Board 346: Plants, Power, and People: Using Agrivoltaics Engineering to Create a Network of K-12 Teachers and Students Contributing to Sustainable Energy Transitions

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Dr. Kelly Simmons-Potter is the Associate Dean for Academic Affairs in the College of Engineering, and a Professor of Electrical and Computer Engineering, Optical Sciences, and Materials Science and Engineering at the University of Arizona (U.A.) in Tucson, AZ. In Spring 2023 she was elevated to the rank of University Distinguished Outreach Professor. Dr. Simmons-Potter is a Fellow of the American Ceramic Society (ACerS), Chair of the Joint National Security Applications Council Peer Review Panel (JNSAC PRP), Director of the Arizona Research Initiative for Solar Energy (AzRISE), and a Professor in the Indigenous Food, Energy, and Water Systems Graduate Interdisciplinary Program (U.A.). She is the co-author of three textbooks in the field of optics, has authored more than 125 peer-reviewed publications, has delivered more than 150 scholarly presentations, and holds several patents. Her research focuses on radiation-hardened optics, photosensitive materials and devices, and sustainable energy system resiliency and design.

Steven J. Zuiker, Arizona State University

Steven Zuiker is an associate professor of the learning sciences in the Mary Lou Fulton Teachers College at Arizona State University. His research is broadly based on the notion that ideas are only as important as what we can do with them. Learning environments like school gardens and video games can each be both useful and used to create value in educational and local communities. Dr. Zuiker's research agenda explores how to design activities, resources, and projects that interconnect classrooms and campus, schools and communities, and, ultimately, educational research and educational practice.

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Plants, Power, and People: Using Agrivoltaics Engineering to Create a Network of K-12 Teachers and Students Contributing to Sustainable Energy Transitions

The Sonoran Desert Photovoltaics Laboratory (SPV Lab) is an NSF-funded Research Experience for Teachers (RET) program that aims to organize a regional approach to pursuing an interconnected set of site-specific agrivoltaics engineering research projects for K-12th grade STEM teachers along the corridor between two metropolitan cities co-located in the Sonoran Desert region of the US. *Agrivoltaics* is an innovative approach to coupling solar energy production with food production by placing photovoltaic (PV) panels over fields or garden beds. By coordinating agrivoltaics projects across two university campuses, SPV Lab involves ten STEM teachers in a six-week summer research experience for three consecutive summers (total of 30 teachers). Participants across sites and across years generate and share insights into how the collection of regional projects contribute to PV performance improvement and use-inspired engineering. Specifically, teachers learn about, learn to practice, and help develop curriculum and protocols related to agrivoltaics citizen science.

SPV Lab faculty and graduate students partner with teachers across university sites to:

(a) inspire and enable K-12th grade STEM teachers within commuting distance of a participating university to engage in authentic agrivoltaics engineering research, and

(b) spread agrivoltaics research experiences to schools serving students from populations historically minoritized in engineering. Given our district partners, this primarily includes students with limited economic means, and students from Latin@ and Indigenous communities.

First, during a six-week RET summer program, teachers are co-located in a university research lab where they (a) learn PV content knowledge, including understanding what is currently known about agrivoltaics systems around the globe, (b) engage in engineering research practices as they conduct their own agrivoltaics research, (c) and co-develop curriculum and resources support their students to conduct agrivoltaics citizen science. They disseminate curriculum and PV citizen science pedagogical models to teachers and administrators in partner districts and beyond through workshops, websites, conferences, and publications. Finally, they create meaningful bonds and long-term relationships between regional K-12 partner schools, industry partners, and host universities through follow up activities and an online citizen science network. Teachers communicate with each other and with mentors, and facilitators through an SPV Lab online platform to share classroom successes and best practices,

as well as to facilitate students' sharing of citizen science data, lab reports, best practices, and their design of garden spaces, PV racking, and irrigation systems.

Returning to their campuses in the fall, the SPV Lab teachers engage their students in meaningful PV engineering, i.e., “real work with real consequences” [1] through citizen science and community energy engineering across the school year. Students create two mirror garden beds on their campus, one with solar panels over the crops, and one without solar panels. Using digital sensors, they collect point-in-time and time series data, which they then analyze, interpret, and share across the SPV Lab network (i.e., other schools, university researchers, and community partners) to create new regional scientific knowledge to benefit their communities. The core research questions guiding students’ work are:

1. How do solar panels impact garden microclimates?
2. How does placing solar panels over growing crops influence solar panel efficiency?
3. How can agrivoltaics benefit people in our communities?

Students in some partner schools also pursue their own research questions.

Heading into our third year, the team has worked to develop a strong learning and sharing community which continues to support SPV Lab teachers and students, with the six-week summer program just the beginning of a long-term relationship. A few representative accomplishments highlight the ongoing work of students: Middle School students from four SPV Lab schools traveled to a university agrivoltaics research site during May 2023, comparing the sites’ work with their own school-based research site. Students from one SPV Lab school traveled to the full-scale urban farm where they exchanged presentations with their industry collaborators, teaching them about agrivoltaics while learning about soil amendments. Students from one SPV Lab school won 4th place in the Arizona MESA competition for their design and working prototype of a solar apartment building that incorporated agrivoltaics; others won awards in the Photovoltaics Specialist Conference (PVSC). One high school teacher initiated a collaboration with a nearby elementary school; students in grades K-3 visited the SPV Lab gardens and learn about agrivoltaics from the high school students.

Evaluation Results

Post-program surveys were used to collect data on the 2023 RET summer research participants. The post-surveys used to assess the RET participants were part of the Tri-ERC Education Consortium’s (TEEC) efforts in developing the ‘Multi ERC Instrument Inventory’ (MERCII, NSF Award No. EEC-2023275). Survey responses indicated that 100% of the RET participants found the SPV Lab program actively

promotes diversity and inclusion in the summer research program. When asked about a culture of equity and inclusion, participants responded to a series of ten items on a 5-point scale. 100% of the RET respondents agreed “quite alot” or “a great deal” that the SPV Lab (a) actively promotes diversity within SPV Lab, (b) actively advances inclusion within SPV Lab, (c) has a culture that accepts people with diverse perspectives, (d) develops its members to support inclusive practices, (e) provides opportunities to work with and learn from others with diverse perspectives, (f) provides opportunities to work with and learn from others with diverse perspectives, (g) provides opportunities to work with and learn from others with diverse perspectives, (h) supports participation from members of groups traditionally underrepresented in STEM, (i) is an inclusive place for groups traditionally underrepresented in STEM, (j)enables individuals to contribute to their full potential, (k) is a safe environment for all, and actively creates equity.

Survey responses indicated that teachers were satisfied with the mentorship they received during the 2023 summer research program. Asked about the quality of mentoring they received, 100% of the teachers rated all components of mentoring as “good” or “excellent, and that their SPV Lab mentors (a) provided support to develop their professional network, (c) encouraged them to strive for success, (d) gave feedback that was constructive, (e) support in conducting independent work, (f) direction on their research project, and (g) advice that supported their future plans. Similarly, asked about their personal experience as a SPV Lab participant, 100% reported that the agree or strongly agree that (a) I belong in SPV Lab, (b) I am treated fairly as an SPV Lab member, (c) my contributions are valued by other SPV Lab members, (d) my voice respected by other SPV Lab members, and that (e) I am given equal opportunities to fully participate in SPV Lab activities. 84% of respondents reported seeing others like themselves succeed in SPV lab.

Acknowledgments

This material is based upon work supported by the National Science Foundation under Award EEC-2055726. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

References

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