Preparing an Inclusive Astronomy Community through Effective Professional Development

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1. **Key Issue and Overview of Impact on the Field**

1.1 The need for professional development in the astronomy community

Alongside enormous potential for forging new discoveries and building understanding of our physical universe, the U.S. astronomy community[a] faces steep challenges. Community members must acquire new knowledge and abilities in emerging disciplines that will drive cutting-edge research[1]. They must collaborate on a global scale and across disciplines. Collectively our community must overcome and reverse longstanding imbalances in who can participate and succeed in astrophysics and related fields.

These challenges will be addressed through individual actions and professional practices, as well as through systematic changes to policies and allocated resources. In this paper we address the first of these channels: training individuals within the astronomy community to innovate, collaborate, lead, mentor, and teach in ways that are both highly effective and poised to support community members who are underrepresented or otherwise marginalized. Whereas such training is rarely a formal aspect of undergraduate or graduate curricula, it may occur across a range of career stages under the umbrella of professional development. While an individual may

In this position paper we recommend two broad strategies for the astronomy community[a]:

1. **Support professional development initiatives informed by research and whose efficacy can be demonstrated**
2. **Support initiatives that address equity and inclusion as an essential aspect of professional skills**

To enact these strategies, institutions, departments, and projects should:

- align professional development opportunities with evaluation and promotion criteria, and invest in training that is demonstrably effective
- leverage professional development toward their overall goals for inclusion

Funding agencies should:

- evaluate proposed professional development activities based on how the activities are informed by professional development research, and how their outcomes will be demonstrated
- fund professional development activities that specifically address equity and inclusion in professional practices

Professional agencies should disseminate "best practices" in a range of professional activities, along with research in support.

We elaborate upon these recommendations in Section 2. **Box 1**

[a] Herein we define the U.S. astronomy community as including scientists, engineers, technicians, and other staff at facilities, companies, and university departments that support astronomy research and education.

encounter a range of professional development opportunities, the most effective ones share specific characteristics that enable lasting implementation of new skills or knowledge. We describe these characteristics and supporting evidence in Section 1.4.

> "Examples of important skills that Ph.D.-level employees typically need, whether they are employed in academia or elsewhere, but for which most new Ph.D.s are ill-prepared include [...] project management, leadership, the ability to work in teams, the expertise to address complex interdisciplinary problems, and the ability to teach."
>
> President's Council of Advisors on Science and Technology, 2012 **Box 2**

1.2 Professional development supporting equity and inclusion

The historic and ongoing underrepresentation of multiple groups in U.S. astronomy and related fields[2–5] - both overall and in positions of leadership - limits the community's overall productivity[6,7] and its relevance to U.S. society. Achieving equity within the astronomy community requires expanding means of entry and inclusion for members of underrepresented or marginalized groups, *and* supporting those already in professional roles or on an astronomy-related career path.

In order to retain and advance underrepresented individuals who are already "in the pipeline," the astronomy community must engage in equitable and inclusive teaching, mentoring, collaboration, peer review, hiring, and promotion. In addition to overt bullying and harassment[8–10], gender and/or racial/ethnic biases have been demonstrated in hiring[11–13], salary[14], development and promotion[15–17], author order[18], citations[19], reference letters[20,21], and colloquium invitations[22], in a range of scientific and technical fields including astronomy. While policy revisions may help remove bias from some of these practices, professionals at all levels can further support equity and inclusion by aligning their individual practice with approaches that counteract implicit biases or even center the experiences of marginalized colleagues.

Several community efforts have produced recommendations for generating equitable and inclusive astronomy workplaces. Below we provide a few examples of trainable professional practices that contribute to equitable and inclusive environments, drawn from recommendations by the Inclusive Astronomy meeting in June 2015 ("Nashville Recommendations")[4], the AAS Climate Site Visits program[23], and LGBT+ Physicists and the AAS Committee for Sexual and Gender Minorities in Astronomy (SGMA)[24].

- Support organization members in receiving training that focuses on how best to mentor students and postdocs, including those from different backgrounds with consideration of issues particular to underrepresented, LGBT+, and/or disabled students.
- Encourage opportunities for individuals in instructor or mentor roles to learn new pedagogical and assessment techniques, and to create inclusive classrooms and group spaces.

- Provide training in recognizing and combating microaggressions, implicit bias, and stereotype threat.
- All members of an organization should receive periodic training covering sexual harassment, bystander intervention, and the importance of inclusive academic spaces. These trainings should include content relevant to the astronomical workplace.

1.3 Role in Decadal Survey

The Astro 2020 Decadal Survey will generate many white papers describing key workforce issues in astronomy, including skill sets and career training needed to advance the astronomy field, and ongoing barriers to equitable participation. Professional development has been identified as a strategic approach to many of these issues, and we outline in this paper how it can be leveraged most effectively to address multiple workforce challenges.

1.4 What makes professional development effective

In order to successfully adapt their professional practice, individuals must implement new concepts or approaches and persist in using them over the long term. This is the mark of *effective* professional development, as opposed to learning experiences that raise awareness but don't have any attributable change in practice, or only produce brief or superficial changes in practice.

Summary of effective professional development characteristics outlined in this paper:

- **Effective professional development includes opportunities to implement new methods/approaches, with coaching and iteration**
- **Professional development should connect recommended practices to underlying principles and rationales**
- **Effective professional development actively engages trainees and is adapted to their goals and expertise**
- **Trainees must invest enough time to digest, implement, and reflect on a new method**

Box 3

Effective professional development includes opportunities to implement new methods/approaches, with coaching and iteration[25–31]**.** As implementation in the workplace is the basic goal of professional training, it follows that training programs should support participants in transferring their experiences from a class or workshop setting to their actual workplace. Indeed, a wealth of research demonstrates the challenges of effectively implementing new methods[30,32,33] and the value of expert coaching[25,34–37]. We emphasize that effective coaching requires experience in the coaching role as well as expertise in the activity being coached. Although peer-training or "train-the-trainers" models can be resource-efficient, they often sacrifice fidelity to research supporting the practices being trained, and may yield weaker outcomes[27,38,39].

While much of the research above examines professional development for primary and secondary school (K-12) educators, prominent training opportunities for college physics and astronomy instructors also have grappled with how to introduce and model pedagogical methods in a workshop setting, such that they can be transferred to real classroom practice[40–43]. A prominent mentoring program in the biological sciences indicates the value of implementation planning and expert coaching toward successful adoption of research-based mentoring strategies[44,45].

Professional development should connect practices to underlying principles and rationales, so trainees can evaluate whether or how to employ them in a variety of contexts[26,46,47]. Recommended approaches or "best practices" in teaching, leadership, and other professional areas are often highly situational[48,49], especially when boiled down to easily digestible "tips" or "hacks." In contrast, articulating and reinforcing a framework that organizes new knowledge helps trainees access the knowledge and apply it in a relevant manner to different problems or contexts[50,51]. For instance, while a research-based strategy for teaching college-level physics may need to be modified for a range of class sizes or structures, instructors lacking deep understanding of why the strategy is effective are likely to remove essential aspects during modification[52]. Employing background knowledge and conceptual reasoning to apply methods appropriately is crucial, and is especially important for equity and inclusion. Many professional practices and initiatives can be made stronger and more equitable by consuming and applying research on identity, persistence, and the experiences of specific marginalized groups[53–56]. Yet bluntly extrapolating an approach shown to support marginalized individuals in a particular circumstance may be ineffective or even harmful in a different setting or with a different group.

Effective professional development is learner-centered: it actively engages trainees and is adapted to their background, goals, and expertise. Numerous studies have demonstrated the advantages of active learning strategies toward conceptual understanding and critical thinking in formal education settings[57–59]. In a professional development environment, there likewise is evidence that structures requiring trainees to activate their own ideas and experiences will promote more growth than passive receipt of information[28,29]. Furthermore, training that is geared to specific challenges individuals face in their professional environment will ease the transition from learning to implementation. In the case of teacher development, training that is embedded in discipline-specific content (e.g. active learning methods for physics classes) yield larger student gains than teacher training that is divorced from the subject discipline[26,30,60,61]. We argue that training in other professional areas similarly will be most effective when it is grounded in trainees' discipline and professional circumstances.

Effective professional development requires investing enough time to digest, implement, and reflect on a new method. While there is no exact threshold for the minimum worthwhile time investment, studies indicate that one-time workshops lasting only a couple of hours yield meager outcomes for adopting new methods[26,62]. Successful professional development experiences for teachers typically require an investment of 30 hours or more[30,63,64]. Many other areas of professional practice can uphold individual examples of successful training programs but lack meta-analysis of a range of programs, that might distill a metric for total time investment. Qualitatively, professional development opportunities in any area must be long

enough to include the effective aspects above: in addition to learning the main elements of a new approach, participants must engage with its rationale and spend time on planning and implementation.

The characteristics above represent common elements drawn from multiple studies on professional training and development, which collectively span a range of disciplines and practices. They are not presented as a definitive list, and they should be weighed in consideration of the specific need that professional training would fulfill. Ultimately, the strongest evidence that any particular professional development opportunity is effective is based on assessing its outcomes: i.e., whether past participants have succeeded and persisted in adopting new practices. Moreover, we caution that self-reporting is a convenient but incomplete method for evaluating professional training, as participants often overestimate or misrepresent how they implement new practices[52,65].

2. Strategic Plan

Professional development occurs and will occur in many arenas throughout the astronomy community, addressing a range of practices and skill areas and the needs of different organizations and individuals. As a general strategy to maximize the local and collective impacts of professional training, we recommend that organizations, projects, and funding agencies:

1. Support professional development initiatives informed by research and whose efficacy can be demonstrated.

2. Support initiatives that address equity and inclusion as an essential aspect of professional skills.

These broad strategic pillars direct the community to leverage bodies of research on effective professional development, equity, and inclusion. They direct professional development programs and initiatives to report their outcomes with respect to how trainees conceptualize and implement professional skills, and consumers of professional development to be attentive to concrete outcomes. Below are some specific pathways for enacting these strategies.

Institutions and departments should align professional development opportunities with evaluation and promotion criteria, and invest in training that is demonstrably effective (Box 3). This could mean activating opportunities for individuals as they step into particular roles (e.g., managing a project or supervising a student). Professional development goals for individuals should be tied to assessable outcomes, and training opportunities should be sought that align with these outcomes and can be evaluated. Allocating personnel time toward targeted and substantial professional development - as opposed to an all-hands workshop that conveys information without supporting practice and implementation - is an up-front investment by institutions and projects that will yield long-range dividends.

Academic departments should utilize campus or inter-university resources for evidence-based teaching. Many universities house centers for teaching that offer courses for adopting effective teaching strategies, and/or provide curriculum development consultation. Alternatively, there are national-level programs on effective methods for college-level teaching; we list some examples in the Appendix. Departments should encourage their faculty and instructors to engage with these local or national programs, and provide teaching credits or other formal support to invest the necessary time for effective training. Likewise, graduate student teaching roles should be approached as an opportunity to implement evidence-based practices, and departments should support graduate students in receiving effective professional development as instructors. Training in evidence-based teaching has been shown to have a positive or neutral effect on graduate students' research preparedness and productivity, rather than detracting from research[66].

Institutions and projects should leverage professional development toward their overall goals for inclusion. This could include training relevant personnel in inclusive practices for leadership, mentoring, and hiring. Metrics for advancing inclusive practices within an institution or project should be developed, tracked, and reported as part of overall outcomes for diversity/inclusion. Likewise, professional or workforce development initiatives should address and report on how trainees apply new skills and knowledge toward equity and inclusion. Finally, institutions and projects should recognize and reward practices such as mentoring and committee work, that are disproportionately taken on by members of underrepresented groups[67–69].

Funding agencies should evaluate proposed professional development activities based on how the activities are informed by professional development research, and how their outcomes will be demonstrated. These standards should be applied to standalone proposals and to professional development activities proposed within scientific or technical research proposals (e.g. "broader impacts" activities for NSF science proposals).

Institutions, projects, and funding agencies should support professional development activities that specifically address equity and inclusion in professional practices. For instance, successfully proposed activities could incorporate research on how approaches impact members of different demographic groups, and define outcomes in relation to project or institutional goals for equity and inclusion. The first two programs in our Appendix are examples that directly address equity and inclusion as a component of other professional skills (teaching, leadership, and teamwork).

Professional agencies such as AAS should disseminate "best practices" in a range of professional activities, along with research in support. Agencies can play an important role in encouraging effective and inclusive practices as informed by research and community expertise. Since these will be employed most effectively with attention to their underlying theories or rationales, agencies should report supporting research and situational contexts for recommended practices.

3. Organization, Partnerships, and Current Status

Professional development occurs in many arenas throughout the astronomy community, with programs and workshops addressing a range of practices and skill areas, and the needs of different organizations and individuals. We believe our description of effective professional development characteristics and our recommendations can be further served by examples of actual programs and workshops. Although a comprehensive list of existing programs is beyond the scope of this paper, we wish to provide some examples illustrating the effective professional development characteristics we have outlined herein, and our broad strategic recommendations. In the Appendix that follows, we list a few programs the authors have experienced and ways they align with effective professional development, and with supporting equity and inclusion within the astronomy community. Our list is not an endorsement of these examples over similar programs, nor is it an evaluation that they are fully effective and inclusive. We note that some of these programs are implemented in coordination with national professional organizations (e.g., AAS, AAPT).

Appendix: Examples of effective professional development in the astronomy community

This appendix contains some professional development programs the authors have experienced and ways they align with effective professional development, and with supporting equity and inclusion. Our list is not an endorsement of these examples over similar programs, nor is it an evaluation that they are fully effective and inclusive.

ISEE Professional Development Program (PDP)[70,71]
https://isee.ucsc.edu/programs/pdp
Professional skills: College-level teaching
Audience: STEM graduate students and postdocs, with the majority being from astronomy and physics fields
History: Annual program since 2001, with 662 participants through 2019.
Program summary: PDP participants attend three workshops, design a teaching activity in small teams with coaching, teach their activity to a group of undergraduate students, evaluate students' learning gains, and complete a written reflection on how they implemented pedagogical strategies informed by research. The total time investment for a first-time participant is ~90 hours. Returning participants have structured opportunities for practice and reflection on leadership.
Alignment with effective professional development: Implementing new methods with coaching is integral to the program. Participants teach activities in their own disciplines. The PDP instructional team holds expertise in professional development, expertise in inquiry-based teaching and supporting research, and expertise in astrophysics and other STEM disciplines. Reflection is built into many aspects of the experience. Studies of PDP outcomes have

demonstrated that participants implement the specific teaching strategies they have learned in the program and measure learning gains by the students they teach[70].
Support of equitable & inclusive practices: Each participant reads an overview of equity and inclusion considerations in STEM and a primary research article on support strategies for underrepresented students in STEM disciplines. Each team of participants creates a plan for how their teaching activity will align with an idea from research on equity and inclusion (for example, supporting learners' STEM identity)[72]. A pre- and post-program study with the 2008 and 2009 PDP cohorts found significant improvement in responses to a survey question on engaging a diverse undergraduate population via teaching and research[73]. Assessment tools are being refined to evaluate recent cohorts' understanding and application of equity and inclusion principles.

New Faculty Workshop for physics and astronomy faculty[40]
https://www.aapt.org/Conferences/newfaculty/nfw.cfm
Professional skills: College-level teaching
Audience: Pre-tenure physics and astronomy faculty
History: The New Faculty Workshop is sponsored by the American Association of Physics Teachers (AAPT), AAS, APS, and AIP. The workshop began in 1996 and currently is held twice per year, with ~50-80 participants per workshop. A 2008 evaluation noted that the workshop was attended by ~25% of U.S. physics and astronomy faculty hired between 1996-2007 [40].
Program summary: Participants attend an intensive four-day workshop with large- and small-group sessions covering a range of instructional challenges, as well as strategies for navigating the first years of a faculty appointment. Participants have the option of joining a Faculty Online Learning Community (FOLC) to continue supporting one another's teaching development after the workshop[42,43].
Alignment with effective professional development: Workshop instructors bring deep experience in physics teaching, education research, and professional development. Although the workshop's ~40-hour duration is consistent with the time investment required for effective professional development in teaching, a program evaluation noted that its effectiveness could be increased with deeper opportunities for practicing and being coached on individual instructional strategies, expanding from the workshop's transmission-based approach covering a broad range of strategies[40]. The FOLC provides opportunities for participants to describe ongoing implementation of teaching methods and receive feedback from peers and an experienced facilitator[43].
Support of equitable & inclusive practices: The workshop includes sessions on developing inclusive classrooms and adopting teaching strategies that are informed by research on equity and inclusion.

Project Kaleidoscope (PKAL) STEM Summer Leadership Institute (SLI)[74]
https://www.aacu.org/summerinstitutes/sli/2019
Professional skills: Leadership; teamwork; STEM higher education transformation
Audience: Early and mid-career STEM faculty, PIs of STEM reform initiatives, administrators of STEM academic units
History: Annual program since 1996, ~20-40 participants per year.

Program summary: SLI participants attend a 5-day intensive, culminating in plans for action on a STEM reform project and on their own personal leadership growth. The total time investment (including pre-readings and follow-up consultation with mentors) is ~60 hours.
Alignment with effective professional development: The SLI blends theory and practice, employs active-learning strategies, and closely pairs experienced mentors with participants.
Support of equitable & inclusive practices: Institute readings include consideration of STEM demographics and case studies in bias. SLI curriculum weaves understandings of systemic power and privilege into discussions of undergraduate STEM and in participants' leadership development.

Astronomy Ambassadors
https://aas.org/outreach/aas-astronomy-ambassadors-program
Professional skills: Science communication
Audience: Early-career astronomers
History: Astronomy Ambassadors is a program run by the American Astronomical Society (AAS) and the Astronomy Society of the Pacific (ASP) in partnership with members of the Center for Astronomy Education (CAE) and other organizations. Workshops have been held annually at AAS winter meetings since 2013, and occasionally at other AAS meetings. Each workshop serves 26-30 participants.
Program summary: Astronomers accepted into the program participate in an 8-hour workshop with exercises for how to communicate science concepts to an audience and demonstrations of hands-on activities (e.g., creating scale models of the solar system). After the workshop, participants receive resources for classroom activities and access to an online forum where they can communicate with other current and former Ambassadors.
Alignment with effective professional development: The workshop is tailored to address relevant forms of communication for early-career astronomers, including professional presentations, hands-on outreach activities, informal conversations. Through the workshop and online forum, participants are given coaching and opportunities to brainstorm and iterate on outreach efforts.
Support of equitable & inclusive practices: Ambassadors are encouraged to seek out venues with diverse audiences for their outreach activities. Based on logged outreach activities, Ambassadors engage with an average audience of 75 people ranging from preschool age to senior citizens; most events serve K-12 students, their parents, and their teachers. The program tracks the demographics of Ambassadors and aims to build cohorts of participants from diverse gender, racial, cultural, and institutional backgrounds.

University of Colorado Boulder Science Speak-Easy
Professional skills: Oral communication
Audience: Early career researchers at CU Boulder (postdocs and graduate students), representing multiple science disciplines
History: Annual program since 2018, begun as a collaboration between Fiske Planetarium and the University of Colorado Astrophysical and Planetary Sciences Department. There were 17 participants in 2018 and 18 participants in 2019.
Program summary: Oral communication training can improve the career outcomes of scientists[75,76]. The Speak-Easy program helps early-career researchers practice and improve their science communication skills, and helps build a network of early-career researchers who are

interested in ongoing skill development. The program briefly addresses science communication career paths and supplies a list of resources and opportunities to continue with outreach.
Alignment with effective professional development: Trained communicators provide hands-on coaching to new participants to improve their approach to communication. Participants actively engage in the practical steps of putting together a successful talk, practice their speaking in front of other participants, and use feedback from peers to work toward a final polished talk. Each year the workshop is adapted to the goals and interests of participants, based on feedback from the previous year.
Support of equitable & inclusive practices: Speak-Easy draws from the Nashville Recommendations for creating an inclusive environment[4], such as establishing norms and preferred gender pronouns and creating space for constructive peer feedback. The workshop focuses on confidence-building practices and holds sessions for participants to collaboratively address imposter syndrome.

Akamai Mentor Workshop
https://akamaihawaii.org/mentor-workshop/
Professional skills: Mentoring students for engineering, computer science, and science projects
Audience: Professionals at observatories and other STEM industry sites on Maui and Hawai‘i Island
History: Offered since 2013 as part of the Akamai Workforce Initiative run by ISEE.
Program summary: Mentors attend a two-day workshop on mentoring strategies, prior to mentoring an eight-week intern project at their organization. The workshop features discussions and time for each mentor to develop a Mentor Plan. Akamai interns are 2nd- to 4th-year college students from the state of Hawai‘i, matched to projects based on their disciplinary background and other technical skills. Only mentors (STEM professionals) attend the Mentor Workshop. The Akamai internship program
Alignment with effective professional development: Each participant develops a Mentor Plan that is tailored to the intern and project they will mentor that summer. Both the workshop and the Mentor Plan are structured around concepts such as STEM identity and transferable STEM practices (e.g., defining requirements, designing experiments), and each mentor devises concrete ways they can support their intern’s growth in these areas. The workshop uses discussions to draw from mentors’ prior experience.
Support of equitable & inclusive practices: Mentors complete a reading and discussion on STEM identity, and each mentor plans one “Design Element” for the 8-week project that will support their intern’s STEM identity. Akamai interns have been found to persist in STEM at a rate of 84% for underrepresented students and 87% for non-underrepresented students, at least three years out from their intern experience[77].

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