INVERNESS RESEARCH

The UCSC Institute for Scientist & Engineer Educators

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Supporting Multi-Level STEM Workforce Development

OVERVIEW

The Institute for Scientist & Engineer Educators (ISEE) is a national-level effort to improve STEM education and workforce development by transforming how the current generation of scientists and engineers teach and mentor their successors. Housed at the University of California, Santa Cruz, ISEE is the legacy of the educational side of the Center for Adaptive Optics (CfAO), a decade-long NSF-funded Science and Technology Center. ISEE's Professional Development Program (PDP) has a 13-year history of development, during which the CfAO education program evolved into ISEE and it continued to improve and refine its approach and activities. Today, the PDP is ISEE's flagship program and the central driving force behind the Akamai Workforce Initiative (AWI) that aims to meet high-tech workforce needs in Hawai'i.

This brief presents an external perspective on the design of ISEE and the PDP, its relationship to the Akamai Workforce Initiative, and the contributions of the PDP to local workforce development at multiple levels. It also distills broader design lessons that may be of interest to other STEM workforce development initiatives. Additional information is available in two companion briefs: The Design and Evolution of the Akamai Workforce Initiative and Contributions of the Akamai Workforce Initiative.

Authors of this brief are Dr. Mark St. John and Dr. Pam Castori, senior researchers at Inverness Research, which has more than 25 years of experience studying the design, implementation, and contributions of a wide range of educational improvement initiatives. Inverness conducted this review through site visits, reviews of documents, and extensive discussions with ISEE and AWI leaders and advisors.

DESIGN RATIONALE OF THE PROFESSIONAL DEVELOPMENT PROGRAM

Because today's graduate students are tomorrow's college and university instructors, preparing them to be motivating, engaging, and inclusive educators can foster significant change in higher education. ISEE is seeking to break the unfortunate, self-perpetuating cycle where graduate students are trained in the same ways that their professors were, and consequently continue to teach through lecture, cookbook laboratories, and other pedagogical approaches that are not supported by research-based evidence of effectiveness. Moreover, many graduate students and postdocs will enter non-academic jobs, where they will serve as mentors, contributing to work environments that also need change to become more equitable and inclusive.

The approach of ISEE and its Professional Development Program is to develop human capital at the highest levels of education, pursuing the premise that how colleges and universities teach STEM ultimately and profoundly affects the quality of the STEM workforce, public STEM literacy, and K-12 teachers.

ISEE's PDP immerses early career scientists and engineers (graduate students and postdocs) in a professional development experience where they interact with college students in "teaching lab"

environments such as the Akamai Internship Program, college courses, and other workforce development activities. They attend two intensive institutes, and then work in small teams to design and teach inquiry-rich units to college students. PDP participants may choose to be involved for several years, receiving support from PDP instructors, and spending over 100 hours each year engaged in PDP training and putting their training into practice.

A WIN–WIN RELATIONSHIP: ISEE'S PDP AND AWI

A pivotal point in ISEE's history occurred with the funding of the Akamai Workforce Initiative in 2007, along with the development of the partnership with the University of Hawai'i's Institute for Astronomy (IfA) and Maui College. Today ISEE's PDP serves as the instructional foundation for the expanding undergraduate Akamai Internship Program in Hawai'i.

The PDP has been critically important to the Akamai Workforce Initiative because of the constancy of the resources and leadership provided over many years. The longevity of ISEE and the multiple capacities it brings to Hawai'i have allowed ISEE to both support and advocate strongly for the Akamai Workforce Initiative. In turn, AWI has proved to be an important laboratory setting for ISEE and a stimulus for the ongoing refinement of its PDP program. The PDP, therefore, has learned much about its own design and implementation as well as about ways to address the more general challenge of broadening participation in STEM workforce development. The integration of the PDP into Akamai also helped strengthen the argument for a focus on inquiry and helped expand the program to include current professionals who then apply the PDP curriculum to mentoring in their home industry and observatory settings.

The Akamai Workforce Initiative is a powerful instantiation of the more general PDP model, where ISEE is able to work with institutions in local settings to create mutually beneficial arrangements, while simultaneously addressing workforce needs at the undergraduate level and the STEM early career professional level. As PDP participants actively engage in designing and teaching courses and workshops for college students, they develop skills that enable them to then contribute to workforce development when they move into career positions.

Currently, ISEE is beginning to implement this model in several new settings, through ISEE chapters. ISEE disseminates the PDP and the Akamai internship model at partner sites through a program called "PREP" (Preparation for Research Experiences Program).[1]

PDP Design: Activities and Experiences

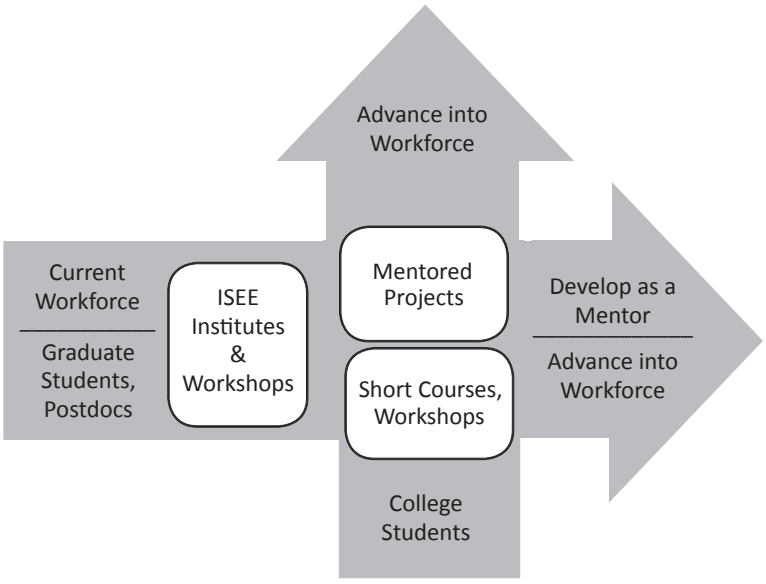
- ISEE finds and creates teaching venues at the undergraduate level that embrace PDP values. Participants are **matched up in small teams** led by PDP alumni.
- Six days of **intensive workshops** support participants as learners in an inquiry experience, move them into designing an activity, or unit, with their team, and finally help them think through how to teach and assess their unit.
- Teams then work **independently to develop their own unit**, which is carefully designed so that learners gain a deeper understanding of a core scientific concept and improve their skills with a cognitive STEM practice.
- Participants **teach the unit and assess its success as a team.**
- Teams **reflect and report** on their experience.
- Participants may **return for more PDP cycles**, taking on increasing leadership roles and new experiences.

[1] Beyond the home institution of UC Santa Cruz and historical partner University of Hawai'i, The University of Colorado at Boulder, University of Houston, University of Toronto, UCLA, and University of California at Santa Barbara have begun implementing the model. Implementations at Michigan State University and multi-institutional consortia in New York City and Pasadena, California are also underway.

CONTRIBUTIONS OF ISEE AND ITS PDP

Direct Program Contributions

- Approximately 380 participants have completed the PDP program over its 13-year history, including graduate students, postdocs, faculty, and other professionals; 116 of these were AWI participants.
- At least 75 participants who started as graduate students or postdocs have now entered the workforce in professional STEM positions, 43 into academic positions and 32 into non-academic positions.
- All participants actually put the PDP into practice by designing and teaching an inquiry activity, a claim about implementation that very few professional development programs can document. Research findings indicate that:
    - PDP participant teams demonstrate a high level of proficiency in the six elements of inquiry defined by ISEE (70% in the cohort studied).
    - PDP participants gain in their understanding of inclusive teaching strategies.
- PDP participants positively impact the college students they teach. ISEE's research efforts include multiple papers citing evidence that students gained understanding of core scientific concepts, engaged in STEM reasoning skills (or "practices"), and increased their self-initiative.
- An estimated 3,000 undergraduates are impacted annually by PDP alumni who have moved into teaching positions.



ISEE Model for Workforce Development

From PDP alumni who are now faculty:

The PDP has had a larger impact on my teaching philosophy than anything else in my academic career. The specific values and techniques taught in the PDP were directly cited as a major reason I was chosen for my current faculty position.

I just passed my tenure review...and based on the feedback I received about my teaching and mentoring, there is no question in my mind that I would not have been half as successful without my experiences with the PDP…

Broader Contributions

ISEE has taken advantage of its academic home and connections both to conduct research and to systematically develop curriculum and assessment tools that contribute to the broader field. The following are ways in which ISEE has been able to draw upon its experiences to increase national-level capacity for improving STEM education and workforce development.

Curriculum and tools: ISEE's research and development group has worked to create and implement objective assessment and evaluation tools, generate new knowledge on education and workforce development, and translate research into practice. For example:

- With funding support from AWI and other sources, ISEE developed a **framework for inquiry**, composed of six elements. This framework has been published and is available at isee.ucsc.edu/programs/pdp/inquiry.html.
- ISEE has worked on learning how to support diverse students and how to create equitable learning environments. With support from AWI and others, ISEE articulated **four focus areas that support inclusive curriculum development**, in particular at the higher education level. The focus areas have been published and are available at isee.ucsc.edu/programs/pdp/diversity-equity.html.

- ISEE conducted a **workforce needs assessment** that demonstrates the alignment of the skills high-tech employers seek in employees and the skills PDP participants learn how to teach. The results are published and available at isee.ucsc.edu/projects/ews.html.
- Each year, PDP participants design approximately 20 **new inquiry-intensive units**, which are taught in the Akamai Internship Program and in additional courses, bridge programs, and other workshops aimed at retaining and advancing students in STEM. (See isee.ucsc.edu/programs/pdp/teams/index.html.)

Community: ISEE's PDP is designed to be more than a high-quality program. It is also intended to serve as an ever-evolving community of scientist- and engineer-educators who utilize the PDP network and infrastructure to continue to innovate and grow their own participation in improving STEM education.

- Though PDP participants (e.g., AWI instructors) receive no funding or university credits for their involvement in the program, many maintain a long-term connection. They consider the group to be a professional learning community that provides them with the needed time, space, and support to explore and refine inquiry pedagogical approaches.
- Alumni return to the PDP year after year, some becoming apprentice instructors, and many taking on leadership roles and actively influencing the implementation of the PDP.
- As alumni have advanced in their careers and moved to new institutions, they have initiated ISEE/PDP activities across the country (e.g., Los Angeles, Pasadena, Boulder, Houston, Lansing, and New York City).

Optical Imaging Inquiry: An Example of a PDP Participant Design Unit

Defining requirements is a nuanced skill that is widely used and highly valued in the technical workplace. For example, the optimal design of an imaging system depends on what will be imaged and what we want to learn from the resulting images. This requires translating scientific interests into imaging requirements. In the "Optical Imaging" inquiry activity, students propose and test a design for an optical system based on a scientific mission such as resolving Earth-size planets orbiting nearby stars.

The instructors facilitate students' learning, acting as advisors and applying strategies they learn in the PDP to assess students' understanding, nudging as necessary in ways that maintain students' ownership of their learning, and managing social dynamics between students. The activity is intentionally designed so that students must make design choices based on concepts (rather than guess and check). They learn about components of an adaptive optics system and how optical components are aligned. At the end of the activity students must present their designs and justify their design choices. The activity lasts a total of ~6 hours (equivalent to two lab periods).

The Optical Imaging inquiry was taught in a career development workshop, as part of an ISEE/AWI partnership with the National Solar Observatory (NSO). Students also participated in mock job interviews with representatives from high-tech companies and observatories and learned about current and future opportunities with NSO.

Response from a student at the end of the activity:
"It forced me to be frustrated, but then proud of myself for figuring out (with the help of others, of course) a complex problem."

ISEE is headquartered at the University of California, Santa Cruz. Funding for ISEE's role in Akamai was provided from multiple sources over many years, including: National Science Foundation (AST-9876783, AST-0710699, AST-0836053, AST-0850532); Air Force Office of Scientific Research (AFOSR) (via NSF AST-0710699 and FA9550-10-1-0044); and Thirty Meter Telescope Observatory Corp. More information on ISEE can be found at: www.isee.ucsc.edu.

Visit the Inverness Research website at inverness-research.org/abstracts/ab2014-06_Rpt_Akamai_Briefs.html to view two related briefs: The Design and Evolution of the Akamai Workforce Initiative, and Contributions of the Akamai Workforce Initiative.

Inverness Research, a national education evaluation and consulting group headquartered in Northern California, has over 25 years of experience studying local, state, and national investments in the improvement of education.

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