

Youth Engaged in STEM and Service:

A Culturally Relevant and Sustaining Summer Solar Camp Leveraging Community-Based Partnerships

By Joanna Totino^A, Rachel Kramer^B, Evan Gattozzi^B, Valeria Fike Romero^A, Melissa Collins^A, Michael Arnold^B, Alex Sanchez^A, and Devin Cavero^A.

Introduction

In the summers of 2021, 2022, and 2023, middle school students from Alameda, California, gathered at the Alameda Boys & Girls Club (ABGC) to participate in Youth Engaged in STEM and Service (YESS), where they learned about solar technology and explored the value of science, technology, engineering, and math (STEM) in their lives, communities, and the world. A team of educators and researchers from [The Lawrence Hall of Science](#) (The Lawrence), in collaboration with [We Share Solar](#), the [Alameda Boys & Girls Club](#) (ABGC), and [Girls Inc. of the Island City](#) (Girls Inc.), designed and implemented the YESS summer camp.

Designed to support STEM identity development in female-identifying youth and youth of color in middle school, the new, hands-on summer program YESS offered culturally relevant and sustaining STEM programming focused on solar technology applications. YESS was funded by the National Science Foundation's (NSF)

Innovative Technology Experiences for Students and Teachers (ITEST) program (award #1949586).

Research shows an underrepresentation of Black, brown (i.e., Black, Indigenous, Latinx, Southeast Asian, Middle Eastern), and female-identifying individuals in STEM careers and pathways. This is a symptom of a larger problem in which the current system of formal science education continues to fail these youth who are given limited opportunities to build and sustain their interests in STEM beyond required coursework.^[1]

Members of Black and brown communities comprise just 11% of science and engineering occupations, compared to 67% for white-identifying and 21% for Asian-identifying.^[2] Likewise, though the percentage of female-identifying STEM degree holders increased from 30% in 1993 to 40% in 2015, there are still pervasive disparities in the STEM workforce, with just 28% of science and engineering professionals identifying as female.^[3]

YESS created a new opportunity for Black, brown, and female-identifying youth to explore STEM concepts, careers, and pathways and experience STEM fascination in ways that are culturally relevant and sustaining for youth from a range of backgrounds and counteract the historical prioritization of cultural values and norms of dominant communities.^[4], ^[5] Ultimately, YESS seeks to contribute to a more diverse STEM field, with more Black and brown women who self-identify as scientists and STEM professionals working in and leading solar and other STEM industries toward energy equity and climate change mitigation.

This article shares highlights and reflections on what it took to create and offer an informal STEM educational experience that was informative, meaningful, and culturally relevant and sustaining.

YESS Camp Background

YESS program leaders developed the curriculum using the foundations they built in the Educational Pathways Into College and Career (EPICC) program, a previous NSF-funded (DRL-1433677) solar energy program developed by The Lawrence as a formal learning opportunity for high school-aged youth. The new YESS curriculum was adapted for middle-school-aged youth in a summer camp context and employs culturally relevant and sustaining pedagogies. The curriculum addresses four key areas: (1) Solar engineering, (2) Identity, (3) Global or local energy issues, and (4) STEM career knowledge-building.

We Share Solar, a nonprofit education program of We Care Solar that provides sustainable energy solutions and education in communities with limited electricity access, served as a partner during EPICC and YESS's development by providing curricular content related to solving environmental issues. The YESS curriculum includes the use of [We Share Solar® Suitcases](#) (or Solar Suitcase), providing a hands-on opportunity to learn about solar energy and engineering. We Share Solar also connected youth in global service learning to partner communities worldwide via video chats and letter-writing exchanges.

Program leaders offered two two-week YESS camp sessions annually for three summers (2021-23), each drawing different youth participants. The first camp session approached STEM concepts through a local relevance lens, and the second through a global service learning lens. Figure 1 summarizes key similarities and differences between the two camps.

The local relevance camp emphasized the complex environmental challenges the city of Alameda faces; Alameda borders Oakland across an estuary canal to the east and the San Francisco Bay to its west. Built atop marshland, this city island is at high risk of flooding. This

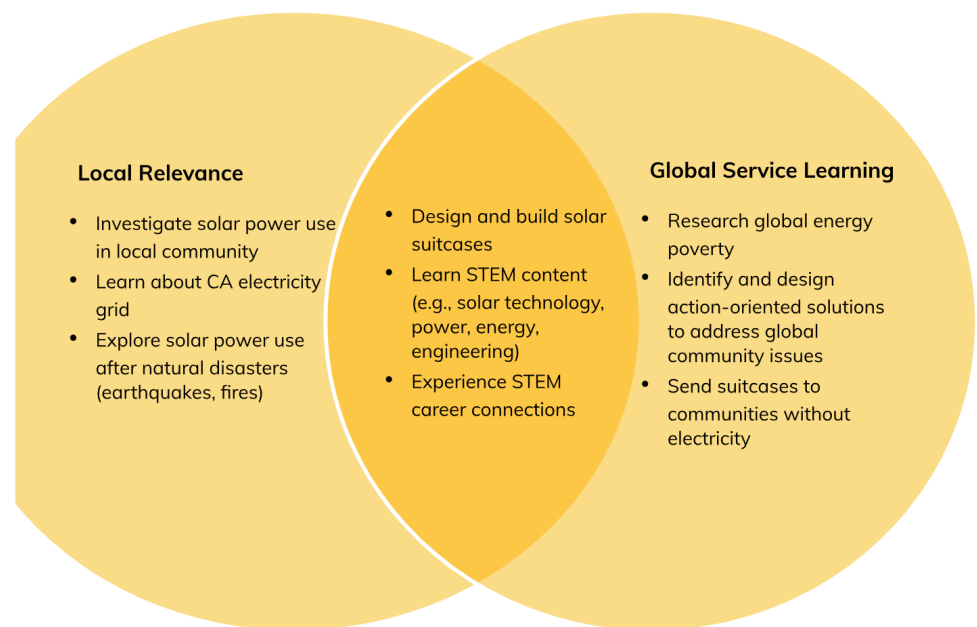


FIGURE 1: Comparison of Local Relevance and Global Service Learning Conditions

camp addressed the question, "How can we use solar power to transport water in our community to address problems associated with climate change?"

Participating youth explored recent local environmental problems, particularly drought and flooding issues, constructed a small-scale portable solar technology system, and built models designed to solve local water issues using solar energy.

The global service learning camp focused on environmental issues, including drought, and lack of electricity access in rural areas worldwide. It addressed the

question, "How can solar power be used for the transport of water to improve the quality of life in rural areas with limited electricity?" Youth explored global energy needs, communicated with partner communities worldwide via video conference, constructed solar suitcases, and designed models using solar energy to solve water issues in rural communities.

SUPPORTING GLOBAL ENERGY NEEDS

- Each year, YESS youth built and sent one We Share Solar® Suitcase to a We Share Solar partner community:
- YESS Year 1's Solar Suitcase was among 38 installed in the Rwamwanja Refugee Settlement, providing electricity for light and charging capacity to over 14,000 refugee students.
- YESS Year 2's Solar Suitcase was among 22 installed in Busia County, Kenya, providing solar electricity for light and charging capacity to children, teachers, and community members.
- At the time of this article's publication, Year 3's solar suitcase is allotted to be installed in the Kilifi region of Kenya.

Collaboration and partnership among individuals and teams made YESS's development and implementation possible. Throughout this article, we reference the various teams and organizations that contributed to the camps' development and success, including, but not limited to, the program team, research team, evaluation team, local youth-serving and educational organizational partners, and local teachers. We include a complete list of teams and partners and discuss their roles at the end of this article.

Learning & Lessons for Educators

Using Culturally Relevant & Sustaining Pedagogy in STEM

At the start of the grant, the first objective for YESS program leaders was to develop the camp curriculum. To do this, the program team, including Joanna Totino and Anna Gomberg, adapted and augmented EPICC content and activities to make them relevant and appropriate for YESS middle school-aged youth, fit within an informal summer camp context, and adopt a culturally relevant and sustaining pedagogy.

Culturally relevant pedagogy is based on the premise that a match or mismatch between the values, beliefs, and norms of an individual's home or community culture and those of their academic learning environments can have tremendous

implications on the individual's comfort, motivation, and success in the learning environment.^[6], ^[7] With this in mind, the program and research teams collaborated to research and then apply tenets of culturally relevant and sustaining pedagogy to the curriculum to support meaningful experiences in the program for youth with various backgrounds.^[8], ^[9]

USING CULTURALLY RELEVANT & SUSTAINING PEDAGOGY IN STEM: SUMMARY OF LEARNINGS

- Having a lead instructor and curriculum writer equipped with formal classroom experience, content expertise, and pedagogical expertise helped the program team seamlessly adapt the program curriculum and create an inclusive learning environment where all campers felt valued.
- YESS campers most enjoyed and were most invigorated by hands-on solar and engineering activities.
- Middle school-aged youth responded best to identity exploration activities when program leaders modeled participation and shared their experiences and when using creative activities.
- Applying a familiar and common theme across all camp programming created a cohesive camp learning experience.
- Middle-school-aged youth were not ready to think about careers, so camps integrated information about STEM classes and school clubs and how energy impacts campers' lives and communities.

The Research and Program teams iterated on the camp curriculum throughout the grant, using design-based research, reflection, and evaluation. The final shareable curriculum engaged campers in culturally meaningful ways and met the camp's learning objectives. Some key learnings that informed the development of the final curriculum are described below:

- A vital factor in the program's success was having a lead instructor and program team member equipped with formal classroom experience, content expertise, and pedagogical expertise. Ms. Gomberg brought her experience as an educator and expertise in

FIGURE 2: Culturally Relevant and Sustaining Pedagogical Principles in Action

solar engineering instruction to her role as the lead instructor and curriculum developer for both the EPICC and YESS NSF grants. Despite an initial unfamiliarity with informal camp settings, her wealth of experience in classroom settings—including teaching high school chemistry and environmental science for Oakland Unified School District before being recruited to be Senior Program Manager for Solar Education at We Share Solar during the third year of YESS—proved immensely valuable to the solar camp. Her knowledge of STEM and child development, communication skills, and activity organization skills created an inclusive learning environment that could appeal to campers with various learning styles, abilities, and backgrounds and where all campers felt valued.

Culturally relevant pedagogy	Culturally sustaining pedagogy
Student learning: Academically rigorous activities about solar energy	Valuing community languages, practices, and ways of being: Community-building activities that opened camp each day
Cultural competence: Reflection and discussion about campers' social identities and lived experience (e.g., social identity wheel, life map)	Accountability to the community: Co-created program curriculum with local community-based organizations
Critical consciousness: Solar engineering design challenges (solar car, solar water fountain, engineering challenges) to address real-world issues and social inequalities	Curriculum that connects to cultural and linguistic histories: Culture Wheel, Humanity's Relationship to the Sun
	Sustaining cultural and linguistic practices while providing access to the dominant culture: Spotlight speakers/career panel of Black, brown, and female-identifying people who work in solar-related and STEM careers

Figure 2 includes a selection of the culturally relevant and sustaining pedagogical principles the YESS curriculum incorporates and examples of camp activities that employ them.

- The Research and Evaluation teams' findings showed that campers most enjoyed and were most invigorated by the hands-on solar and engineering activities in which they built solar-powered cars, solar fountains, solar suitcases, and mechanisms to move water using solar energy.
- The YESS team noticed a lot of variation in the comfort and experience of the middle school-aged YESS campers in thinking critically about identity, especially compared to the EPICC high school youth who had a few additional years to develop their identity and more readily explored identity-related topics together. YESS program leaders found that YESS campers were most engaged when program instructors led by example in participating and sharing their own experiences in the identity discussion and via age-appropriate activities like "My Multicultural Self," produced by [Learning Justice](#).
- Program leaders found that middle school-aged campers were not ready to think about careers, which was initially planned to be a focus of the camp. Instead, the identity-focused activities were most successful when they helped campers consider what STEM classes or clubs they may be interested in participating in high school and how energy impacts their lives and communities.

- Applying the common theme or topic of "moving water" to all activities was a successful approach to creating a cohesive learning experience across the two weeks. The theme was relatable for campers because many Alameda residents live in a flood zone (emphasized in the local relevance camp) and could understand the specific global need to relocate water in places with extreme drought but limited infrastructure (emphasized in the global service learning camp).

Drawing on Local Assets for Robust Implementation

YESS's success is thanks to the collaboration and contributions of many partner organizations and individuals. YESS's two local partner youth-serving organizations, ABGC and Girls Inc., brought a unique understanding of Alameda and long-standing relationships with the camp's intended audience. In addition, ABGC provided space to host the camps, and Girls Inc. provided expertise in mentoring middle school-aged [girls and gender-expansive youth](#). Local teachers also contributed to the camps as thought partners and instructional assistants before and during the camp sessions. In addition, local STEM professionals dedicated their time as STEM career panelists.

The YESS team's experience highlights a few key learnings about running a program that involves multiple partner organizations and collaborators:

- Operating through various partnerships strengthened the planning and implementation of the YESS camps. The partnerships with local youth-serving organizations were mutually beneficial for recruitment and membership; camps drew on membership rosters from ABGC and Girls Inc., and the camps reciprocally helped the two youth-serving organizations recruit new members from the camper pool.
- Collaborating with local teachers to design the curriculum and implement the camps created a bridge between school-year instruction and the summer camp's programming. As a result of teachers' thought partnership, the YESS curriculum was rooted in and complemented school-based engineering design thinking as defined in the adopted Next Generation Science Standards. The identity-oriented activities encouraged youth to consider what type of STEM classes they may want to take in high school, creating a feedback loop between the summer's informal STEM learning, personal growth, and identity formation and the school-based formal curriculum. In some cases, these teachers could deepen and build on relationships with local students outside the constraints of in-class instruction. Collaborating with local teachers also contributed to the program's sustainability (discussed in the next section).
- While vital to the camps, the partnerships with local youth-serving organizations were not without challenges. The Program team hoped that staff from ABGC and Girls Inc. could implement YESS curriculum components

in their organization's existing youth programming and bring the skills they learned through YESS to their organizations. However, staff turnover and limited availability—which notably may have been exacerbated by the COVID-19 pandemic—to receive training in the skills and curricular knowledge needed to implement YESS impeded this goal. To mitigate challenges related to staff turnover, program leaders learned that early buy-in from organization leaders was essential for a successful partnership and reimagined ways to sustain the program that did not rely on a single staff member (discussed more in the next section).

Partnering to Sustain Program Access

The YESS program was designed with the explicit intent that at least some aspect of the program's model or curricular components would live beyond the NSF grant. Specific goals were to (1) provide partner organizations and other informal educators with a way to integrate STEM education and environmental issues into their programming more seamlessly, (2) demonstrate the potential to incorporate STEM and environmental issues into youth programs, and (3) increase the availability of culturally relevant STEM programs for middle school-aged youth.

The original camp was fully funded through the NSF grant, which included funding for staffing, materials, and space. As a result, YESS was available to youth-serving organizations without any financial barriers to participation. While neither youth-serving organization has secured funding to implement the program fully following the grant's end, the partner organizations did adopt program components that were most beneficial to them and supported each organization's goals, capacities, and program model:

- ABGC was most interested in the program's STEM components and sought funding to continue offering an adapted version that fits ABGC's program model. In the summer of 2024—the first following the end of the NSF-funded camps—ABGC will offer an adaptation of YESS, featuring shorter sessions (one week instead of two) multiple times throughout the summer. The programming will include dedicated instructors, including an Alameda-based teacher who participated in YESS's third summer. To support the program's adaptation and rollout, the YESS program director worked with the ABGC and the instructor to ensure they had the resources and information needed to be successful.
- Girls Inc. integrated select YESS activities and approaches related to identity and solar energy into its programming. These activities and approaches augment Girls Inc.'s identity-based empowerment activities and mentorship program for girls and gender-expansive youth in grades 8-12.

- The Lawrence also adapted YESS for the organization's youth programs, focusing on the solar curricular components. To meet their interest, the YESS program director and lead instructor adapted YESS into a one-week curriculum and worked with the summer camp directors at The Lawrence to offer the camp in the summer of 2024.
- Three local teachers, including two teachers who provided instructional assistance during YESS camps in Year 3, are integrating aspects of the curriculum in their classrooms.

YESS can also be replicated via YESS curricular resources, which are now publicly available free of charge. We Share Solar packaged the YESS STEM identity lessons into a standalone resource hosted on their website. Informal and formal educators interested in culturally relevant and sustaining STEM opportunities can access the resources at no cost and readily implement the lessons in their classrooms or programs (to access the curriculum, you'll need to sign up for [We Share Solar's free solar learning portal](#), then navigate to the curriculum sequence on "Developing Student STEM Identity").

The YESS research team is also preparing a research manuscript for the informal STEM research community. The manuscript will highlight additional learnings from YESS and be disseminated across the field to help others design and implement informal learning experiences that are culturally relevant and sustaining and promote positive STEM identity development among youth.

Conclusion

As the NSF grant ends, the YESS team leaves the field with an informative, meaningful, and culturally relevant and sustaining curriculum developed and refined through ongoing reflection, iteration, and program improvement. The curriculum is now a resource for an informal, hands-on STEM education experience that can be adapted for different audiences and remain relevant; the partners' ongoing interest in and use of the program showcases how local youth-serving organizations can maintain and integrate STEM education and environmental issues into their programming, effectively increasing the availability of culturally relevant and sustaining STEM programs.

The YESS program has had and will continue to have a positive impact on Alameda youth, the Alameda community, and beyond. We hope educators can incorporate these learnings into future culturally relevant and sustaining STEM experiences, empowering youth to address local and global environmental challenges.

Thanks & Gratitude

We extend our deepest gratitude to the many individual and organizational partners who dedicated space, ideas, insights, knowledge, and time to creating this hands-on, culturally relevant, and sustaining STEM opportunity for Black, brown, and female-identifying youth. You have made YESS camps a success. Special thanks to:

- [Alameda Boys and Girls Club](#), which hosted the camps, provided equipment, offered logistical support, and recruited youth.
- [Girls Inc. of the Island City](#), whose staff supported the facilitation of select camp activities, gave feedback on the curriculum plan, and recruited youth.
- [We Share Solar](#), a nonprofit organization that created the Solar Suitcase solar learning suitcases for hands-on STEM education included in the YESS curriculum. At the time of publication, We Share Solar is piloting a new design, the Solar Learning Kit.
- YESS Program Director Joanna Totino, who developed the camp curricula, planned and implemented the camps, recruited youth, and managed the partnerships.
- The Lawrence Hall of Science research team led by co-principal investigators Valeria Fike Romero and Melissa Collins, along with research coordinators Alex Sanchez, Devin Cavero, and Salina Yun, who researched the camp's design, implementation, and outcomes for youth.
- Lead Teacher Anna Gomberg, who developed the camp curricula and taught the camps.
- Program Support from Betsy Mitchell, who supported camp implementation and material management.
- Informing Change, an Oakland-based strategic learning firm, which served as a third-party evaluation partner for the camps for all three years of implementation. The Informing Change team included Michael Arnold, Evan Gattozzi, Rachel Kramer, Andrea Leitereg, Emily Medica, Inti Chomsky, and Ayenna Cagaanan.
- Local collaborating educators who learned the YESS curriculum and supported camp implementation, including Kevin Blagrove, Alameda math and engineering teacher who provided instructional assistance at Year 3's local relevance camp and who will serve as ABGC's 2024 solar camp instructor; Natalie Musik, Oakland High School science teacher who provided instructional assistance at Year 3's global service learning camp and teaches part of the YESS curriculum in their class; and Nga Nguyen, an Alameda engineering teacher who contributed to YESS's engineering curricular design and teaches part of the YESS curriculum to his students.
- STEM professionals from the following organizations dedicated time to participate in the STEM career panels to support youth in thinking about STEM

pathways and possibilities: [GRID Alternatives](#); [Mee Panyar](#); [We Care Solar](#); [Sunlight and Power](#); [Greywater Action](#); [Environmental Protection Agency, Region 9](#); [City of Alameda, CA](#); [Youth VS Apocalypse](#); [Global Electric](#); [Amber Kinetics](#); [ACTA NON VERBA](#); [Native Renewables](#); [Trees, Water & People](#); and [Audubon Center, CA](#).

- Local STEM companies and employers, [DOER Marine](#) and [Saildrone](#), who hosted field trips to showcase their impactful work, aiming to inspire youth to consider the vibrant landscape of STEM career opportunities within their own community.
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This post was written by Joanna Totino¹, Rachel Kramer², Evan Gattozzi², Valeria Fike Romero¹, Melissa Collins¹, Michael Arnold², Alex Sanchez¹, and Devin Caverro¹.

1. The Lawrence Hall of Science, University of California, Berkeley
 2. Informing Change
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Footnotes

[A] The Lawrence Hall of Science, University of California, Berkeley

[B] Informing Change

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