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Applying the PDP to Government and Industry Career Pathways

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Abstract

Transitioning from graduate student roles in academia to professional careers in industry and government affords ISEE's Professional Development Program (PDP) alumni the opportunity to apply lessons and techniques learned at the PDP to new environments with new goals. In mission-focused government roles, PDP alumni apply their expertise in inquiry-style teaching to mentor junior staff and develop projects that meet governmental requirements, while preserving STEM learner identities. Alumni find that the principles of inquiry-style teaching have applicability across professional development spectrums — from mentoring high school interns through training postdoctoral researchers and managing teams of diverse career stages. In industry, where fast-paced corporate goals drive innovation, alumni have found that PDP principles in developing explicit content and practice learning outcomes have helped them develop unique roles within their companies. Additionally, across both industry and government roles, all PDP alumni on this panel report that PDP's focus on leadership development, effective meeting strategies, and inclusive management practices have readied them for their post-academia careers.

Keywords: course design, government, industry, inquiry, internships, mentoring

1. Introduction

During graduate school, when striving to earn a Ph.D., industry and government career pathways are often referred to as 'alternative career paths,' despite studies that show more people now enter STEM disciplines of industry and government than become professors (The Royal Society: Science Publishing Centre, pg. 14, 2010). While the fundamental skills necessary to be a skilled scientist or engineer are technically the same, the relative importance of soft skill sets for each career path are not inherently identical. Therefore, the skills impressed upon graduate students to be important from their academic advisors or departments are not always aligned with what industry and government agencies seek in job candidates (e.g. Hancock & Walsh, 2014; Fuhrmann et al., 2017). To address this disconnect, some studies on graduate school education for STEM doctorates recommends supplementing technical development with professional skill development through internships or extracurricular professional organizations (Hancock & Walsh, 2014; Fuhrmann et al., 2017; Schnoes et al., 2018). At the University of California Santa Cruz (UCSC), the Professional Development Program (PDP) by the Institute for Scientist and Engineer Educators (ISEE) served this role for STEM graduate students across a wide range of disciplines for a diverse assemblage of universities.

This panel paper serves as a detailed anecdotal synthesis of how four alumni of PDP have applied the principles and lessons from the program to their jobs in industry and/or government. Additionally, we include a summary of pertinent conversations held during this panel at the 20-year PDP reunion (May 18–21, 2022, Hilo, HI). The authors and panel participants in this paper represent a portion of the ever-growing majority of post-baccalaureate graduates that have ended up in industry and/or government roles. As such, this paper aims to highlight the applicability of professional skills imparted by participation in the PDP. Furthermore, as we evolve in our careers, we envision future opportunities where we may continue to implement lessons learned from the PDP and ISEE.

2. High school and undergraduate mentoring at JPL

The Jet Propulsion Laboratory is a federally funded research and development center and NASA field center in the city of La Cañada Flintridge in California, United States.

To support the robotic space exploration mission work, the Deep Space Network (DSN) presents telecommunications infrastructure including antennas, high-power transmitters, sophisticated receivers, and complex ground station processing hardware and software to the spacecraft in deep space (more distant than the Earth's moon) to allow these spacecraft to talk to Earth. Unfortunately, the DSN is burdened by lack of funding and aging infrastructure, including information display and command software for the operators of the telecommunications equipment. Attempts to update this software in the past were met with resistance, in part due to the long development times and lack of interaction with the operators who must then use the software. My colleague Krys Blackwood and I saw an opportunity in which participatory design with operators and realistic design simulation tested iteratively with those same operators could yield to operators accepting the software once it went live. But there were only two of us, and there was a lot of work to get us to that stage.

2.1 Intern project design

Krys and I recruited student interns to design and develop concept software for operators of the DSN. Student interns included high school, undergraduate, and graduate students; internship durations were 8 weeks (high school) to 10 weeks or more. There were three key areas an intern could contribute, because of the broad scale of work we needed to accomplish. User research is a task in which an intern learns what operators of the DSN do now, what works well, and where the inefficiencies are; and invents and tests design hypotheses in a controlled and repeatable way. Design is an activity in which an intern turns knowledge (through research and other means) into testable, visual elements in a variety of media. Software development is an intern contribution which allows designers and researchers to test hypotheses in a realistic, simulated environment, similar to the environment used by the DSN operators. We defined these three key areas based on extensive preliminary research, and came up with many potential contribution paths so that any interested student could find the work that best suited their experiences and growth interests.

The first task each intern had was to define the scope of their work. Krys and I described the problem space and hinted at potential investigation paths. For example, in describing the six-monitor layout of the operator's control center: "The operator then has to find these six pieces of data — here, and here, and here [pointing at different monitors]. Hmmmm!" The implication being that this task is inefficient, and one can find a better way to organize the data for quick readability. It was important that the implication remain just that — implication — because Krys and I intended to invite the intern to ask questions and develop a path to satisfy their own curiosity. Krys and I then worked with each intern to create a custom internship experience with deliverables and stretch goals suggested by the intern and codified in the project plan.

2.2 Hierarchical mentorship and project selection

As any research and design task in which the final solution is not known and there is no right answer, the experience of the interns required real-world problem solving and collaboration. One summer, Krys and I grouped our four interns into two teams. Each team consisted of a team lead who was a senior member (an undergraduate student), and a junior member (a high school student). This breakdown happened naturally, as Team A's students both wanted to work on design and user research, and Team B's students were drawn to software development. We created a hierarchy with Krys and me facilitating the two groups' team leads, and the team leads mentoring the junior members.

Both teams visited the DSN facility and met the operators. They spent one day as anthropologists, observing the operators' work, taking careful notes, and building rapport. Afterwards, the interns, Krys, and I had a session called a brain dump to synthesize what we learned. Together we came up with a design directive: "How do you know everything is ok?" (Meaning: what kind of design can help an operator know that everything is ok?) We broke this down into many questions, including "what does ok mean?" and "where do you look?"

Team A created information designs and developed testing protocols for these designs. Team B began work on a software prototype that could display realistic DSN data so these designs could look real to operators.

2.3 'The switcheroo'

A little more than halfway into the internships, the teams developed interest in each other's tasks. Team A's had created, iterated, and tested their information displays; Team B's software development, which included a "false data pipeline" to simulate any visual information display, was nearing completion. Team B began expressing interest in a new piece of information design to complement the one Team A had completed, and Team A asked whether they could finish their work by coding their design without Team B's help. Krys and I agreed it was a natural transition point, and a natural transition, and we asked the teams to swap roles. Team A began programming work to bring their design to usable software prototype, and Team B worked on iterative paper prototypes to create a new information display. The result at the end of 8 to 10 weeks (high school and college internship duration, respectively) was that each of the four students had the opportunity to contribute in each of the three main areas Krys and I had defined at the beginning of their internship.

In the end, each intern demonstrated mastery in the areas of research, design, and software implementation corresponding to their background and stretch goals; and delivered realistic, tested, usable design prototypes to the DSN project. A full report of our experiences facilitating internships from 2014 to 2020 is found in our full paper (Holloway & Blackwood, 2022).

2.4 Future directions

To Krys and me, one of the most important things we could do as mentors in an internship is to provide an authentic science, technology, engineering, and math (STEM) experience. In many cases, internships with us were the students' first ventures into a STEM field. Our goals were to demonstrate real-life problem solving in a complex, loosely-bounded problem space; and to give students the opportunity to select a project that would sate their curiosity. We wanted students to choose their own adventure, and within that adventure, to experience success as well as challenge. Most importantly, we wanted students to learn to ask their own questions to the best of their ability, and we wanted to expand that ability in the course of their internship.

2.5 Conclusion and lessons learned

Internships provide low-cost labor to projects already strapped for funding. They are also an excellent way to develop and retain workers. Therefore, it is critical to train the kind of worker one would need. Presenting loose constraints and allowing the interns to feel like they design their own projects allows the mentor to act as a facilitator in helping the interns hone their abilities to problem-solve, ask questions, and grow as STEM professionals.

3. Applying PDP principles at NOAA

The National Oceanic and Atmospheric Administration (NOAA) is a government agency with a mission based on science, service, and stewardship. Research positions at NOAA often involve a mix of delivering products to serve the nation and executing basic and applied research to further mission-relevant science. In both cases, two roles in particular can benefit greatly from principles acquired though the PDP: mentoring postdoctoral researchers and leading interdisciplinary research projects. In both cases, a valuable recognition for me has been that while we learned the PDP principles primarily in the context of relationships between educators (or facilitators) and learners, they are applicable and powerful across different career stages and in interactions with all sorts of different formal and social hierarchies.

3.1 Mentoring postdoctoral researchers

Postdoctoral scientists are critical to NOAA's science enterprise. While often employed through universities, they work in NOAA labs and conduct much of the work that makes up the agency's research portfolio. Government scientists who mentor these postdoctoral scholars have a role similar to that of an academic advisor — preparing early career researchers to be confident and effective in all aspects of their future careers (e.g., research, writing, collaboration). Additionally, the hope is that these young researchers will become the next generation of government scientists, so it is important that they develop ownership of a role in contributing to the agency's mission.

When mentoring postdocs at NOAA, the crux of a productive relationship is often finding the right level of direction to allow growth but avoid floundering. In this respect, all of the components, frustrations, and successes of a PDP-style inquiry activity are played out on a larger scale, taking months or years instead of hours or days. When mentoring early career scientists, I can draw directly on my experience facilitating activities and discussions within the PDP. As a research project is being developed, guiding questions help to ensure that the postdoc finds a viable pathway for the research: What phenomena are of interest to you? What is an investigable question? What is the experimental design? For myself as a mentor, the same practices used in facilitating inquiry activities apply: What is the ideal level of engagement and direction? How much does one let the learner struggle on their own before stepping in and providing concrete guidance? Engagement in the PDP, both as a participant and as an instructor, provides the ability to answer these questions in real time and adjust the mentoring style to a given situation. In my own mentoring, I have used this process to tailor the frequency of meetings, adjust the level of autonomy to the individual, and encourage different postdocs to either continue pushing until they solve a problem, or to reach out for a quick solution when the struggle is not productive (e.g., for simple issues with programming syntax).

3.2 Leading interdisciplinary research projects

Within NOAA, there is an increasing desire to break down silos, conducting research across divisions, offices, and disciplines within the agency. In NOAA Fisheries, this cross-cutting research is exemplified by efforts to understand the impacts of climate change on fish and fisheries, which requires collaboration across climate science, oceanography, ecology, and social sciences including economics. As PI of one such project, "Future Seas", I was fortunate to lead a group of 20–30 scientists with diverse expertise, at career stages ranging from graduate students to postdocs, university faculty, and senior government scientists. While these individuals may have had clear roles in a hierarchy in their respective institutions (e.g., supervisors and subordinates, advisors and students), within the context of the project that hierarchy was largely irrelevant.

In managing a group like this, there are several elements of my PDP experience that have been valuable to draw upon. Specifically, there is direct applicability of PDP focus on ensuring that roles are well established, everyone can contribute effectively, voices are heard, and credit is given when due. Establishing roles has been especially important, as the contribution of a NOAA scientist to a research project is often in addition to their regular responsibilities. In these situations, I have found success by ensuring I am up to speed on all the different components of the research and how they interact, to ensure everyone is on the same page about individual responsibility and who needs to provide info to whom. Establishing these roles avoids ambiguity about group hierarchy, which is based on relationships between people in the context of the project, not on inequalities related to a formal or perceived power structure (Bunderson et al. 2016). This focus on establishing roles also minimizes process conflict (conflict over organization of member roles, responsibilities, and relations in order to perform a group's work), which is the type of conflict that has the strongest negative correlation with group performance (De Wit et al. 2012).

Finally, an enduring lesson from my PDP experience, particularly in facilitating group discussions, is the importance of ensuring that all contributions are acknowledged. I have on a number of occasions witnessed the classic case of one person offering an idea that motivates little discussion, only to have it said by someone else later without recognition of the original idea. In one case, during a large group meeting that I was leading, a female professor suggested an avenue for further research, and later a male professor made effectively the same point without recognition of the original idea. In other words, he "hepeated" her (Horisk 2021). In order to amplify the original point and give credit, I noted that this was a good idea and sounded like what she had said earlier in the meeting — a tactic I learned in my PDP experience. The person who made the original point later emailed and thanked me for recognizing her contribution, as this was an all too common occurrence that usually goes unnoticed.

4. PDP principles in data science industry

Included Health is a data-driven healthcare company that aims to understand patient needs, meet patients where they are in their care journey, provide guidance and care where possible, and direct patients to providers who will lead them to the best health outcomes possible. This goal involves an immense amount of medical and population health expertise in addition to data science, and my primary role at Included Health is to enable these population health experts to scale their expertise. This has meant developing software to make machine learning tools accessible, training these experts in the use of existing technology, and working with stakeholders to determine the right processes for scalably developing and validating clinical measurements. In my first months of work in industry, I was unsure of which skills were transferable from academia and what new skills I needed to develop. For several reasons, I found that the skills I had developed during PDP were highly applicable to my new role. Explicitly articulating intended and realized outcomes, similar to student learning outcomes, is a necessity. In the rare cases where management approves a training session, an inquiry-based approach is both efficient and effective. Designing tools with the inquiry-based learning curve in mind increases user buy-in and the overall impact of the work. Simply put, skills taught at PDP respect students' time, intellectual independence, and curiosity — which is precisely the philosophy required for educating professionals.

4.1 Value communication

PDP stresses the importance of establishing clear learning objectives when designing inquiry-based learning activities. For many educators, this sort of task can feel bureaucratic or unnecessary, especially if the learning outcomes are perceived as self-evident or if the instructor is working in isolation. However, there can be no such illusions of inefficiency when designing tools or learning in industry. There is no set curriculum that must be met. There is no student roster. There are no grades or degree requirements. As such, developers will have to answer hard questions from management up front about required time, required resources, and what quantitative impact the work will have. The value of tools and learnings must also be clearly demonstrated to potential users in every step of the process. And upon successful completion, the developer will need to measure and communicate the value of the work so that stakeholders have a tangible reference point for this sort of development.

Before work even begins on building a tool or designing a training program, the cost and benefits of the work must be clearly articulated to all stakeholders. What will this enable users to do that they were unable to do before? How much time and resources will this save users performing these workflows? Employee time is expensive — how much time will this take to develop, and how much time will it take to train new users? The answers to these questions will dictate whether or not it makes sense for the business to invest in the technology, and often plays a big role in the initial scope of the project. During development, these channels of communication should remain open. Unforeseen technical snags often push back timelines and/or limit the impact of the project, and these sorts of changes must be communicated to stakeholders when they occur.

Once initial development is complete, an important value communication tool that is often underutilized is the proof of concept. This is not the same thing as a tutorial. A proof of concept is not a basic training exercise to onboard users to a new technology quickly. Its purpose is value communication. All stakeholders should be able to look at the proof of concept and immediately comprehend the impact it will have. As such, it should focus on a workflow where the impact of the technology is most clearly demonstrated. Within my first 6 months at Included Health, I noticed that analyst workflows were Excel-based and highly inefficient: a single report could require an entire workday for an analyst. It occurred to me that if analysts were familiar with Python this would be much more efficient. So, as a hackathon project, I automated a particularly time-consuming report using a Jupyter notebook, and demonstrated that the workflow could be completed end-to-end in just a few minutes. This gained buy-in from both management and analysts to invest in a Python crash course and study group for our analytics teams, which I led.

After users are onboarded and using a new technology to deliver value, communication remains important to ensure that the value of the technology is maintained and so that decision makers will continue to invest in future technology training.

Onboarding materials and documentation should be centralized, maintained, and easily accessible. A dedicated channel must be established for questions, bug reports, and feature requests. And information should be gathered on the actual impact the technology is having on the business (this often means surveying users directly), with key insights communicated to management. Upon completion of the Python training for analysts, I was encouraged to gather such statistics: about a dozen analysts participated, most of those completed the training, and about 6 began using Python regularly in their reporting. Value communication is essential to project prioritization, and these outcomes gave management the confidence to invest in future training.

4.2 User training

The application of PDP methodology to training itself appears to be self-evident. That being said, organized training events are not particularly common in industry. Employees come and go and technology changes quickly, so the business impact of learning from a scheduled education session typically goes stale within a few months if these considerations are not taken into account. As such, most training in industry settings ends up being self-directed. But this is, of course, where inquiry-based activities shine — the entire philosophy is to encourage and enable self-directed learning. As such, inquiry-based learning as a framework has clear benefits when designing onboarding activities that are meant to last.

In my experience, management does not like to allocate too much time to scheduled group training sessions. It's common to expect a 1-hour meeting, and perhaps a 1-hour follow-up a week later. With this in mind, a general training structure that I have found works well consists of

1. A short introduction with learning outcomes, proof of concept, and links to documentation and communication channel. The goal here is to remind participants why they should care about this session.
2. A short, structured tutorial for learners to complete. The purpose of this section is to have learners iron out any technical issues with installation, basic usage, and a complete example workflow.
3. Individual or small group projects. These projects should be real tasks that are valuable to the business to cement the importance of the learning. The communication channel should be used to field user questions, and there should be time set aside for participants to share out results. This step is especially important — participants will educate other participants, and will often alert software developers to bugs and desired functionality.

I used this framework when leading a training for approximately 20 analysts on how to use Github. Participants were given a short overview of the pain points in current workflows, how versioning work in Github solves these problems, and some Github basics. We ran through an example workflow: making a branch in a codebase, committing to the branch, opening a pull request, reviewing, and merging. From here, users went and completed the workflow themselves, with SQL queries they had developed and needed to be versioned. Github doesn't have a shallow learning curve, and the Slack channel we created was essential for fielding questions and helping with technical issues. All analytics teams now use Github regularly.

4.3 Inquiry-based software design

Lessons for PDP have also had a major influence in the design of the tools that I have built. One of the most common pitfalls for developers is that the tool they are building works, but was not built with the user in mind. This can easily lead to a worst case scenario where weeks or months are spent on development, only to result in the target audience ignoring the tool entirely. There are many resources available for making software that is user-friendly

(Honig 2022, Resource Data 2017, Alcanja 2019). In short, several important questions need to be asked prior to writing a single line of code. For example, what is the best way for the user to interface with the software? How difficult is the software to install? How will users know if they did something incorrectly?

Inquiry-based learning provides a powerful lens through which such design decisions can be informed: specifically, I also ask the question "how will a new user *experiment* with this software?" Probably the largest contribution I have made at Included Health is the development of a SQL templating tool, where a population health expert codifies the details of some clinical measurement — e.g. "Adult patients with chronic hypertension who had complications in the 12 months after a first encounter with a cardiologist" — and the tool is able to spin up SQL to query any of our sources of claims data and make the measurement. The design of this needed to be extremely flexible and intuitive, so that users could experiment with the tool and sanity check the resulting queries. Error messages needed to be clear and specific when users tried something that wasn't allowed, and links to documentation and communication channels were centralized and established early to field questions, bug reports, and feature requests. This paved the way for users to quickly grasp the program's underlying conceptual logic, and become power users of (and contributors to) the codebase.

4.4 Discussion

Overall, PDP emphasizes a style of teaching and learning that is much more organic (in my opinion) than the sort of top-down instruction more typical of most academic institutions. It is for this reason that it has been much more applicable for me. Outside of academia, all stakeholders (potential instructors, potential students, and decision makers) have agency in determining prioritization of instruction, so clear communication about the value of this instruction is absolutely essential. This has a clear parallel to the student learning outcomes we were required to distill prior to development of my PDP group's inquiry activity. Workplace trainings are time-constrained and simply more effective when self-direction and experimentation can be utilized, so the inquiry-based model carries over naturally. And with this in mind, developing inquiry-based activities is a useful exercise for designing software with the idea that the user will — and should — experiment with the software's capabilities instead of trying to sit down and read through extensive documentation (or tutorials for specific use cases). I am not a population health expert, and the population health experts I work with are not experts in statistics, programming, or machine learning. Having the framework to effectively transfer knowledge has made all the difference for me, has multiplied our effectiveness as a team, and has had a measurable and significant impact on the quality of the medical care Included Health members receive.

5. PDP principles in an industrial laboratory

Post-Ph.D., I left inorganic geochemistry academia for a job in the biofuels industry, which was a 50/50 split of analytical method development and technical innovation.

5.1 Transitioning from an academic to industrial laboratory

Industrial laboratory settings differ from academic ones through one key difference: the emphasis is not on training and development, but on deliverables — getting samples processed and data exported to the stakeholders that need it. As a post-Ph.D. academic without previous industrial experience, this atmosphere felt foreign and alarming at first. I experienced imposter syndrome quite strongly as I was hastily trained to productively operate instruments that I had never used before in my life. Thankfully, the PDP prepared me for this experience through their explicit teachings on *growth mindset*, namely believing that skills, abilities, and expertise can be developed through dedication, hard work, and practice — that one's native talents for a skill are only a starting point.

5.2 Training junior laboratory staff

As a scientist in the lab, part of my job was the training of new and/or junior staff on routine analyses or operations. The associate scientists and laboratory technicians were generally joining the lab soon after graduating with their bachelors, with varying degrees of academic lab experience. Given my experience first joining the lab, even with the PDP principles and lessons supporting my transition, it was difficult; therefore, I felt it was my responsibility to strengthen the *STEM identities* of junior lab staff — another PDP core concept. The concept of a STEM identity is, essentially, that how you think of yourself as a scientist, technology user, engineer, or mathematician is your STEM identity. Repeated outside recognition of one's STEM identity (e.g. "as a microbiologist, you are…" or "as a chemist, you are…") is especially effective from people more senior in the field (Dou et al., 2021). Recognizing that I was one of the few scientists situated in the lab with this background knowledge, I attempted to use every opportunity to explicitly recognize the STEM identities of each lab member. Occasionally, when unsure, I would even ask the staff member directly, "what type of scientist do you identify as?" The positive expressions I observed when they responded with their STEM identity made clear that this was a welcomed opportunity.

In addition to STEM identity strengthening, a key concept from PDP that I implemented in the lab — to the extent possible — was inquiry-style teaching. The difficulty with conducting an inquiry-style lesson in an industrial lab is that there is little room for self-governance; daily, routine tests need to be done and this can feel monotonous or, sometimes, not like "real science." The best academic analogy to this work is completing worksheets every day, rather than performing original experiments. To address this challenge during training, I would first ask staff what skills they were hoping to improve upon through the job and then focus on highlighting opportunities to practice that skill in each of the necessary tasks we would train on.

5.3 Holding efficient meeting principles

During my second year at the PDP, I had the opportunity to participate in a lesson on how to hold efficient meeting with teams. This meeting, at the time, was intended to help me lead a team of instructors as we collaboratively designed an inquiry-style activity on renewable energy. However, the lessons translated well when I began hosting weekly update meetings with senior scientists and executives at the company regarding method development. The most applicable steps that I learned from the PDP on convening an effective meeting included:

- Sending out a meeting outline in advance
- Stipulating firm start and end times for the meeting
- Practicing the use of transition phrases, such as "that is an interesting thought that I'd be open to discussing offline" or "thank you for that idea, I will give it further consideration after this meeting," to keep to the schedule and avoid tangents
- Reiterating next steps for each meeting participant to complete before the following week's meeting

These four lessons: outlining, scheduling, transition phrases, and reiterating next steps, were the soft professional meeting skills that I found most helpful from the PDP. Had I not participated in the PDP, then my academic meetings as a Ph.D. student would not have been sufficient enough to start me at a productive place in industry, since the power dynamics of meetings with committees is always too great and the meetings infrequent to practice these skills. All in all, the soft skills learned from the PDP helped me become a more confident industrial laboratory scientist, better trainer for staff, and more effective meeting leader.

6. PDP principles at a national lab

Lawrence Livermore National Laboratory (LLNL) is one of 17 national labs in the United States. The primary mission of LLNL is research and development in support of national security. “As a nuclear weapons design laboratory, LLNL has responsibilities in nuclear stockpile stewardship. LLNL also applies its expertise to prevent the spread and use of weapons of mass destruction and strengthen homeland security. Other areas include advanced defense technologies, energy, environment, biosciences, and basic science” (https://www.energy.gov/ea/lawrence-livermore-national-laboratory).

6.1 Transitioning from an industrial laboratory to a national lab

When I initially interviewed to join the lab as a scientist, I specifically included a slide in my job talk on my experience with science outreach and inquiry style education as a means of engaging diverse students and stakeholders in scientific concepts. Later, after I had begun the job, I was informed that this was a piece of interest from the lab’s perspective, where the science I would be working on is in need of effective and broad dissemination. While most graduate students gain teaching experience through serving as a teaching assistant while earning their Ph.D., I felt especially empowered during my job talk and subsequent interviews to be able to discuss education research-based insights into STEM outreach and this seemed to bolster my reception with the interviewing committees.

Now, after six months in my role as an outward-facing research scientist in the Atmosphere, Earth, and Energy Division researching carbon dioxide removal, a large part of my job is to ensure that I communicate my results clearly and swiftly to a broad range of audiences, since climate change is a global problem that affects all communities. I feel that my graduate school education, the lessons of the PDP, and my experience implementing all the lessons in industry, culminated in securing me this position that I now covet so much.

6.2 Future plans for implementing PDP concepts

One project I am currently working on involves environmental justice, carbon dioxide removal, and climate change adaptation — technical topics that can have real-world, personal implications. Every person entering a discussion on these topics brings with them a host of past experiences, perceptions, and different knowledge bases to launch from. To ensure that each participant in a future lesson or workshop about this topic feels heard and appreciated, I am in the midst of designing an inquiry-style lesson (e.g. Acar & Tuncdogan, 2018) on carbon dioxide removal, where community members could design what carbon dioxide removal methods they would want implemented in their community. They will each be given data-rich maps pertinent to each technology, a list of environmental justice trade-offs for each method, and a carbon dioxide removal goal for their community to reach “net neutral,” which would be based on their hard-to-decarbonize sector emissions. The expertise and diversity of experiences that each lesson participant has will bring a new lens to the metaphorical table, which should lead to a richer, more compelling plan for place-based carbon dioxide removal.

The goal of a lesson/workshop such as this would be to empower bottom-up/community-driven carbon dioxide removal approaches to combat climate change — a critical strategy for developing and deploying equitable carbon removal projects (Batres et al., 2021). However, a further issue with this ‘just transition’ is that communities often lack the necessary resources to engage and invest in these efforts, which is why it is the responsibility of a a national lab scientist, such as myself, to bring together the science, policymakers, and citizens to produce projects that bolster our nation’s security in the midst of climate change.

7. Panel audience input

At the 20-year reunion for the PDP, five PDP alumni contributed their insights into PDP main applications to industry and governmental career paths. One insight from a senior engineer at a private technology company said that imposter syndrome is a chronic issue for their team and described applying PDP facilitation principles to provide grassroots support for imposter syndrome on their team. Another participant described how they used PDP principles to inspire their team to be more innovative in their work through growth recognition and performance reviews. Another participant shared how they have taught PDP growth mindset principles to encourage mentees with diverse backgrounds that have been discouraged in other STEM disciplines to pursue data science career pathways. The final participant asked the panel for guidance regarding facilitation and leading strategies with remote co-workers/employees, to which the panelists said that they did not receive any formal training/recommendations on remote facilitation at their workplaces. However, the PDP's seminar series on effective leadership taught panelists the importance of recognition and purposeful agenda design, which Stephen and Mike said they've been applying at their workplaces through virtual meeting platforms too.

6. Conclusions

In conclusion, PDP alumni find that the skills they learned through the program have helped them enter the professional world with confidence and an ability to foster innovative and inclusive STEM workplaces. Through the professional evolution of these alumni post-graduation, they have applied and communicated the PDP principles of growth mindsets, inclusive mentoring, STEM identities, and purposeful meeting design to others in industry. Panel participants report that these principles are not broadly available in government and industry pathways, so receiving this training from the PDP was invaluable and helps them to be more effective in their roles. By perpetuating these PDP principles into their respective pathways, PDP alumni are extending the reach of the PDP into the general population.

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