

Reimagining the Astronomy PhD for the 21st Century

**A white paper from
The Fellows of the National Osterbrock Leadership Program (NOLP)**

Executive Summary

As the needs and wants of the modern world have changed, the technical skills of astronomy PhD holders have become more broadly valuable. The astronomy PhD experience, however, has not evolved to foster the newly enlarged potential of graduate students. Historically, astronomy PhD earners have been trained, nearly exclusively, to be researchers. Through this training, graduate students obtain a wide variety of technical skills, such as large-scale data analysis and visualization, instrumentation, and software engineering. These skills position them to hold high-impact roles in a wide range of public and private sector organizations, as well as enable them to develop and execute policies that shape science/education. While these technical skills afford many career opportunities, equally important are leadership and interpersonal skills, which are not part of standard astronomy graduate student curricula. This broader set of skills includes, but is not limited to: coordinating large and small team efforts towards a common goal and in light of a deadline, facilitating open and inclusive communication across various career stages, maintaining resilience in the face of unforeseen events/mishaps, conflict resolution, budgeting, and public-speaking. It is often assumed that students will learn these leadership and interpersonal skills along the way in grad school, which students do with varied success. This can leave students underprepared for challenging careers after grad school in both academic and non-academic settings.

As a potential solution, the NOLP Fellows recommend that the community reimagine the astronomy PhD more equivalently to a professional degree; one that, in addition to technical skills, places emphasis on learning leadership and interpersonal skills. Through this human investment, astronomy students will become better prepared to play leadership roles both in and beyond academia. To accomplish this, the NOLP Fellows recommend that departments include grad students in departmental leadership and decision-making, develop peer-mentoring and mini-grant programs, and promote non-academic career paths alongside traditional academic ones. Specific recommendations are detailed in the *Action Items* section of this white paper on page 6. Through these experiences, graduate students will acquire leadership and interpersonal skills of significant value which will propel them to be leaders in any one of a wide range of fields. The modern world has a strong need for people trained as both scientists and leaders; the field of astronomy can play a large role in meeting this need.

Background

The National Osterbrock Leadership Program (NOLP) is an outgrowth of an innovative leadership program initiated in 2016 at the UC-Santa Cruz Department of Astronomy. It has grown recently to comprise three university astronomy departments (UC Santa Cruz, UC Irvine, and Columbia U.), where it trains graduate students in both science and general leadership. Operating under the umbrella of the AAS and managed by senior professors, the NOLP challenges and supports its Fellows through a variety of activities that build skills in decision-making, team building, communication, conflict

resolution, and budget management. More specific information on the NOLP and its Fellows is given on our website: <https://aas.org/nolp>.

Motivation

The astronomy PhD has traditionally been considered a pathway towards training new astronomers to conduct research and to teach. Today, astronomy and its associated sub-fields are saturated with researchers; it is well understood that the number of new graduates each year exceeds the number of available postdoc positions and far exceeds the number of tenure-track faculty jobs. In its January 2023 report¹ on career outcomes, the American Institute of Physics (AIP) finds that 67% of new astronomy PhD holders accept postdoc positions. They find that this number has stayed nearly constant over the last ~40 years. While there are more postdoc positions and prize fellowships than ever, there are still more students wanting these positions than can hold them; for example the 2023 NASA Hubble Fellowship had an oversubscription rate of 19 to 1. **The reality is that many people who hold a PhD in astronomy will not continue to practice astronomy in a strictly academic/university setting beyond their graduate school education.**

The over-emphasis on research productivity in astronomy graduate training has engendered a competitive atmosphere that brings about a highly unfortunate stigma: “academia or bust”. The notion that an R1 academic faculty position is the prime mark of a successful scientist is widely held. It is born out of a strong survivor bias: those who achieve faculty positions often do not fully acknowledge the environment from which they started, the internal/external help they received along the way, and/or just plain luck. This stigma further does not acknowledge the reality of academia being an environment that systematically rewards privilege, where time and effort go largely uncompensated as the price for the opportunity to “do what you love”. In light of real world circumstances, job availability, and the workplace of the future, this ever-perpetuating “academia or bust” mindset needs to be rethought.

Concurrently, the very same stigma ignores the quickly evolving view of astronomy PhD holders that is held by industry and other non-academic circles. Within the last ~20 years, the technical skills that are required to succeed in astronomy are now the very same technical skills that the modern economy demands and the labor market values highly. **Astronomy skills are economically valuable.** The modern world still has a strong need for astronomy as a science, and this white paper is by no means discounting or arguing against the academic pursuit of discovery for its own sake. But the world at large also needs people who are trained broadly as scientific leaders. An astronomy PhD should no longer solely equip individuals with skills to do astronomical research. It should also train students in leadership and interpersonal skills, so that students can be best prepared for their next career step, wherever it may be.

While students learn leadership and interpersonal skills to some extent during their time in graduate school, these skills are almost never formally taught or emphasized by PhD programs. Most students learn these on their own, in a sink-or-swim environment. These are skills that are vital to the professor leading a group as large as a multi-university collaboration or as small as a single grad student.

¹ <https://www.aip.org/statistics/reports/new-astronomy-phds-what-comes-next-181920>

These are skills that are also vital to tech industry roles, business roles, government roles, non-profit roles and more. We can, and should, do more to prepare students to be the leaders of tomorrow. This will have far reaching effects within and beyond academia. The strength and health of the field of astronomy should be assessed equally by both the science and the people we produce.

Let us reimagine what a PhD in astronomy can be: a more professionally oriented degree that deliberately teaches and emphasizes a wide range of skills that are valuable to academia, industry, and the world.

Methods

We believe that replicating the kinds of opportunities that the NOLP provides at a wider scale would effectively train graduate students with equal success and empower them to thrive in any career they wish to pursue. Here we describe in some detail the activities of each of the three nodes, UC Santa Cruz, UC Irvine, and Columbia University. We further highlight the experiences of some NOLP Fellows and how these experiences have benefited the student, their department, and their community at large.

The primary component of NOLP activities at the **UC Santa Cruz** node is the Mini-Grant Program. Each winter, UCSC Osterbrock Fellows issue a call for proposals which invites the department's graduate students to apply for grants of up to \$2000 to pursue opportunities that provide the awardee with a unique leadership experience. Osterbrock Fellows are eligible to apply for a mini grant themselves, with care taken that those applications are not reviewed by the proposer themselves. Mini-grant proposals can span a range of themes, including direct support for scientific research (e.g., an astrobiology-relevant study of Alaskan cave bacteria), DEI-oriented projects (e.g., helping to cover prohibitively expensive graduate school application fees for undergraduate students in need), and projects oriented towards advocacy (e.g., visiting government agencies to understand their scientific outlook).

Opportunities to pursue their own, autonomous interests allows students to take initiative and bring their vision to life in tangible, impactful ways, which benefits students as people, thereby enriching their PhD experience. The leader of the latter project mentioned above said, "An Osterbrock-sponsored visit to the California Council on Science and Technology changed the course of my life. I decided that I wanted to use my PhD for policy advice to the US government, and that is what I am now doing." This testimony shows not just the impact on the students as people, but also the benefits to the field as a whole – having scientists in public service is crucial for well-crafted science policy. UCSC Fellows have also been invited to listen in on the Time Allocation Committee (TAC) discussions of the Hubble Space Telescope (HST) and the Chandra X-Ray Telescope. One Fellow said, "Sitting in on the HST TAC panel discussion was a revelation. It taught me how to write more clearly and how to better anticipate all the comments and questions that might come up as people read my proposals."

At the **UC Irvine** node, students lead and manage the Physics and Astronomy Community Excellence (PACE) Program. Founded by and for grad students in the department, PACE seeks to 1) foster community across cohorts through a peer mentorship program and 2) put on a workshop series to welcome and orient the new first-year students. Some workshop topics include: what to look for in an advisor, how funding works within the department, professional development opportunities in summer

months, as well as time and project management best practices. These topics are pertinent to new first-year students everywhere, yet they are seldom formally taught by any graduate program; instead graduate students are expected to figure this all out along the way. Therefore, this knowledge transfer within a formal learning setting from experienced grads to new first-year grads is a major component of the PACE program. In particular, PACE leadership aims to foster an environment where the new first-year students can ask the kinds of questions that departments don't typically answer. These non-mandatory workshops are highly valued by the first-year students: we see average attendance from each cohort over the 5 years of the program of 65%.

Furthermore, the peer mentorship program has helped increase student interest in department activities and generally assist students through a very difficult transition year as they join graduate school. The peer mentorship instantly provides new students with someone who is "in their corner", someone they can go to when issues arise, someone to help them navigate the new school environment. Grad students enjoy and value this kind of programming. In cohort sizes of ~30 students, in the five years of PACE we have never had more than 4 students in one year opt-out of the program. Additionally, the mentors themselves benefit through practicing their own mentoring, leadership, and interpersonal skills which are vital for any future career, especially those within academia. As a testament to program success and value to the students, 34% of first-year participants each year sign on to be a mentor in their 2nd year, and many continue to play mentorship roles beyond their 2nd year. This was true before the position became paid; now that PACE mentors are paid for their time, more students can make the time to participate as mentors and we have instituted an application to select mentors. Similarly, the NOLP Fellows of UCI, who lead PACE, also benefit greatly from the program. They build up many leadership, interpersonal, and organizational skills through managing the peer mentoring network and preparing workshop curricula. They have ample opportunities to practice public speaking as well as presentation design. They manage a budget, learn to balance their time with research, and learn to "manage up" with the various circles of people above them including department leadership, advisors, research mentors, extra-curricular program leaders, etc., to get the most out of their time and conversations with these groups of people.

At the **Columbia University** node, the NOLP has taken full advantage of the university's prime location in New York City to connect Fellows with prominent leaders in the local community. The Columbia Fellows have engaged in workshops on conflict resolution, DEI, and communication run by professors from various schools within the university, including the Columbia Business School and the Teachers College. Further, the Fellows have had dinners with leaders in technology, finance, and astronomy from across NYC; one Fellow remarked that these dinners allowed them to "see what leadership looked like for different people and in different contexts," teaching them that they had "the freedom to discover what leadership meant for [them] in [their] own context."

Applying what they learned from these experiences, the Columbia Fellows have each spearheaded the implementation of their own long-term projects. Each Fellow is given freedom to choose their project and is supported by a \$4,000 budget over the span of two years. The projects implemented by the first cohort of Columbia Fellows includes a wide array of topics. One Fellow developed a new astronomy outreach

program at a local pediatric cancer hospital; another led the organization of a “Science Policy for Scientists” lecture series open to all Columbia STEM graduate students. A third Fellow started a new paid astronomy research opportunity for undergraduates at Columbia and CUNY, for which the Fellow also served as a research mentor. This Fellow reported that “[they had] learned so much about developing an effective ‘curriculum,’ engaging students in person (and on Zoom), and formally (and informally) evaluating a research experience for undergraduates. After this experience, [they] felt much more capable and confident in [their] ability to take on a significant leadership role as part of a larger program.”

Across all nodes, Fellows have shared ideas and held discussions, many of which have become the basis for this white paper. The Fellows additionally have participated in events together, including meeting with leaders such as the President of the AAS, the NSF Director, and the Mayor of Santa Cruz. Through these opportunities, the Fellows have had the chance to ask questions and learn about leadership and managing organizations. Additionally, the NOLP Fellows have organized and run two splinter sessions at AAS conferences. At AAS 240, Fellows put on an information session about the NOLP, advertising our activities and their benefits to our Fellows, departments, and communities, as well as starting a community discussion on the topics of graduate student leadership. Then at AAS 241, we hosted a roundtable discussion on the topics of “re-imagining the astronomy PhD”. We solicited community input, gathered ideas, and ultimately much of this formed the inspiration for this white paper. Through both of these splinter sessions, NOLP Fellows took ownership of the planning and implementation, practicing all kinds of leadership skills in the process.

Through the activities at each of the nodes, the NOLP Fellows are given opportunities to design, manage, run, and improve programs that they have considerable ownership over. This level of ownership encourages the Fellows to practice and hone the skills associated with leading a project and people, including decision making, conflict resolution, and resource management. The Fellows overwhelmingly feel that the leadership practice they get through the NOLP and their projects within it have demonstrably improved their abilities to lead and manage teams and projects, while also improving their confidence across many axes. This is shown through a short census of “where are they now” of former NOLP Fellows. At the UCSC node, 15 Fellows have graduated since the inception of the program. Of these, roughly half are in academic or astronomy-related research positions, and half have gone into industry or government. Many of the latter acted on positive messages that they received from the NOLP about the possibility of fulfilling and successful careers outside of academia. At the UCI node, 5 Fellows have graduated. Of these, 4 have earned prize postdoc positions (NSF and Hubble), of which 2 will be starting tenure-track faculty jobs within the next year. The fifth student holds a grant-tied postdoc position. The Columbia node is new enough that no Fellows have graduated yet.

We believe these successes show the power of emphasizing leadership education and providing opportunities for students to practice the associated skills. Many of the NOLP Fellows have chosen to pursue careers within academia, and they have done so while being able to lean on their leadership experiences for guidance. Similarly, these extra-curricular experiences and the skills they have fostered appear to be highly valued by fellowship award and faculty hiring committees.

Action Items

The following describes several (non-exhaustive) concrete steps that department/university leaders and faculty members can take to empower their students while in school, as well as better prepare them for life beyond graduate school both in and out of academia. Many of these ideas were developed based on conversations among NOLP Fellows and also with graduate students from other departments in the splinter sessions at AAS 240 and AAS 241. We believe that they will not only benefit individual students but also the field as a whole, as the students of today become the leaders of tomorrow.

- Create and define positions within the department governance that are specifically for graduate students. These should be official roles within the department. These positions are intended to provide students with genuine ownership of a program/idea through which they are empowered to learn skills associated with project, team, and time management, communication and preparation, and general leadership.
 - Some examples include but are not limited to:
 - an organizer of journal club(s)
 - a head TA position
 - an organizer for accepted student visit days
 - a local elementary school outreach program leader
 - a student representative on the admissions committee
 - an office manager
 - a student representative to faculty meetings
 - These positions are not limited to a single person and many of these roles should have multiple leaders. That said, there should be few enough leaders within any one role to guarantee that each has considerable ownership over the program, its management, and its success.
 - **Ideally, each of these positions should be compensated with pay** (though not necessarily each at the same rate). This formalizes the duties of the role, incentivizes students to complete tasks when they could be instead advancing their paid research or teaching responsibilities, and provides ownership over the role.
- Develop, actively manage, and fund a peer mentoring program among the graduate students. Peer mentorship has been shown to foster community, as well as increase the rate at which students participate in department activities and programs^{2 3}. That participation naturally leads to taking on leadership roles within programs which in turn develops the leadership skills that are so important to success beyond grad school. But additionally, the role of a peer mentorship program leader can and should be a current grad student(s) who can in turn sharpen their own leadership skills through the management of the program.

² Lueck, A. J., & Boehm, B. (2016). Graduate Student Peer Mentoring Programs: Benefiting Students, Faculty and Academic Programs. In G. Wright (Ed.), *The Mentoring Continuum: From Graduate School Through Tenure*. Syracuse University Press.

³ Steiner, J.F., et al. (2004). Assessing the Role of Influential Mentors in the Research Development of Primary Care Fellows. *Academic Medicine, Journal of the Association of American Medical Colleges*, Vol. 79, No. 9.

- Allocate funds to develop a mini-grant program similar to the ones hosted at UCSC and Columbia nodes.
- Actively support and promote non-academic paths to students. Through exposure to alternative paths, students are empowered with information to pursue the areas that are most interesting to them and imagine the ways in which their astronomy skills can be applied beyond academia. Some examples include but are not limited to:
 - Bring in industry leaders for colloquia and seminars.
 - Stay in touch with alumni who have gone into industry. Track their careers, include them at accepted student visit days, and consider asking them to mentor students who show interest in non-academic trajectories.
 - Invite speakers from the university's business school, psychology department, sociology department, philosophy department, and more, as well as local industry and government, etc., to speak about the topics of management, working in teams, modern needs industry, ethics, and more.
 - Fund and advertise workshops for graduate students on topics beyond academia such as communication skills, writing, and conflict resolution
 - Provide travel support to non-academic conferences.
 - Support students to explore and take on summer internships in industry.

Conclusions

The astronomy PhD has been and always will be a permanently enriching experience for those who participate in it. Learning at the frontiers of knowledge is fundamentally good for the individual and for humankind; this ideal should not be lost within this white paper. But the modern astronomy PhD should also reflect modern values and skills, for all lines of work, including those beyond academia. Each PhD is unique, but each should also maximally benefit the earner in more ways than raw research skills and knowledge. Through this lens, we envision the modern astronomy PhD as a means to engage with the limits of humankind's knowledge without necessarily committing to or even pursuing the role of research scientist for life. With this in mind, we urge departments to implement as many of the suggested action items as possible. Through inclusion of graduate students in the governance of departments, development of ancillary programs like peer mentoring networks and mini-grants, and a general promotion of all career paths, we can make the astronomy PhD an even broader track to success. These action items are intended to replicate the experiences of NOLP Fellows, and hopefully bring the successes of the NOLP experience to more students.

This white paper is not a panacea nor is it intended to be. The challenges that pervade the field, i.e., the bottleneck at each rung of the academic ladder (especially graduate admissions), the need for increased DEI programs and training, the need for formal mentorship programs, and more, will not simply disappear were the action items from this white paper to be widely implemented. However, we, the NOLP Fellows, believe that these are important steps towards broader solutions to strengthen investment in the students of today, all of whom will be the leaders of tomorrow, in astronomy and beyond.