particularly helpful in identifying the one to three themes that structure the personal narrative and tie into the proposed research (Box 2).

Next, applicants write a short summary of their proposed research essay (Research Proposal) in their preferred format (e.g., brief summary, outline, or bulleted

list), which is then reviewed within core groups. Additionally, voluntary external reviews on these summaries from faculty, research scientists and postdocs are helpful to applicants in the early stages of proposal development. Although the ultimate direction of the research proposal should be determined by the applicant and her or his academic advisor(s), the review of the research summary at an early stage by core group members can provide feedback on the clarity of the ideas and highlights areas that need further development.

Writing begins following the development of themes and ideas for the Personal Statement and Research Proposal. Applicants circulate drafts of their essays among their peers and student mentors, written feedback is provided, and core groups discuss applicants' essays during workshop meetings. We aim for at least two rounds of reviews during the course of a workshop. A third round of reviews during the final workshop meeting involves shuffling core groups so that drafts are critiqued by new peer-reviewers. This final review is done rapidly (25 minutes per application package) to simulate the

Box 3. Initiating the Workshop

Implementing a student-led workshop for the first time requires one or two students willing to lay the groundwork and initiate the workshop. Students who have applied to the target fellowship are the ideal workshop coordinator(s), as they have first-hand experience with the parts of the application, the nuances of the fellowship, and the timeline and effort required.

Step 1: Discuss workshop with department head(s) to obtain support. The first step is to present the workshop plan to department administrators and request basic resources (i.e., a classroom in which to meet). Because the workshop is built upon volunteer efforts and does not require specialized resources or support, gaining approval to initiate the workshop can be relatively straightforward. However, we recommend consulting with members of the curriculum committee as well as the department head(s) to address any concerns and identify synergies between the department curriculum and the workshop.

Step 2: Identify and request the participation of 1-2 faculty advocates who support the concept and potential benefits of the workshop. At a minimum, faculty advocates should agree to discuss and promote the workshop among their co-faculty. Additionally, faculty advocates may serve as workshop guests addressing specific topics of interest to applicants. For example, faculty advocates for our workshops have addressed topics such as the basics of proposal writing, “behind the scenes” grant reviewer perspectives, and advice on how to obtain strong letters of reference.

Step 3: Compile workshop materials, recruit, and organize logistics. The primary job of and time commitment for initial workshop coordinator(s) is logistical and focuses on collecting materials (see Box S1), recruiting student mentors, and advertising the workshop to students. Depending upon the availability of student mentors, workshops can be designed to operate within a department or across departments. For example, our workshop at the University of Washington was open to only graduate students in the School of Aquatic and Fishery Sciences during its first year. However, in every year since it has been open to all students in the multi-departmental College of the Environment. We prioritize access for graduate students within our department, and give remaining spots to all others on a first-come, first-enrolled basis (our fall 2016 workshop was the first time we had to turn away interested applicants, indicating growing success and interest within the College). In our workshop, approximately three-quarters of applicants are graduate students, and the remaining are graduating undergraduate seniors or post-baccalaureate students intending to return to graduate school. The workshop is advertised at graduate student orientations and in e-mails to new graduate students prior to the start of the fall quarter (or semester). As more faculty, graduate advisors, and students become familiar with the workshop over time, word-of-mouth has become another important means to encourage potential student applicants to take part.

evaluation an applicant may receive from fellowship reviewers who are reviewing several applications in a short timeframe. Applicants are expected to also work closely with their academic advisor(s) throughout this process, and we encourage applicants to develop a timeline for exchanging drafts with their advisors.

Throughout the workshop an applicant may receive feedback from as many as 4-8 different reviewers (including peer applicants, student mentors, experts, and their own advisors). Reviewers typically span a range of expertise and backgrounds, ensuring that an applicant’s ideas are clear to a diverse audience. However, it is important to remind applicants that not all suggestions need to be incorporated. Reviews offer an important opportunity to sharpen one’s ideas, but a writer’s voice should remain intact. Throughout this process, the workshop teaches applicants to compile and filter feedback from a diverse group of peers to achieve their best writing possible.

A major strength of the workshop format is its flexibility; components or activities listed here are to some extent modular, and not all parts require inclusion. Workshop coordinators and participants can tailor the workshop schedule to fit the needs and interests of the group, and written advice from experts and online resources may suffice where time or scheduling constraints prohibit in-person expert visits. We have found that using an online collaboration and document sharing tool to supplement workshop interactions, including allowing and encouraging student mentors and applicants to share resources, useful links, and feedback, is a helpful attribute of the workshop. For example, we utilize Google Drive and its associated applications (e.g., Google Documents, Google Sheets) for exchanging information. Regardless of how students implement the workshop at their college or university, we recommend prioritizing the core group interactions as they represent the primary strength of this workshop design. Figure 2

provides one example of a workshop timeline with the major workshop components outlined.

Workshop Implementation

The effort and investment required by workshop organizers, student mentors, and faculty advisors is moderate to small and is designed to fit within the time constraints of research and teaching commitments. However, there are some important considerations regarding time investment when initiating the workshop. First, the workshop requires 1–2 graduate students who are willing to act as coordinators. Coordinators ensure that the workshop runs on schedule, facilitate teaching and peer-review sessions, compile resources (e.g., links to online guides, example proposals from previous years), and coordinate guest experts (e.g., student panelists and faculty or senior scientists to advise on scientific writing and reference letters). Coordinating the workshop is a unique leadership opportunity that provides the chance to gain experience organizing and teaching in an informal educational setting with tangible outcomes. In our experience, having two workshop coordinators to share responsibilities is optimal and can facilitate “passing the baton” of leadership between academic years.

The largest time investment for workshop coordinators is the initial workshop creation; the time commitment for coordinators is moderate to light in subsequent years. For example, creating and establishing the workshop at the University of Washington required approximately 30 hours each by two graduate organizers prior to the start of the workshop. This initial set-up included: communicating with the department’s leadership and building support for the workshop among faculty and the broader community, assembling the workshop materials and resources, developing the workshop design and timeline, recruiting student mentors and applicants, and arranging and scheduling guest speakers and expert reviewers (see Box 3 for details). Once the workshop is operational, a moderate time commitment is required by graduate student coordinators (approximately 20–25 hours over the duration of the workshop) and by peer mentors (approximately 10–20 hours for workshop meetings and peer-review, over the duration of the workshop). We found that recruiting takes less time each year as the workshop becomes more established. Former applicants who received the NSF GRFP often returned as student mentors in following years, contributing to the sustainability of the workshop.

Recruiting and involving 1–2 faculty members as workshop advocates, advisors, and liaisons can help ensure the success and sustainability of the workshop. Not all advisors are equally aware of graduate fellowship criteria and timelines; having a few faculty members directly involved can help communicate the goals,

Figure 1. Components of the workshop, with a suggested core group structure to diversify expertise and balance peer-review effort. Arrows indicate the direction of information exchange, peer review, and mentoring; double-headed arrows indicate interactions in which workshop participants can learn from one another. Dotted arrows are optional or “as-needed” opportunities for workshop components. Balancing expertise in this small group setup can diversify strengths and feedback between applicants and student mentors.

timelines, and opportunity of the workshop to other faculty. To engage these supporting faculty members, we met with them one-on-one to discuss the aims of the workshop and to invite feedback on workshop components. To engage with the faculty more broadly, we contacted other faculty directly to encourage them to share the workshop with their graduate students. We have found that time (e.g., several years) and some amount of proof of concept have further demonstrated the need for and opportunities from a student-led workshop; recruiting faculty advocates can provide critical support, advocacy, and continuity during those early years. However, we have found that faculty are generally very supportive of the workshop, and this is likely because faculty benefit professionally when their graduate students’ proposal writing skills improve and particularly when their students obtain fellowships.

It is important to allow the workshop format to evolve between years as there may be changes to fellowship timelines, criteria or structure. For example, over the four years we organized this workshop at the University of Washington, the structure of the application essays and the eligibility for the NSF GRFP both underwent major changes. Additionally, the deadlines differ between scientific disciplines by up to 6 days in a given year, and

<p style="text-align: center;">Advise</p> <ul style="list-style-type: none"> • Introduction to the NSF GRFP from workshop coordinators. • Scientific writing tips from faculty guest. • Guide to obtaining supportive reference letters. • “Expert Panel” with current and former NSF GRFP fellows. 	<p style="text-align: center;">Develop</p> <ul style="list-style-type: none"> • Identify strengths and construct narrative from CV or resume. • Research Proposal abstract, with feedback from guest reviewers. 	<p style="text-align: center;">Write, Review, Revise</p> <ul style="list-style-type: none"> • First drafts and review of both essays. • Second drafts and review of both essays. • Final drafts and timed, mock-NSF GRFP review with new peer reviewers.
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	Session 1	Session 2	Session 3	Session 4	Session 5
Advise	<ul style="list-style-type: none"> • Introduction to NSF GRFP • Reference letters 	<ul style="list-style-type: none"> • Scientific writing tips 	<ul style="list-style-type: none"> • Advice from NSF GRFP fellows 		
Develop	<ul style="list-style-type: none"> • Build narrative from CV 	<ul style="list-style-type: none"> • Proposal abstract 			
Write, Review, Revise			<ul style="list-style-type: none"> • First drafts 	<ul style="list-style-type: none"> • Second drafts 	<ul style="list-style-type: none"> • Final drafts, review panel

Figure 2. Components and an example timeline of the student-led graduate fellowship workshop, designed around the National Science Foundation’s Graduate Research Fellowship Program (NSF GRFP). Activities include (upper panels): 1) advising and mentoring from senior students, GRFP recipients, postdoctoral mentors, and faculty guests (top left); 2) developing the applicant’s narrative for the personal statement (Box 2) and the communication of the research proposal (top center); and 3) writing activities, peer reviews, and revisions within and between core groups (Figure 1). The timing and order of these activities should be determined by university or department logistics (e.g., the academic calendar) and the NSF GRFP deadlines. We provide an example timeline for five workshop sessions taking place over 5-6 weeks (lower panel).

the first deadline has shifted earlier in the year from November 14 (in 2011) to October 26 (in 2015). Maintaining a workshop format that is external to the academic calendar allows the workshop timeline to adapt annually, and workshop coordinators will need to account for these changes when scheduling the workshop each year.

A student-led fellowship workshop benefits applicants and student mentors

To assess the benefits of this workshop to fellowship participants, we surveyed all applicants and student mentors who participated over the four-year period the workshop was held at the UW’s School of Aquatic and Fishery Sciences (71% or 47 participants completed the questionnaire). The survey assessed the extent to which applicants and student mentors felt the workshop contributed to general skills expected of early career

scientists. These general skills were structured following the “Core Competencies” expected of postdoctoral researchers (National Postdoctoral Association, 2007–2009) and reflect skills identified as important in many scientific careers (Blickley et al. 2012, Fleet et al. 2006). Graduate student learning goals do vary across institutions, but they generally align with the same themes of the Core Competencies. Therefore, many of these same general skills overlap substantially with graduate learning goals. Additionally, some questions were designed to gauge the utility of specific workshop components.

When asked how the workshop contributed to general scientific skills, applicants reported improvement across several competencies. Applicants consistently reported gaining familiarity with fellowship applications (85% said “a great deal” or “a lot”), and the workshop also contributed to applicants’ ability to provide critical feedback (65%), define scientific questions (47%), design studies

Figure 3. Results of the survey assessing the extent to which applicants and student mentors felt the workshop contributed to general skills expected of early career scientists. These general skills were structured after the “Core Competencies” expected of postdoctoral researchers (National Postdoctoral Association, 2007-2009). Skills are ranked in order from the highest (top) to lowest (bottom) mean ranking for workshop contribution, and responses are scaled proportionally by size and color (darker = greater proportion of responses).

to test specific hypotheses (44%), and plan projects (44%; Figure 3). Applicants also reported improved time management skills and ability to establish priorities (41%), and they reported improvement in their ability to request supportive letters of recommendation (32%). A large majority said the workshop specifically helped them learn to write research statements (82%) and personal statements (85%) (Figure S1). Applicants also reported “a great deal” or “a lot” of improvement in more general skills, including writing resumes (45%), communicating with lay audiences (45%), and scientific publishing (21%) (Figure S1).

Student mentors also consistently reported benefits from their participation across a range of skills (Figure 3), although gains were more moderate than those of applicants. Specifically, student (or peer) mentors benefitted from the opportunity to practice skills relevant to teaching and communication, including providing critical feedback in a supportive way (42% said the workshop improved their ability to provide constructive, critical review by “a great deal” or “a lot”), motivating and inspiring others (23%), and working with individuals of diverse backgrounds (23%) (Figure 3). Student mentors also reported improvement in their

understanding and familiarity with fellowship applications (23%).

When asked about the specific components of the workshop, applicants overwhelmingly viewed the peer-teaching activities of the workshop as the most valuable components. Applicants considered all workshop components helpful to some extent, but they consistently ranked student mentors as the most highly valued workshop component (97% said student mentors improved their application “a great deal” or “a lot”) (Figure S2). The next most valued component was the structure and timeline for writing and review (85%), followed by fellowship-specific guidance (79%). In contrast, general writing tips were considered less valuable to applicants (35%), indicating that applicants gained more from fellowship- and mentor-specific advice (Figure S2). Applicants ranked the support of peers as highly as expert panels (both 64%), underscoring the value of a social support system and peer-mentorship in learning to write proposals. All survey results are reported in Table S1.

Conclusions

After four years of workshop implementation and participation from more than 65 students and early career scientists, we have observed numerous and substantial advantages for both graduate student mentors and applicants that extend beyond proposal writing skills. Although many factors affect the success of any given application, overall award rates were higher for workshop participants than the national average (awarded a fellowship: 22% of workshop participants, 13% national average; Honorable Mention: 22% of workshop participants, 14% national average). More broadly, the workshop provides an opportunity for applicants to receive guidance in the proposal writing process and feedback on their work. Senior graduate students and early career scientists (e.g., postdocs) are able to gain experience with mentoring, peer review, and constructive criticism. The structure of this student-led workshop—which effectively pools the knowledge available in a department—ensures that students have equal access to expert advice and mentoring from senior graduate students, postdocs, and faculty. This community of student mentors generates a wealth of collective knowledge and advice (Box 1). The workshop format provides an organized and sustainable framework for iterative peer-review, which has been found to enhance students’ proposal writing and critical thinking skills (Dowse and Rensburg 2015). In addition to the primary benefits of improved proposal writing skills, mentoring, and providing feedback, all participants reported gaining experience in balancing technical writing (e.g., communicating methods and anticipated results) with communicating the broader messages about their work (e.g., the role of their work in advancing the field).

Learning to strike that balance is key to a strong foundation in science communication and all its benefits (Kuehne et al. 2014).

A student-led workshop provides an opportunity for graduate students to gain experience with proposal and fellowship writing, complementing traditional or more formal proposal or scientific writing courses. In cases where formal proposal writing instruction is absent, a student-led workshop presents a significant opportunity for graduate students otherwise left to lab-based activities or their own pursuit of resources. The workshop may also help students begin the development of their thesis or dissertation. Indeed, the benefits of the workshop for applicants’ project planning and study design skills were clear in their survey responses.

In the future, this workshop framework could be expanded and can continue to evolve in a few key ways. First, our post-hoc evaluation of applicant and mentor perspectives on skill improvements and knowledge gains can be improved with more rigorous assessments of skills before and after workshop participation. This could be guided by a formal suite of learning goals for the workshop, determined by departmental graduate curriculum and learning goals. Second, with support from departments and/or institutions, the effect of the workshop on funding rates could be compared in a more statistically rigorous way to determine whether and how the workshop is affecting the success of student applicants. Third, providing formal training in mentoring for student and postdoc mentors may help benefit student (or peer) mentors in their professional skill development. Finally, the scope and scale of the workshop could be increased to involve more cross-disciplinary interactions and to assess directly the degree to which the workshop promotes network building and interactions between individuals from diverse backgrounds.

In conclusion, the workshop framework presented here provides a sustainable, flexible strategy to address the long-recognized need for early training and experience in proposal writing for early career scientists (Wasby 2001, Weissmann et al. 1990). It provides the tangible benefits of improved fellowship applications among applicants while providing mentoring and peer-review experience for graduate students and postdocs. Finally, by facilitating interactions between applicants and student mentors across graduate cohorts or even departments, the workshop can strengthen networks between and among graduate students, postdocs, and faculty within and across departments and allow equal access to the benefits of mentorship and feedback to all students.

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Supplemental Materials

Figure S1. General skills that the applicants reported improving as a result of the workshop. Skills are ranked in order from the highest (top) to lowest (bottom) mean ranking for workshop contribution, and responses are scaled proportionally by size and color (darker = greater proportion of responses).

Figure S2. Workshop components that applicants found the most helpful in the development of their fellowship applications. Components are ranked in order from the highest (top) to lowest (bottom) mean ranking for workshop contribution, and responses are scaled proportionally by size and color (darker = greater proportion of responses).

Table S1. Complete survey results from workshop mentors and applicants.

QUESTIONS FOR MENTORS AND APPLICANTS

MA-1. Over the four years the workshop has been conducted, did you participate as (select one):

Role:	Count:
Mentee only (GRFP applicant)	26
Mentor only	14
Mentee and mentor (different years)	7

MENTOR QUESTIONS

M-1. Overall, how much did you advance your own research and mentoring skills? (Select one)

Answer:	Count:	%:
Not at all	0	0
A little	6	29
A moderate amount	12	57
A lot	3	14
A great deal	0	0
Total	21	100

M-2. Which of these motivated serving as a mentor for the workshop? (Select all that apply)

Answer:	Count:	%*:
Personal fulfillment	13	62
Helping friends and lab mates	14	67
Getting to know new students and other mentors	9	43
Practicing and developing mentoring skills	18	86
CV- or resume-building activity	5	24
Other	2	10
Write-in responses:		
<i>"Want to help other students win a fellowship and pay it forward from when I was a mentee"</i>		
<i>"Giving back the great help I received"</i>		

*Percent of mentor respondents (21 total).

M-3. Specifically, how much did the workshop advance your skills and/or understanding of the following? (Select one in each category)

Category:	Not at all	A little	A moderate amount	A lot	A great deal	Count
Respecting, evaluating, enhancing, etc.	0	3	9	6	3	21
Grant and fellowship applications	0	6	10	4	1	21
Teaching and mentoring	0	7	11	3	0	21
Motivating and inspiring others	2	6	8	5	0	21
Working with individuals of diverse backgrounds	3	7	5	5	1	21
Serving as a role model	1	9	9	2	0	21
Scientific writing	2	10	6	3	0	21

Table S1, continued.

APPLICANT QUESTIONS

A-1. How much do you think this workshop improved your GRFP application?

(Select one)

Answer:	Count:	%:
A great deal	26	79
A lot	6	18
A moderate amount	1	3
A little	0	0
Not at all	0	0

A-2. How helpful were specific workshop components in preparing your GRFP application?

(Select all that apply)

Category:	Not at all	A little	A moderate amount	A lot	A great deal	Count
Mentors	0	1	0	9	24	34
Fellowship-specific information and guidance	0	2	5	10	17	34
Structure and timeline for writing	2	0	3	12	17	34
Writing tips	0	2	10	11	1	34
Expert and student panels	0	5	7	14	8	34
Support of my peers	0	6	6	15	7	34
Other	1	0	1	0	3	5
Write-in responses:						
<i>"Feedback at different stages of the writing process"</i>						
<i>"The example essays of the mentors were incredibly helpful templates for style and content"</i>						

A-3. To what extent did the workshop help with the following general skills? (Select all that apply)

Category:	Not at all	A little	A moderate amount	A lot	A great deal	Count
Defining scientific questions	3	6	9	8	8	34
Designing a study to test specific hypotheses	4	6	9	7	8	34
Gaining familiarity with grant applications	0	1	4	12	17	34
Providing critical feedback	0	2	10	13	9	34
Working with individuals from diverse backgrounds	5	10	12	5	2	34
Time management and establishing priorities	1	6	13	7	7	34
Short- and long-term project planning	3	7	8	10	5	33
Requesting letters of recommendation	4	7	2	4	7	34
Write-in responses:						
<i>"Writing skills"</i>						
<i>"Time management with writing deadlines"</i>						

Table S1, continued.

APPLICANT QUESTIONS, CONTINUED

A-4. To what extent did the workshop help with general skills in preparing the following?

(Select all that apply)

Category:	Not at all	A little	A moderate amount	A lot	A great deal	Count
Scientific publications	5	10	11	5	2	33
Career documents, such as a CV, resume, or cover letters	0	3	15	9	6	33
Research statements	0	1	5	10	17	33
Personal statements	0	1	4	11	17	33
Research communication to scientific and lay audiences	2	4	12	9	6	33

A-5. What was the outcome of your NSF GRFP application? (Select all that apply)

Note: These numbers represent survey respondents only. Comprehensive outcomes are reported in the manuscript text.

Category:	Count:	%:
Awarded a Graduate Research Fellowship	9	25
Awarded Honorable Mention	10	28
Not awarded a Graduate Research Fellowship or Honorable Mention	17	47

A-6. Is there anything else we should know? (Write-in responses)

"Timing of the workshop is pretty important, last year the timeline was cut short since the due date for the Ecology GRFP was pushed up and so mentees only had a month to prepare. Might have to revise the workshop as well given that the eligibility requirements for graduate students have changed."

"I am very certain I would not have submitted a strong application without this workshop. The feedback and support from the mentors was critical to improving my application, as were the examples of previous successful applications. I have had the opportunity to pass on what I learned to others applying for the GRFP."

"The only drawback from my perspective was the short timeline for a brand new student with still-unformed study questions. This is, of course, outside the control of the GRFP organizers and mentors, who supported my process TREMENDOUSLY. In future years, though, especially if there will only be one application accepted per individual, it might be wise to counsel new students to wait until they have hypotheses slightly more formulated. Regardless, my writing and idea synthesis certainly benefitted from the workshop."

"I think there is a lot of specific knowledge that I gained from my mentors that you can't really capture with these questions. Kind of like the ins and outs for NSF - what we know the judges want to see, such as how intensive your "broader impacts" should be."

"This workshop was invaluable in so many ways (also the year it was offered as a course was great!). I hope it continues far into the future!"

"Since some mentees are not from SAFS, it would be excellent if you could recruit more mentors from sciences other than SAFS. This will help match mentor expertise with mentee field a little better. But otherwise thank you so much for all your work and help. The Google Docs you shared were immensely helpful. Please don't unshare them! I'll use them in my next attempt."

"The workshop was very helpful, especially the mentors that I worked with. The workshop would have been more beneficial if I could have established communication with mentors before the first meeting to get a question worked out."

Box S1. Workshop materials

As workshop coordinators, we provide the following materials to applicants and student mentors and use these materials to help guide the workshop sessions. Note that because details regarding the NSF GRFP change on an annual or near-annual basis, these materials often require minor to moderate updates between years. For that reason, we provide a guiding list here (rather than the materials themselves) as these items will change interannually and between institutions. If you would like to see some examples with more detail, please contact M. Mims.

1. Introductory presentation: We provide a PowerPoint introduction to our workshop and the NSF GRFP application. In this presentation, we introduce the core elements of the application, the deadlines and workshop timelines, and review criteria (for example, NSF's Intellectual Merit and Broader Impacts criteria). The introductory presentation is structured around the specific program solicitation for a given year. Most students are not yet familiar with the language of fellowship applications, and discussing it in detail has helped student applicants and mentors who may be new to a specific fellowship and its requirements. We also include the broader learning goals of the workshop.

2. Example applications: Each year we ask previous applicants who have been awarded a fellowship or received an Honorable Mention to provide their application materials to serve as examples for workshop participants. These have been very useful resources to participants. Note that if your department does not currently host fellows or honorable mention recipients, the names, contact information, institutions, and fields of study of previous fellows and honorable mention recipients are published online for the NSF GRFP. The GRFP awardee database is a good resource for identifying awardees within your institution. Alternatively, a university's office of sponsored programs may be able to provide contact information for past awardees as well.

3. Handouts: We provide a number of handouts during the first two workshop sessions, including:

- a) Advice for obtaining strong letters of reference: We have a document drafted by one of our faculty members on how to get strong letters of reference. This touches on key points such as how far ahead to request a letter and how to provide a letter writer with key information that will contribute to a strong letter and one that is relevant to a particular fellowship application.
- b) Writing tips: We provide a handout listing a number of tips to promote clarity in writing. The tips sheet was written by one of our previous faculty mentors who served on numerous grant review panels and who often agrees to present and discuss these tips in one of our workshop sessions.
- c) "Number One Tips": The tips we provided in Box 2 came directly from one of our handouts and are a written record of the favorite pieces of advice from previous mentors, applicants, and fellowship awardees.

4. Outreach and Broader Impact opportunities: We have an online (i.e., living) document of ways previous students have been involved in the academic, local, and regional communities. This helps new students jump-start their Broader Impacts contributions and activities.