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Applying Principles of the PDP Towards Mentoring

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Abstract

In this paper, we explore how core principles of the mentoring training offered by the Institute for Scientist & Engineer Educators (ISEE) Professional Development Program (PDP) have been adopted by PDP alumni and applied in different contexts. The core themes of the mentoring work conducted by ISEE, which are Inquiry, Equity & Inclusion, and Assessment, form an extensible basis for PDP participants to use as they develop their own mentoring programs. The panel/paper is structured to briefly identify core components of mentoring in the PDP model and then discuss how former PDP participants have applied these in a variety of other venues. With the goal of broadening access & persistence in STEM, the PDP emphasized: the role of ownership and agency, the practice of explanations, the creation of opportunities for recognition, providing formative assessment, and a recognition of and introduction to STEM culture. The PDP has had a unique way of "staying with" participants and provided a framework for mentoring in other modalities including: peer-to-peer, informal, and in the development of new formal programs. These offshoots include key PDP ideas such as: providing support for belonging in STEM, placing value on teaching, promoting adaptability and cultural relevance, and a "training the trainers" modality of mentorship. The panelists will provide examples from programs for undergraduate students, graduate students, teaching professionals, and faculty. The session also provided opportunities for attendees to share their experiences and take-away lessons from the PDP model of mentoring and some of the panel feedback is included in this paper. The ISEE community has a shared vocabulary, toolset, and ethos that continues to inform alumni mentoring since the inception of the PDP.

Keywords: assessment, backward design, equity & inclusion, growth mindset, inquiry, mentoring, STEM identity

1. Introduction

We begin this paper with a brief description of the mentorship model the authors received during their participation in the Professional Development Program (PDP), developed and managed by the Institute for Scientist & Engineer Educators (ISEE) at the University of California, Santa Cruz (UC Santa Cruz). We then present a series of reflections by the authors, who have taken these ideas and are implementing them in their latter careers at a variety of institutions and in a variety of modalities.

ISEE, managed at UC Santa Cruz and collaborating with partners across the United States, provides early career scientists and engineers with training in inclusive teaching, mentorship and other professional development opportunities (Institute for Scientist & Engineer Educators, n.d.). The PDP began in 2001 and has prepared over 500 participants through a sequence of workshops and paired teaching experiences (Professional Development Program, n.d.).

The PDP presents a mentoring model based on the themes of Inquiry, Equity & Inclusion, and Assessment and is designed to broaden access & persistence in the STEM workforce (Metevier et al., 2015). The PDP stresses several important elements including: the role of ownership and agency, the practice of explanations, the creation of opportunities for recognition, providing formative assessment, and a recognition of and introduction to STEM culture. Further ideas essential to the mentoring model of the PDP include: providing support for belonging in STEM, placing value on teaching, and promoting adaptability and cultural relevance. PDP participants often return to the PDP in leadership roles that further develop their skills. This kind of "training the trainers" modality of mentorship parallels the crossed threads seen in PDP teaching venues: apprentice mentors (graduate students and early career scientists) receive training, while they themselves train a population of college students in venues like summer internships.

We are alumni of the PDP training, and can be viewed as "users" of the mentoring model at various stages in our post-PDP careers. Serving as mentors in a variety of venues and to various audiences, our reflections show how the core principles of the PDP can be applied in different contexts. The modalities of mentorship are myriad: peer-to-peer, informal, and the development of new formal programs. In the following section we provide examples from programs for undergraduate students, graduate students, teaching professionals, and faculty. We follow with participant feedback from our panel, in which we provided opportunities for attendees to share their experiences and take-away lessons from the PDP model of mentoring. We end with a summary of the main PDP mentoring principles that have informed alumni mentoring since its inception.

2. Panelist reflections

We break down our individual mentoring program descriptions and reflections by author in the following subsections. We end Section 2 by including a brief description of the mentoring themes and reflections shared by participants during the conference panel.

2.1 Mentoring undergraduate capstone experiences —Scott Severson

ISEE training via the PDP provided me with a model for effective and inclusive teaching and mentoring that changed the trajectory of my career. In part because of these experiences, I moved from a full-time research astronomer path to pursuing and attaining a faculty position at a public liberal arts institution, Sonoma State University (SSU). I state this to emphasize the value of the ideas and processes presented within the PDP. In this reflection, I describe some of the lessons I have taken from the PDP and applied to the mentoring of undergraduates studying physics and astronomy.

The PDP is an adaptable program, and participants often attend over multiple years. I began as a participant in 2002, and transitioned to facilitation and staff roles as I continued my participation through 2007. When I began my tenure-track position at SSU in 2007, it was natural that my supervision of undergraduate student research was informed by my PDP experiences. I developed a model for designing undergraduate research experiences that was built on principles I learned within the PDP (Severson, 2010). Central ideas include: defining content, process, and attitudinal goals for the research experience; continuous formative assessment of student development; addressing student motivation; and providing student ownership of the research by implementing aspects of the inquiry process. This student research model includes connections to resources highlighted during the PDP and a structure based on effective practices. I wish to expand upon these ideas with a broader reflection on mentoring.

Students majoring in degrees within the Department of Physics & Astronomy at SSU are required to complete a Senior Capstone. This experience pairs a student with a faculty mentor and requires at least a semester-long research or teacher-training experience structured as a contract-course (though this is often preceded by at least an additional semester of such work.) While mentoring plays a role in many faculty-student interactions, the Senior Capstone is built around it. The PDP-inspired model for mentoring extends beyond my individual mentoring, as I have worked within the department to build structures within our curriculum for all our majors. These include required poster presentations and culminating talks as well as a newly developed support course, the Capstone Preparatory Seminar.

PDP ideas on mentorship provided a useful framework for designing our Capstone experience, beginning with mentoring as a designed STEM experience. Intentional "backward design" approaches led to designing each Capstone with the questions: "What do I want to see from the student's experience?" and "What does evidence of success look like?". Setting goals for the student is essential, and it has been helpful to consider the following types of goals: content I want students to learn; process skills I want students to master; and attitudinal goals such as student ownership of their Capstone experience.

I would like to stress that student ownership over their work is essential. Two things I noticed early in assessing student research: students are often confused as to the "Big Picture" reasons why their particular work is important; and students often have difficulty in identifying the importance of their contribution, even as they are making excellent progress! An important tool in addressing these issues is supporting student metacognition. Having students monitor what they are doing and why they are doing it, promotes their recognition and explicit ownership of the capstone process. A frequent prompt during weekly meetings of the Capstone Preparatory Seminar is to have students share why their work is important and what are their latest short-term goals. This is part of how we scaffold metacognitive practices and encourage student ownership of the Capstone experience.

Another support for student ownership and skill development is the use of inquiry, authentic engagement in STEM ideas and practices. Throughout the mentored research, I endeavor to have students make the following progression. Their early work should be exploratory, learning essential ideas in the field while they form research questions and goals. Their work then transitions to a focused investigation, where they become adept at essential research skills. Throughout, the students have support in developing competence in communication of their ideas and results. This includes the practice of explanation, so essential to collaboration and scientific argumentation. The final presentations, both a research poster and a talk, task them with providing a synthesis of their work and placing it within the broader scientific context.

This process is inextricably linked to an important goal, making sure the process is authentic. That is, care is taken to make sure that the project has intrinsic value and is not a 'facsimile' of research. At an undergraduate-only Physics & Astronomy department with a small number of faculty, this is an important point. It takes effort to support students while providing them with a degree of agency in the direction of their research. It is certainly meritorious to have a strong research program where students are slotted into a pre-existing research role and topic. I have personally led such work, but have found it particularly rewarding to go outside of my direct expertise while supporting student research in such varied topics as: Airborne Particulate Monitoring; Black Hole Growth; Transiting Exoplanet Detections; Thermodynamics Expressed by Dance; and Supernova Modeling.

It is important to situate the student's effort in a broader social setting. Fostering STEM identity and belonging in the STEM community is a specific goal of our undergraduate Capstone experiences. This occurs in two locales within our program. One is within an individual mentor's research group; another is in our Preparatory Seminar. I routinely have three or four students at a time conducting their Capstone research with me. Because of my PDP training, I place the students in a research group, even when their topics appear disparate. This is true across the support course as well, where the number of students is usually ten to twelve. Within the class or research group, we set norms, including framing a growth mindset and setting a collaborative esprit de corps. Students are expected to communicate via weekly progress reports and the use of question-and-answer sessions that are low stakes and supportive. Building this community of practice is integral to our Capstone program.

The active practice of STEM leads to persistence in the field (Graham *et al.*, 2013). We include opportunities for student recognition. These include our scaffolded support as students produce tangible products such as weekly reports, a symposium poster, and ultimately our Student Research Symposium where each student presents their work in a 15-minute talk. We hold this event the day before Commencement and invite the department and the students' friends & family. It is my favorite work day of the year and has a direct lineage to the PDP summer intern programs I mentored in my past.

I would be remiss if I didn't mention how the student work is assessed. I present the Learning Objectives for the Physics & Astronomy Department's undergraduate majors:

1. Knowledge, understanding and use of the principles of physics and/or astronomy
2. Ability to use reasoning and logic to define a problem in terms of principles of physics and/or astronomy
3. Ability to use mathematics and computer applications to solve physics or astronomy problems.
4. Ability to design and/or conduct experiments and/or observations using principles of physics and/or astronomy and physics or astronomical instrumentation
5. Ability to properly analyze and interpret data and experimental uncertainty in order to make meaningful comparisons between experimental measurements or observation and theory
6. Ability to effectively communicate scientific research and results

The development of our Senior Capstone allowed a single place to complete a final, summative assessment of our graduating seniors, and in-turn evaluate how well we are doing as a program. I am pleased to say the PDP-inspired components of our department's Senior Capstone program have an intrinsic role in our success.

2.2 Mentoring as a teaching professor and faculty developer —Robin Dunkin

In my first meeting as a graduate student with an undergraduate mentee, I remember being simultaneously excited to share my work with this eager student and completely unprepared for how to guide her given that I was just barely figuring out how to work independently myself. This early experience of mentoring, largely characterized by stumbling through it and basing my strategies on the few experiences I had had as a mentee, is not unlike what many new faculty experience when they first begin to work with graduate students. New faculty certainly have the benefit of more years of experience than I did at that point, but rarely do graduate students receive evidence-based training in how to be a mentor in an academic setting. Like many of the other duties that go along with working in academia, mentoring has historically been a skill that academics learn from their mentors usually in an informal capacity. Yet, despite a large and growing body of research that has highlighted that the mentoring relationship in graduate school is among the most critical for supporting retention of diverse students in STEM (NASEM, 2019) we are only beginning to see formal training and real adoption of evidence-based, culturally aware mentoring strategies take root in R1 institutions. In this respect among others, the Institute for Scientist and Engineer Educators Professional Development Program has been a program ahead of its time.

ISEE PDP and mentorship programs have long recognized and taught mentoring as a skill that is critical to support student learning. In particular, ISEE programs and the PDP have focused on the importance of mentoring relationships to support students in developing their science identities, recognizing that this is a critical aspect for supporting and retaining diverse students in STEM fields. This key idea of supporting development of science identity threads through many aspects of PDP training. In my own PDP training, I was introduced to the idea that the development of STEM identity is bolstered through hands-on, skill building inquiry activities and that through skilled mentoring practices, mentors can actively create opportunities for students to take ownership of their work, can and should be authentically recognized for their progress, and through these activities are more likely to develop a sense of belongingness in the community.

My training and exposure to these ideas in the PDP program carry forward in my work today at an R1 Hispanic-Serving Institution (HSI) university as a teaching professor and faculty developer with our teaching center. In particular, the key idea that mentoring can and should be active and purposeful in helping students develop their STEM identities sits at the core of the many mentorship workshops that I have co-developed and facilitated for faculty in departments from nearly all STEM disciplines. This theme also is prominent in our New Faculty Teaching Academy, now in its fourth year, where we offer initial evidence-based teaching and mentoring training to all new faculty at our institution. Our critical mentoring curriculum (Weiston-Serdan, 2017) starts from the idea of the importance of the development of STEM identity and builds to include the ways that identity interference, in which students feel they must hide aspects of their identity to be successful in science, prevents the development of science identity and contributes to mental health challenges in graduate school and beyond. Similarly, our mentoring workshops offer many of the concrete mentoring skills that are taught in PDP programs to help mentors work effectively with mentees. For example, the idea of authentic recognition of mentees for successfully performing the skills and practices of their discipline, features prominently in PDP programming; we build on and develop this idea in mentoring training for graduate students, post docs, and faculty as one strategy mentors can take to support the development of STEM identity in their mentees.

Another area where the PDP has informed my work with faculty around mentoring is how to offer mentees effective feedback. The PDP training emphasized feedback that was actionable, positive, and constructive. These principles are echoed in our faculty and graduate mentoring workshops in which we train mentors to use the WISE feedback approach (Yeager et al., 2014). Specifically, this approach is used to signal to mentees that the mentor has high expectations for their work and simultaneously a genuine belief in the mentee's ability to meet or exceed these expectations. This feedback is paired with specific recommendations for how the mentee can achieve these high expectations.

The foundational ideas and skills I gained through my training and work in the PDP program over multiple years have formed a core understanding of active and effective mentoring practices I use regularly and share with many dozens of faculty, graduate students and others each year. I feel fortunate to have been exposed to these core principles so early in my graduate training through participation in the PDP and can say it surely altered the trajectory of my career. I also have been in a position to observe a vast cultural change around both teaching and mentoring practices on our campus over the past two decades with much more widespread acceptance and even eagerness for training and support for both graduate students and new faculty to develop their mentoring skills. I attribute this in part to a persistent, sustained effort on the part of the ISEE PDP to train graduate students in these practices with the intent of influencing future faculty. This has certainly been my experience and I see the threads of PDP training woven into my work each and every day.

2.3 AstroPALS peer mentoring —Samantha Walker

My initial experience with the Institute for Scientist and Engineer Educators Professional Development Program was very early in my graduate student career, during my first year in graduate school. It was this exposure to the PDP mentoring model and my experiences adjusting to my department during my first year, including feeling isolated from my peers as one of only a few Hispanic graduate students in my department, that motivated me to spearhead a new community-led peer mentoring program. With a small group of graduate students, many of whom were also ISEE PDP alumni, we started a peer mentoring program called Astronomy Peer Advising LeaderS, or AstroPALS, the summer of 2018, after my second year of graduate school. AstroPALS was designed to provide better support structures for incoming graduate students in the context of an astrophysics and planetary sciences department at a public R1 institution, the University of Colorado Boulder. While the idea a peer mentoring program was based off the successful program at Georgia State University (AstroPAL, n.d.), we developed our program around different core goals. AstroPALS has three goals which are: 1) creating an inclusive culture and supportive community, 2) reducing feelings of isolation felt most acutely by students with marginalized identities, and 3) elevating student voices and concerns in order to effect positive change. The program was designed to encourage and engage in active and purposeful mentorship based on the PDP core theme of Equity and Inclusion. We focused on Equity and Inclusion in mentorship from among the PDP themes as it has been shown to be crucial in the retention and success of underrepresented minorities (URMs) in STEM (Seagroves et al., 2018).

Specifically, while designing AstroPALS and in the years since, we have implemented a few of the practice-oriented focus areas recommended by the ISEE PDP regarding Equity and Inclusion (Seagroves et al., 2018). For example, we structured AstroPALS to enable participants, who are primarily graduate students and postdocs in astrophysics, planetary science, solar physics, and space physics, to be able to productively participate with this program in multiple ways. First, each fall semester, we structure AstroPALS into smaller groups or pods, of about four to five people, generally including one

postdoc and multiple graduate students across years, where we pair people based on multiple factors, including, but not limited to, research interests, career goals, and hobbies outside of graduate school. In this way, we aim to help graduate students and postdoc participants form a community of peers, where people have different backgrounds and experiences. This structure also helps early graduate student participants learn how to navigate graduate school and upper year graduate students and postdocs gain valuable mentoring experience.

Another way in which AstroPALS implements Equity and Inclusion focus areas of the ISEE PDP, including leveraging participant's goals, interests, and values and helping participants develop their identity as a person in STEM, are through workshops which we host a few times a semester for all participants based on community-suggested topics. For example, with inspiration from Dra. Nicole Cabrera Salazar, we developed a workshop about thriving as a minority in Boulder, a predominantly white town, through a self-care framework. One of the activities during this workshop includes value affirmation statements about things that are important to participants. Value affirmation has been shown to reduce the achievement gap of URM students compared to white students in other contexts (Jordt, et al., 2017). Another workshop we host at the end of every spring semester is a summer research strategies workshop, aimed at helping early graduate students develop a positive STEM identity or seeing oneself as a "science or engineering person," which has been shown to be linked to pursuing a career in STEM among women of color (Carlone & Johnson, 2007). As part of this workshop, we have participants fill out a handout to affirm their general values and describe their expectations for the summer. This exercise is designed to help students structure their weeks during the summer, when research is carried out full time, by applying a backward design approach based on their goals for the summer. In this way, we aim to help participants develop greater ownership of their work, including feeling proud and accomplished about their work for the summer.

The core themes and focus areas of the ISEE PDP are far reaching and provide a practice-oriented framework that participants can build on in their own lives. I have found them particularly helpful in the context of mentorship, especially as it relates to the design and implementation of a peer mentorship program like AstroPALS among graduate students and postdocs. AstroPALS was inspired by the PDP theme of Equity and Inclusion and some of its recommended focus areas. We continue to incorporate this theme through the pod group structure at the heart of the program and the workshops we host. Since its founding, AstroPALS has continued to offer peer mentoring informed by research and practice.

2.5 Panel participant feedback

This panel occurred on May 20, 2022 at the "Advancing Inclusive Leaders in STEM: 20 Years of the PDP" Conference (PDP 20-year Reunion Conference, 2022). There were two portions of the panel dedicated to attendee feedback.

Attendees were polled with the following prompt: "What words or *short* phrases capture key aspects of mentoring that you took from the PDP?". The responses are shown in Figure 1. A key take-away is the broad grouping of responses into two themes: support for the mentee's STEM identity and attitudinal posture ("growth mindset", "STEM identity",

Figure 1: A word-cloud of panel attendees' PDP-inspired "key aspects" to mentoring. The size of the text indicates frequency in response. "Growth Mindset" made up 10% of attendee responses.

"confidence", "trust", "equity", "respect", "agency", "patience", "belonging", "community", and "recognition" make up 50% of responses); and intentionality of designing the mentoring experience ("Intentional" and "Backward" Design; "Scaffolding", "Guidance", and "Facilitation" make up 20% of participant responses). The attendee responses paint a picture of the PDP mentoring model being a carefully designed experience that is aware of, and supports, the mentee's identity within the STEM community of practice.

The second prompt for feedback at the panel was an open-ended question: "How have you integrated PDP mentoring practices into your current work?". Selected answers are listed below:

- "Providing space to let my mentees express their goals and values so that I can offer my time, energy, and resources to facilitate their path toward their goals. Their wants/needs drive my efforts — I'm not trying to pull them to where I think they need to be."
- "Encouraging my students to develop growth mindsets and take ownership of both their projects and our lab community."
- "Changed [the] way I design undergraduate summer research projects, incorporating backwards design and more emphasis on inquiry. I now incorporate formal, up-front discussion about mentoring styles, check in about frequency of interactions."
- "Mentoring workshop to grads, post docs, faculty for working with undergrads in research. Using PDP principles centered on transferring ownership, inclusive mentoring practices."
- "My experience is mainly with constrained projects due to organizational/project priorities, but I still am [able] to find some piece that my mentee can have complete agency/ownership over and support/scaffold them in executing the task."
- "I sometimes mentor African students who want to go to astronomy graduate school. I try to support their identity as a person in STEM."
- "I practice PDP principles with my co-workers, especially giving constructive feedback."
- "I try to be super transparent with my students, sharing what techniques and concepts I found challenging — so they'd feel reassurance if they too struggled. Likewise, I am transparent with my reasoning and experimental design to help the students build their own reasoning skills."
- "Authentic STEM practices; I run a summer undergrad program where they get to do a research project with faculty, and partner with high school students to introduce them to science and research; my mentees become mentors in the program"
- "Intentionally share the rationale/motivation behind *why* I'm asking the mentee to do what I have them do or they've done themselves."
- "Starters for new students to inspire and give them context for project options. Give students ownership by letting them choose from an array of projects with different content, skills practice, and outcomes."
- "Attempting to foster a growth mindset by encouraging working through being stuck and providing encouragement through that process. Giving precise feedback. Making my thought process visible and encouraging students to do the same. Trying to bring in student experiences and make the learning more personal for them. Try to guide students to their desired career outcomes rather than my assumptions about their outcomes. (I'm a postdoc, co-mentor 5 grad students)"
- "Trying to display my own thinking, modeling my way of working through a problem, being open about what I don't know or am stuck on"
- "Encouraging a growth mindset."

- "Knowing that students don't arrive as empty boxes but as people with beliefs, and that those beliefs can be changed, has helped me be much more patient. I'm also more likely to say 'I don't know, let's figure it out.'"
- "Being more thoughtful about providing useful and wise feedback"
- "I run a department grad student peer mentoring program and created a coalition of several other department peer mentor programs to share ideas, resources, build division wide community and advocacy"
- "I focus on creating projects and opportunities where students have ownership over their own learning. This empowers them to lean in to discussions, labs, etc."

It is evident from these comments that the PDP alumni community is engaged in mentoring in diverse settings, each with their particular goals and constraints. The PDP has provided us with core principles of mentoring that guide our current work.

3. Summary

The PDP has provided a framework for participants to apply towards mentoring. Common elements are visible within the three panelist reflections presented, and in the participant feedback. Our PDP training emphasized intentional design and the "Backward Design" paradigm provided an outcomes-based and evidence-based approach to this work. PDP alumni continue to work to support mentees' STEM identity and encourage their ownership and agency. Some PDP practices that have been adopted by PDP participants in their mentoring include: providing scaffolding, supplying constructive feedback, and building independence and confidence. The PDP core theme of Equity and Inclusion is apparent in the programs and methodology of PDP alumni in their mentoring programs (e.g. AstroPALS). Programs inspired by or built upon PDP mentoring principles span a variety of venues and audiences. We see programs for: undergraduates, graduate students, post-docs, and faculty in academia; in industry settings; and in government agencies and labs. The ISEE community has a shared vocabulary, toolset, and ethos that continues to inform alumni mentoring some 20-years after the inception of the PDP.

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