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Publication Date

2022-09-05

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The Unseen Impact of Inclusive Professional Development and Pedagogic Training on Underestimated Minority Graduate Students

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Abstract

Ostensibly, the main goal of the ISEE Professional Development Program (PDP) is to teach scientists and engineers how to be intentional, inclusive educators by experiencing and designing inquiry-based learning activities. However, the PDP program has many indirect, positive effects on its participants as well, including building community and a sense of STEM identity, fluency to understand and discuss diversity, equity, and inclusion topics, and recognizing the importance of psychological safety in learning, academia, and industry. We present four narratives from past participants with underestimated minority identities, who discuss how the PDP program had a positive impact on their growth as scientists and engineers. In each case, the PDP provided critical tools, knowledge or support that enabled their success as graduate students and into their respective career and life journeys.

Keywords: community, equity & inclusion, growth mindset, metacognition, psychological safety, recognition, STEM identity

1. Introduction

During the “Advancing Inclusive Leaders in STEM: 20 Years of the PDP” Conference in Hilo, Hawai‘i on May 19–20, 2022, the PDP community came together to reconnect, share their past and current PDP work, and discuss how to improve and

continue PDP-related work at various scales. In addition, participants reflected on the impact and outcomes that the PDP program had on their respective life journeys and careers.

In the course of engaging in these discussions, it became evident to several conference participants that an important but not yet documented component of

the PDP's impact was in providing the tools, information, community, and psychological safety that enabled participants to thrive, especially those who identify as members of underestimated minority groups (see Section 3.1). Anecdotally, many conference participants commented in closing celebration testimonials and formal or informal discussions that they stayed in their STEM (science, technology, engineering, mathematics) graduate programs because of the PDP and that their PDP experience influenced their entire career.

The impact of the PDP on conference participants in relation to community and life journeys is reflected in the number of times participants attended the PDP (Figure 1) and number of attendees per program year (Figure 2). Excluding the original core PDP instructors and staff, 75.6% of attendees at the 20-year reunion participated in the PDP more than once and 44.6% participated three or more times. Of the PDP participants, 20 eventually became PDP instructors (27.4%). The distribution of PDP participation year suggests that there may be a stronger sense of community among specific years (Figure 2) although this is likely compounded by other factors such as where people are in their careers (early participants are likely to be in senior positions and have less time to attend conferences) or this pattern could be attributed to other factors, such as number of participants in specific years. Although the conference attendees were self-selecting, these data reflect the strong, enduring community of the PDP and the value of multiple years of PDP participation. The career identification of attendees also reflects the impact of the PDP across multiple types of careers (~34% primarily teaching focused, including lecturers, teaching faculty, and science educators; ~25% tenure/tenure-track professors, ~10% primarily research-focused, including university and government researchers; ~21% graduate students and postdocs; ~11% industry/non-profit). The number of participants that eventually became PDP instructors also illustrates the desire of participants to maintain and amplify the impact of the PDP.

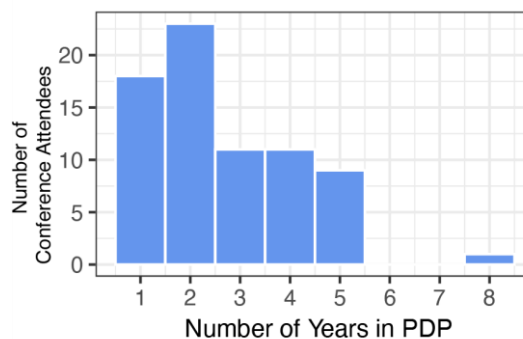


Figure 1: Number of years that attendees of the 20 Year PDP conference participated in the PDP. Total number of attendees represented is 74. Four of the attendees first participated in 2019 and thus would not have had the opportunity to have multiple PDP training experiences. Figure generated using ggplot (Wickham, 2016).

In this manuscript we explore some of the reasons that PDP participants found the program so valuable. Specifically, we discuss how the PDP has intertwined Diversity, Equity & Inclusion (DEI) with teaching STEM skills in a psychologically safe and inclusive environment, and how this approach benefitted participants beyond training in pedagogy, into their respective careers, and more.

2. Methodology

All authors discussed the impact of the PDP on their careers and agreed on themes and topics to highlight in personal narratives. The four narratives presented highlight the impact of the PDP on STEM careers in relation to the role of metacognition, sense of belonging in STEM, community, DEI topics, confidence to conduct research, and psychological safety. The narratives are by former PDP participants who self-identify as coming from an underestimated community group (see Section 3.1). These narratives began as group oral discussions from the conference, and here take the form of written critical self-reflections which examine the impact of the PDP program in our respective life and career pathways.

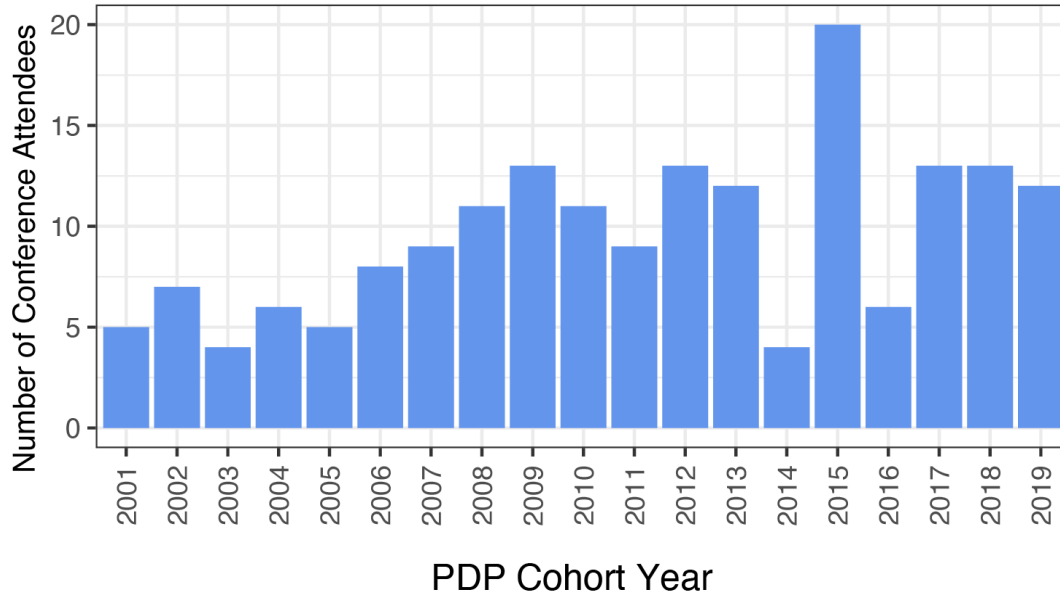


Figure 2: Number of “20 Years of the PDP” conference attendees that participated in the PDP in specific years. Note that the same attendee may have attended the conference multiple years as illustrated in Figure 1. Figure generated using ggplot (Wickham 2016).

3. Definitions

3.1 Underestimated minority or group

In higher education, the evolving use of terms to describe minoritized or marginalized groups, such as “underserved minority,” “underrepresented minority” (URM), and “highly underrepresented group” have good intentions, but are often seen to lack sensitivity and are ineffective in describing the disparities of specific subset groups. In addition, these blanket labels do not acknowledge the unequal outcomes of different groups of peoples for various measurable indicators (i.e., health, economic, etc.). For example, in the continental United States and Alaska, the term “Asian American and Pacific Islander” (AAPI) category sidelines the diverse heritages of hundreds of ethnic groups and, ironically, the long-term effect of using this term has been erasure of these groups’ distinct identities (see Empowered Pacific Islander Communities, n.d.; AAPI Nexus, n.d. Data/Data Disaggregation; National Commission on Asian American and Pacific Islander Research in Education, n.d.). Page et

al. (2013) developed and deployed a cross-sectional survey of 106 diverse leaders in U.S. academic health centers and found the definition of URM varied widely.

The authors of this manuscript come from four distinct social, cultural, and linguistic backgrounds and wanted to use a term that reflected our commonality but also honored our distinct communities at the same time. As such, we use the emergent term “underestimated minority” (see use in Bradley, 2019; Simon, 2021; Sun, 2019) to describe a subset of a population that have historically faced negative bias by a dominant perceived norm (i.e., beliefs about the consensus views of others).

3.2 “Growth” vs. “fixed” mindset

The concept of “growth mindset” (Dweck, 2007; Blackwell et al., 2014) is taught during the PDP inquiry institute training (Hunter et al., 2010b) and describes a view that intelligence can grow. In contrast, a “fixed mindset” describes the view that the intelligence someone has is what they were born with and cannot be changed. The PDP encourages participants to use language that promotes a growth

mindset for their learners, as it provides resilience against the negative effects of stereotype threat and failure, improved motivation, and increased performance (Hunter et al., 2010b).

3.3 Psychological safety

Psychological safety was first defined by Dr. Amy Edmondson as “a shared belief that the team is safe for interpersonal risk-taking” (Edmondson, 1999). Psychological safety can refer to (1) the feeling of inclusion, that you are accepted for who you are, (2) the feeling that it is safe to make mistakes, experiment, and ask questions as you learn, (3) the feeling that it is safe to contribute to the group, and (4) the feeling that it is safe to challenge others in the group or the status quo, especially without the risk of damaging personal standing or reputation (Clark, 2020).

3.4 Metacognition

Metacognition can be described as self-monitoring during learning (Flavell, 1971; Georgiades, 2004; Hunter, et al., 2010a). Metacognition is an awareness of one’s thought processes and patterns and often comes in the form of internal dialogue. The PDP encourages its participants to metacognate (Seagroves, et al., 2010) and the structure of the PDP training itself with jigsaw discussions and other opportunities to reflect facilitates metacognition.

4. Individual narratives

4.1 Lauren Lui, PDP participant 2011, 2012, 2013

The PDP had a tremendous impact on my career and self-esteem by not only giving me the confidence to be a more effective STEM educator, but also by providing me with a community and a space to reflect on what being a STEM professional meant to me. I decided to pursue a career in scientific research because of my natural curiosity to discover how the world works and my desire to use that knowledge to improve the world. However, at the

time that I participated in the PDP, I felt stifled by the emphasis on papers in graduate school and the need to publish in top journals; my self-worth was wrapped up in what novel findings I could get from my research. My experience in the PDP allowed me to (re)discover my love of learning and exploration of the world, recognize the diversity issues I was facing as a STEM graduate student, and build a community that supports me to this day.

I entered the Bioinformatics doctoral program at University of California, Santa Cruz in 2007. Participating in the PDP in 2011 was one of the first places where I felt valued for caring about teaching, and I went on to participate in 2012 as a Design Team Lead and in 2013 in a special project group. In my graduate program, the emphasis was of course on research. However, although there was an expectation that most of us would aim to be professors, there was also a strong impression that spending too much time on lectures or grading was a waste of time. This perspective was in conflict with my own values to care about my students and how I presented course material. Now more than ever, I understand that the PDP presents an alternative to lecture-based education where people with different learning styles can thrive. A learner-centered approach felt radical to me because this approach meant that anyone could learn material if they found the right avenue for absorbing it. Previously in higher education experiences, I had the impression that if I couldn’t figure out the material, it pointed to a failing of my own intelligence. Reflecting on the PDP 10 years after I first participated, I see that “Beliefs about learning, achievement, and teaching” is a core item in the Diversity and Equity Theme of the PDP (Hunter et al., 2010). Finding a community that had a more inclusive view of learning was the first time in graduate school where I didn’t feel like it was odd to care so much about teaching and science education.

The PDP provided a space to discuss STEM processes in relation to pedagogy, but it also gave me a safe metacognitive space to think about what I was

doing with my own research. With a growth mindset I realized that I could *learn how to figure out a problem*, that there was no inherent problem-solving ability that some people had and others didn't. These inquiry lessons taught me that I could improve my problem-solving skills and I wasn't stupid for not being able to predict the outcome of my experiments. That perspective feels a little silly now that I understand how much failure is part of the research process, but it was a major roadblock in my development as a researcher that finally broke by embracing a growth mindset. Often STEM is achievement-oriented, so learning that development of my own abilities was more valuable than trying to chase down the next great discovery in my field was a revelation. The simple act of naming specific STEM processes, such as building a model, helped me realize that I had primarily thought of STEM as a series of facts and theories and not also as a process of solving questions.

The PDP provided a space to think about the research process (what I was supposed to be learning in graduate school) in part because I did not worry about the DEI issues I was facing at the time. Participants in the PDP were more diverse than my graduate program, especially in relation to gender equity, so simply being in the PDP environment made me realize how aware I was of often being the only woman in a room in my graduate program, or being a racial minority. The nearly equal gender ratio, higher racial diversity, and openness to discuss diversity issues in the PDP made me feel comfortable. Learning about the social science studies of negative bias showed me that not only did people care about DEI issues enough to gather data and demonstrate what was happening, but also that I was not the only one experiencing these issues and that they could be named. In the PDP, I am treated based on the person that I am, not who I am perceived to be based on my appearance. Participating in the PDP gave me a vision of what it *could be like* for me in science and engineering without the extra

psychological burden coming from being an individual from an underestimated group and experiencing microaggressions.

Potentially the biggest lesson I learned from the PDP is that I had set my own values in accordance with the power structure around me, rather than asking myself what my values were. When I taught as a teaching assistant, my colleague told me that I was very good at lecturing. This was surprising to me because at the time I felt like a terrible public speaker. I realized that when I taught, I forgot about how I was being judged as a scientist and I focused on communicating information. Although I love discovering how the world works, I also like helping others understand ideas and scientific concepts. I find that when I approach my presentations as teaching opportunities, even if it is a scientific presentation, my audience understands my main points better. Working in accordance with my own values, such as helping others understand something new or discussing diversity, is when I shine the most. I feel like myself and I don't need to hide who I am. Although in the PDP we learn that values affirmation is a way of negating the effects of stereotype threat (Cohen, et al., 2006), I did not realize how important it has been for me in relation to my self-esteem as a STEM researcher until the 20 Year PDP Conference.

The PDP community is inherently collaborative and provided an example of what STEM could be, rather than the fierce competition that permeates many STEM fields. Unfortunately, the current US research system often encourages competition rather than collaboration, but the PDP community provides a vision of how the system could be more collaborative and place higher value on DEI. I am starting to see more emphasis and value of DEI in evaluations and grant applications, so I am hopeful that the system can change, especially with impactful actions by those in the PDP community and others with similar intent.

4.2 Danica Roth, PDP participant 2011, 2012, 2014

As an undergraduate transfer student majoring in physics and astrophysics at the University of California, Berkeley (2008), my ADHD often left me feeling lost and out of place, blindly copying derivations from blackboards without conceptual context. I learned to do well on exams and assignments by following a formulaic approach to problem solving, but I struggled both with developing a deep understanding of material and with what I now understand to be gender bias and imposter syndrome as one of a small handful of female students in any given STEM class. While I grew to identify as a feminist in college, this identity was entirely distinct from my STEM community and rooted in student activism rather than an awareness of social sciences research. As a PhD student, I entered the geosciences—the least racially diverse STEM field (Dutt, 2020), which, while more gender balanced than physics, also struggles with issues of gender equity, harassment and assault, particularly in field settings (St. John et al., 2016; Marin-Spiotta et al., 2020; Giles et al., 2020; Mattheis et al., 2022). While I had some outdoor experience, I had never attended the field camps required for most undergraduate geosciences students and did not yet feel confident in a field setting. A chronic autoimmune condition and asthma also left me embarrassed about my inability to keep up with my lab mates' early starts and strenuous hiking speeds in the field.

In 2011, during my second year of grad school, I TAed for a PDP alumn who introduced me to Carol Dweck's growth mindset literature and encouraged me to apply to the program. My first year in the PDP was life altering. The PDP introduced me to cognitive and equity-related social sciences research, which both helped me understand the context of my experiences and indoctrinated me to the practice of following this research. The metacognitive tools and knowledge I gained helped me understand and improve my own approaches to learning, in particular around my ADHD and what I soon realized

was a fixed mindset. For the first time, I viewed my experiences through the lens of social sciences research and understood that much of what I had perceived as my own failing was due to pedagogic methods well known to be non-inclusive and less effective—not only for women and students with ADHD, but for most learners. The PDP showed me that I was not alone in struggling to understand the rapid chalkboard derivations, or in feeling like an imposter. Over the years, the awareness that my experiences are not unique has served as a foundational source of assurance and a tool to combat imposter syndrome.

The PDP also gave me a sense of belonging and community for the first time among scientists and engineers who valued inclusion and making STEM fields more accessible to people like me. The PDP was the first time I felt like all aspects of my identity were truly valued and respected in an academic community. Reflecting back, I think learning that such a community existed early in my graduate career shaped my impression of STEM fields and inoculated me against burnout when I encountered less inclusive or even toxic STEM communities in the future.

The PDP community also opened further doors to growing my knowledge and building the support networks that would sustain me throughout graduate school, an isolating postdoctoral fellowship and into the tenure-track position I hold today. For example, several friends I met through the PDP were also involved with Women in Science and Engineering (WiSE) at UC Santa Cruz, including Lauren Lui (co-author of this manuscript and WiSE President). PDP participant Carley Corrado introduced me to WiSE outreach, which led to my involvement and eventual officership. PDP participant Tisha Bohr and I eventually co-ran the WiSE outreach program for several years, and, along with two other officers, later co-founded a reading group for equity in STEM.

Awareness of research on equity and inclusion gained through the PDP and these later pursuits

equipped me with the tools to both be a more effective advocate and to recognize and develop strategies to deal with adversity I encountered throughout my own career. For example, one of the first and most impactful concepts I learned at the PDP centered on community building. I later came to appreciate research indicating that the lack of a sense of belonging or identity and the perception of a lack of shared values (Cohen and Garcia, 2008; Huntoon et al., 2015; Sherman-Morris and McNeal, 2016; Carter et al., 2021) are major reasons that underestimated students often leave STEM fields, and the geosciences in particular with our non-inclusive field culture. My own career trajectory can in large part be attributed to the community I gained through the PDP, and the communities I built with informed intention after leaving graduate school.

4.3 Lelema Irvine, PDP participant in 2012

Much is known about the extreme need of underestimated students to pursue higher education and careers in STEM. The paucity of Native Hawaiians in STEM is even more acute. In 2011, at the time that I entered the Civil and Environmental Engineering (CEE) Ph.D. program, there existed only two Hawaiian faculty members in STEM—that I was aware of—in all of the University of Hawai‘i at Mānoa (UHM).

After completing my BS in bioengineering (BE) in 2009, that summer I went to Dresden, Germany to study riverbank filtration with Dr. Chittaranjan Ray (he/him/his) and Dr. Thomas Grischek (he/him/his). That was an amazing research opportunity. Fast-forward to spring 2011, I was walking down the stairs of Kuykendall at UHM when I ran into Dr. Ray. He lovingly stopped me to check in on me. Dr. Ray encouraged and invited me to apply to the UHM CEE Ph.D. Program. He mentioned that if I got in that I would be the first Hawaiian in the program. At the time of our conversation, according to Dr. Ray, the CEE program never had nor graduated a student with (verifiable) Hawaiian ancestry in

their Ph.D. program, likewise for the College of Engineering. That conversation with Dr. Ray uplifted my spirits—nudging me forward on my dream career path.

Since taking an introductory BE course as an undergraduate, I set my heart’s compass toward becoming a Professor. I belong to a generation that was born with analog technology but grew up during the expansion of the internet. Since I was a first-generation college student in a time before ubiquitous internet access, I did not have the accessibility to learn about the professoriate beyond what I experienced in my courses. When I took my introductory BE course in college, that was the first time that a professor explained what it means to be a professor. From that lecture, I came to the realization that the pathway exists and Dr. Daniel Jenkins (he/him/his) was the first to show me the road map to the professoriate. He awakened in me that idea that the professoriate has potentially a high impact for current and future generations. Instead of being a medical doctor treating a certain number of patients, I would rather be the professor to train multiple doctors to treat more patients than I could combined. Thank you, Dr. Daniel Jenkins for sharing with me the pathway of what it means to become a professor. From that class forward, I sought out advice from many sources to learn how to become a professor.

Sometime during the 2011–2012 academic year, I received a direct email from Lisa Hunter who encouraged me to apply to the PDP program. She knew me from when I participated in the Akamai Program in the year 2006. With her compassionate encouragement, I did and was accepted as a PDP participant. From my personal experience, personalized emails to potential students go a long way to motivate students to apply to programs. Why? Lack of structural and cultural resources coupled with feelings of personal inadequacy are legitimate barriers that contribute to students of higher education to leave STEM (Seymour, 1992; U.S. Department of Education, 2006). Just by suggesting to a student that they consider a program helps them expand

their options and makes them feel valued. The targeted email by Ms. Hunter provided the extra evidence showing me the invalidity of such a flawed internal dialogue and the unconscious limitations I placed upon myself.

The PDP program gave me the vocabulary through evidence-based practices to learn how people learn STEM. Through love, the program taught and gave us tools we can use to teach others. From the entire program, “metacognitive thinking” is what I took away from PDP and use daily in my engineering/scientific practices. Without shame, PDP instructors showed through their actions by modeling “metacognitive thinking,” the fancy way of saying “thinking out loud.” I was struck by the openness of PDP to share freely without expectation of anything in return—something that resonated with values that my father taught me at home, however, my undergraduate and graduate experiences in Engineering at UHM were oftentimes siloed as compared to the interdisciplinary approach of the PDP.

The PDP experience of going to another island, learning and networking were instrumental in my development as a scientist/engineer and an academic. At the workshops, there was limited time to interface and build relationships with other participants but we made the time and still did. These relationships have carried me through graduate school and to this very day as a professor. Although I was unable to continue with multiple PDP programs due to my demanding graduate degree program, experiencing one iteration of the PDP program was sufficient enough and gave me enough nutrients, seeds, soil, and water to grow into the thriving plant that I have become. The PDP reunion conference was a productive time to reflect on the pluses, minuses, and deltas of the two-decade history. In addition, it allowed opportunities for participants across various cohorts to meet, network, and intellectually cross-pollinate with each other. The PDP multiplier effect will continue beyond this paper and our lives. I look forward to what unfolds in PDP 2.0 and beyond.

4.4 Gabriel Roybal-Jungemann, PDP participant 2007–2011

I grew up as a queer person of color in the small town of Pojoaque, New Mexico. Pojoaque is a community in which minorities compose the majority of the population. According to the 2012 U.S. Census, New Mexico was one of the five “majority-minority” states/districts which also included California, Texas, Hawai‘i, and the District of Columbia. As a result, my community was composed primarily of Latino, Indigenous and Hispanic people.

Pojoaque is located just fifteen miles from Los Alamos National Laboratory and yet there are significant disparities in education, economics, health justice and opportunity between the two towns. Growing up, I had limited context of how to navigate higher education, how to achieve success in STEM, and moreover that I would be in a minority outside of Pojoaque. I became acutely aware of these disparities when I left Pojoaque to attend the University of Pennsylvania in Philadelphia. In this new environment I attempted to excel in STEM, in which I was an underestimated minority. Along with friends, I became one of the inaugural participants in La Casa Latina: Center for Hispanic Excellence, which provided a sense of community, mentorship, leadership opportunities, and a safe space to share the challenges of being a minority in the Ivy League.

During my undergrad years, I started to believe that I was inherently less intelligent and capable than my counterparts in STEM. I started to force myself to behave like the majority in the hope that I would be passable enough to be considered as competitive, naturally intelligent and to express my unique voice, thought processes and style. While this form of distress tolerance allowed me to succeed in fields in which I was nearly always a minority, it was at the expense of psychological safety, a genuine sense of belonging, and a distorted sense of self.

As a PhD student, the PDP was the first framework I was provided to deploy approaches that prioritize Diversity, Equity and Inclusion in education. The

PDP provided me with a framework and a scaffold to become the mentor and manager that I previously needed as a queer person of color in higher education STEM. The PDP provided me with the capacity to create innovative curriculum, inclusive inquiry activities, novel approaches to mentoring, and the courage to create an environment that not only includes but celebrates diverse approaches, unique thought processes, and multiple ways to achieve success. The PDP laid a solid foundation and established a thematic series of experiences both as a teacher and as a learner within the Native Hawaiian Community College system, Hartnell Community College, and the UCSC Workshop for Engineering and Transfer Students.

I credit the PDP with providing me the skillset to be a successful recipient of the NIH IRACDA Scholars in Science Postdoctoral fellowship. This fellowship allotted me with funding as well as protected time to teach at San Francisco State University which is a minority serving institution. I have benefited professionally and personally from the network of mentors and advocates within the PDP community and often draw on this community for a source of motivation, insight and a sense of belonging.

Since leaving academia, I have drawn on my experiences at the PDP to create an inclusive and mentee first approach to management in industry. The foundation I developed regarding how people learn, malleable mindset, multiple approaches, and multiple ways to succeed have allowed me to identify and highlight my teams' unique styles and to provide opportunities to new hires that are from professional backgrounds that are not traditionally represented within industry. Moreover, the PDP has provided me with a scaffold to consistently focus on Diversity, Equity, and Inclusion in my approach to hiring, mentoring, and creating safe spaces for underestimated minorities within my organization.

5. Conclusions

During the 2022 PDP Conference, Anne Metevier presented the PDP core team's elements of "AISLEs", or "Authentic, Inclusive STEM Learning Experiences" as a replacement for the term "inquiry" in PDP training (Figure 3; Metevier et al., 2022). She commented that the aspects of AISLEs make stronger connections to DEI, and specifically to ISEE four E&I focus areas used in the PDP (Seagroves, et al., 2022). Some of the participant experiences described in the narratives here reflect this observation, including exercising agency in learning STEM practices and participating in social aspects of doing STEM. Some of the participant experiences described in the narratives here reflect this observation, including exercising agency in learning STEM practices and participating in social aspects of doing STEM.

Although there are only four individual experiences recorded here, we have highlighted themes that appeared in many discussions with other participants at the 20 Year PDP Conference. We therefore suspect that, while the narratives we record here describe our personal experiences, these experiences reflect those of other participants as well. The PDP program provided tools for us to understand the DEI issues we were facing, but also language and agency to discuss them and make a difference in our respective communities. The environment of metacognitive thinking also provided an avenue to reflect upon what we were learning in graduate school and become better researchers. Finally, and perhaps most importantly, the PDP created a psychologically safe space that reflected our values and made us feel valued and respected as individuals. This, in turn, allowed us to recognize and find healthy ways of coping or disengaging with STEM communities in which we felt unsafe or undervalued. The PDP trained people in how to change STEM culture and teaching, but it in itself was a microcosm of what the program was attempting to achieve in the broader STEM community.

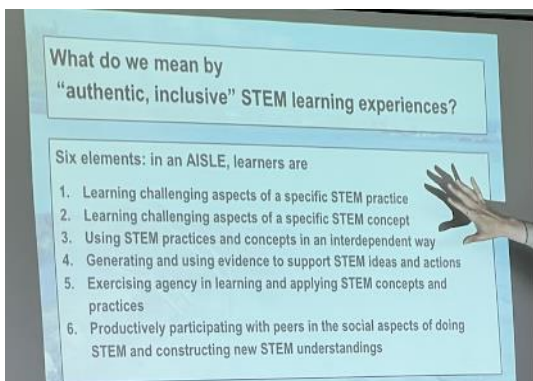


Figure 3: Anne Metevier presenting “ISEE’s Framework of Six Elements to Guide the Design, Teaching, and Assessment of Authentic and Inclusive STEM Learning Experiences” during the 20 Years of PDP Conference.

Acknowledgements

Danica Roth and Lauren Lui acknowledge that the UC Santa Cruz WiSE community played a large role in amplifying PDP experiences and lessons about DEI and community. Many other WiSE officers and members not directly mentioned in this article also participated in the PDP.

This work was funded in part by the National Science Foundation (NSF), AST#1743117. The PDP was a national program led by the UC Santa Cruz Institute for Scientist & Engineer Educators. The PDP was originally developed by the Center for Adaptive Optics with funding from the NSF (PI: J. Nelson: AST#9876783), and was further developed with funding from the NSF (PI: L. Hunter: AST#0836053, DUE#0816754, DUE#1226140, AST#1347767, AST#1643390, AST#1743117) and University of California, Santa Cruz through funding to ISEE.

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