The Lawrence Hall of Science

UNIVERSITY OF CALIFORNIA, BERKELEY

Improving Outdoor Science Teaching and Learning: The Implementation of a Capacity-Building Model in Outdoor Science Programs

Valeria Fike Romero, Melissa Collins, Aujanee Young, Vicky Laina, Rena Dorph, Aparajita Pande, Craig Strang, and Jedda Foreman

Abstract: The Better Environmental Education, Teaching, Learning, and Expertise Sharing (BEETLES) Project and The Research Group at the University of California, Berkeley's Lawrence Hall of Science engaged in a five-year broad implementation project designed to improve the quality of the science learning experiences at outdoor science programs (OSPs). Their aim was to position OSPs to support schools to implement Next Generation Science Standards (NGSS) and to contribute to youth science and environmental learning. This paper examines the role and value of professional learning and organizational capacity building in outdoor science education by investigating several questions: (1) Which components of the BEETLES capacity-building model were implemented? (2) What were the perceived impacts of BEETLES materials and resources on program practices, structures, and capacities? (3) What challenges did programs face in using materials and resources? Analysis utilizes several data sources from 68 participating programs to answer these research questions: (1) *Post-Institute Surveys* from 127 program leaders, (2) *End-of-Year Program Leader Surveys* from 54 program leaders, (3) 14 *Program Leader Interviews* from 8 case study sites and (4) *Implementation Plans* from 54 program leaders. Study results indicated that participation in BEETLES had a positive impact on program planning, goal articulation, and pedagogical practices; program leaders value and use BEETLES materials and resources; and programs faced multiple challenges including those related to capacity building and long-term sustainability. This paper also discusses several themes that emerged from the study including ease of implementation vs. transformative impact; impact on science learning; going beyond teaching and learning; and the intersection of equity, inclusion, and science learning. Finally, this paper highlights implications for program leaders and funders, professional learning and curriculum developers, and future research.

Introduction

Outdoor science programs (OSPs) provide opportunities to engage in meaningful learner-centered and nature-centered science and environmental learning experiences for youth representing a range of ages, demographics, previous experiences, and interests. There is evidence of positive impact on academic, health, social-emotional, and environmental conservation outcomes (Ardoin & Bowers, 2020; Ardoin, Bowers, Roth, & Holthuis, 2018; Rickinson, 2001). However, OSPs have been under-resourced, overlooked, and underutilized for decades (Sanford & Sokol, 2017). The COVID-19 pandemic further challenged this field, resulting in hundreds of millions of dollars in lost revenue, millions of youth losing out on outdoor learning opportunities, and thousands of staff in the field being laid off or furloughed (Collins et al., 2020; 2021).

Now more than ever, the field is in need of high-quality, effective, and intentional capacity building and professional learning systems. Organization leaders need to understand the conditions and capacities that will enable them to successfully reopen, reinvent, and continuously improve their programs. Historically within OSPs and the environmental education field, however, a systematic infrastructure to support organizational capacity building and professional growth of educators has not existed. Few studies have focused on understanding the organizational features that impact uptake of organizational improvement, professional learning, and shifts in praxis (Li & Kransy, 2019). With improved governance and work environments combined with high-quality professional learning and instructional materials, OSPs have a tremendous opportunity to play a pivotal role in science education improvement (Romero et al., 2021), just as schools are recovering from pandemic closures and the resulting racial and economic disparities in disrupted learning.

IMPACT OF OUTDOOR SCIENCE PROGRAM LEARNING EXPERIENCES

OSPs exist within the broader fields of outdoor and environmental education to provide science learning experiences in outdoor settings. OSPs serve multiple audiences (youth, teachers, and families) and engage participants in a range of activities and experiences to foster authentic discovery, curiosity, and caring for the natural world. OSPs, especially those offering multiday residential programming, frequently serve youth in grades 4–8 who are at a pivotal point in their educational pathways when interest and performance in science often begins to drop (Gonzales et al., 2008). The long-term implications of this developmental period can be critical, as interest in pursuing a STEM career by grade 8 is an important predictor of whether youth will continue science learning through and beyond high school (Tai et al., 2006; Dorph et al, 2018).

Research provides evidence that outdoor learning experiences support cognitive and social-emotional outcomes, including increased interest in science (NSTA, 2012; Sanford & Sokol, 2017), improved retention of content (Avci & Gümüs, 2020), and corresponding academic achievement (Lieberman et al., 2000; Quibell et al., 2017; Tas & Gulen, 2019; Williams & Dixon, 2013). These experiences are effective at helping youth perform measurably better in school and at increasing learner engagement and enthusiasm to learn (Kuo et al., 2018; Sanford & Sokol, 2017). These experiences can also support social and personal growth, such as

confidence, leadership, and motivation (McLeod & Allen-Craig, 2007) and a myriad of benefits that come from simply spending extended time in nature (Coyle, 2010; Liddicoat & Kransy, 2014; Powell et al., 2011; Stern et al., 2010).

In addition to directly serving youth, outdoor and environmental education programs also benefit teachers through professional learning opportunities to increase teachers' content and pedagogical expertise. These programs may be especially beneficial for elementary school teachers, many of whom do not have a formal background in science or environmental education and need support to provide learner-centered, phenomenon-based engagement within the classroom (Merritt, 2018; Sanford & Sokol, 2017). Middle school science teachers also benefit from partnering with informal science instructors. Those who do partner have a better chance of engaging their learners in science, engineering, and environmental education through inquiry-based learning in informal science settings such as zoos, aquariums, museums, and gardens (Weinstein et al., 2014).

Beyond benefits for learners, OSPs also support efforts to mitigate climate change through experiences that introduce participants to topics and strategies in environmental and climate literacy, ecosystem restoration, and environmentally sustainable practices. OSPs engage learners directly in the outdoors—in places such as watersheds, bogs, forests, shorelines, or hiking trails—extending opportunities to see firsthand the impact of human activities on organisms and ecological systems. Such immersive and experiential outdoor science opportunities support significant improvements in learners' knowledge, awareness, motivation, and critical thinking about climate change and environmental issues (Ardoin et al., 2020; Karpudewan & Khan, 2017) and can foster a greater sense of connectedness to nature (Grimwood et al., 2018) and empathy and responsibility for the environment (Barak, 2009; Stern et al., 2008).

Finally, evidence suggests that outdoor science and environmental education may disproportionately benefit learners who hold identities that have been historically marginalized or excluded from school-based science, including Youth of Color, emergent multilingual learners, and learners from low-income communities (American Institutes for Research, 2005; Danforth, 2008; Collins et al., 2022). OSPs, because of their direct connection to schools, serve a higher percentage of

historically marginalized populations than many other types of informal science programs (National Research Council, 2009). Accordingly, opportunities to engage in OSP-based learning experiences may be an especially important strategy for bringing equity to science engagement and learning.

CAPACITY BUILDING IN OSPs

Despite the plethora of meaningful and impactful contributions of OSPs, they face many challenges, some of which are critical to their own existence and ways of operating. While there are a number of professional networks within the field of environmental education (e.g., North American Association of Environmental Education, Association of Environmental and Outdoor Education), there continues to be a call for field-wide professional learning and capacity building that attends to the specific context of OSPs (Snow & Romero, 2014). Professional learning and/or capacity building efforts have the potential to not only impact the consistency of high-quality science learning experiences, but also can impact the long-term sustainability of OSPs (Romero et al., 2021).

Lammert and colleagues (Lammert et al., 2015) conceptualize capacity building as a process to strengthen the management and operations of an organization to better achieve its goals. They describe that, in education, capacity typically encompasses four types: human capacity (knowledge and will), organizational capacity (collaboration and communication), structural capacity (policies and procedures), and material capacity (e.g., fiscal resources and equipment). Efforts to increase capacity require a combination of multiple methods and buy-in from all stakeholders. There is little research that examines capacity building within the context of environmental education. We provide a brief overview of efforts to support the knowledge building within the field and highlight ways in which a capacity-building approach can better support the field.

Within the field of environmental education, professional learning has largely focused on what Lammert et al. (2015) describes as human capacity, specifically related to the professional development and enrichment of instructors. Scholars have examined how to support instructors to build skills and confidence to facilitate science learning experiences outdoors. They have found that professional learning and mentoring can support instructors to engage learners in hands-on

inquiry-based science learning (Feille, 2017) and cultivate early childhood educators' confidence in the value of nature-rich outdoor learning experiences to support active play (Wishhart & Rouse, 2019). However, one of the limitations to this body of research is the sole focus on the professional learning of teachers in school-based contexts (Wishhart & Rouse, 2019; Ernst & Erikson, 2018), leaving the specific context of environmental education, outdoor education, and/or outdoor science programs underexplored. Further, Li & Kransy (2019) found that the transfer of professional learning to practice largely varies based on the programmatic goals and audience across programs, reinforcing the notion that there needs to be capacity-building models that are designed with the specific context of OSPs in mind. In addition, researchers have also found that in order to shift practice, it is critical to build organizational capacity to support instructors in shifting their practice (Lammert et al., 2015). These findings underscore that the application of capacity-building models is context dependent, and, given the wide variation of organizations and programs within the environmental education field at large, careful attention to context is needed when engaging in capacity-building efforts.

For the field of outdoor science education, when it comes specifically to the recruitment of personnel and the efficient use of existing human resources, recent research highlights established practices in the field that may perpetuate the marginalization and exclusion of Black, Indigenous, and People of Color (Mack et al., 2012; Taylor, 2014; Rogers, Taylor, & Rose, 2019; Romero et al., 2019) both as learners and as instructors or leaders. For example, when learners and instructors hold different views of environmental issues, what is controversial or what is relevant, this can directly impact learner engagement and meaning-making (Rickinson et al., 2009). The field has historically emphasized learning outcomes that are grounded in colonialism (Payne & Wattchow, 2008); therefore, instructors may cultivate learning experiences that marginalize and displace many learners' experiences. When learning is understood as a culturally shaped activity, we recognize the ways in which instructors mediate learners' experiences and how this influences how learners make meaning of the world around them (Hart, 2008). As a result, reflection time for instructors is critical in examining their own ideologies, values, and pedagogical approaches (Hart, 2008) and how they impact learners. If there is limited knowledge-building on how we understand learning, there is a potential to see negative impacts on efforts to broaden

Figure 1: BEETLES Project Theory of Change
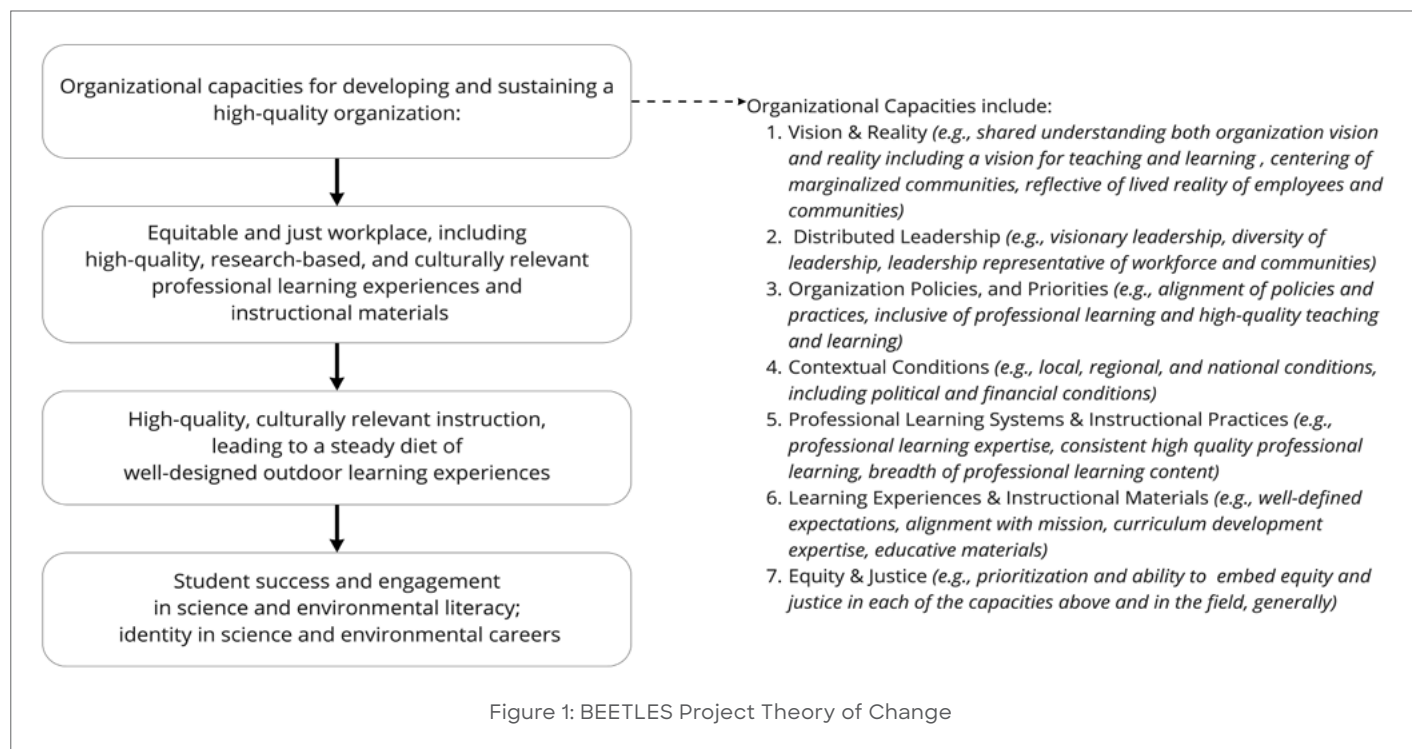
participation in the field that can also hinder progress on climate change education and communication (Pearson et al., 2017).

While there is growing consensus on the educator experiences and the knowledge and skills that are developed during outdoor learning experiences, there is little research in understanding how to build up systems that improve whole organizations or the collective capacity of the field (Cutter-Mackenzie, Clark, & Smith, 2008; Powell, Stern, & Hill, 2008). As Lammert et al. (2015) noted, "capacity building is not limited to training personnel or the provision of [technical assistance], but may include overhauling systems, remodeling physical infrastructure, recruiting new personnel, and improving the efficiency of the use of existing resources" (p. 1). It is therefore important to further study how a model of capacity building (that includes but is not limited to human capacity) may be adapted and implemented across organizations, particularly at a national level. This study aims to address this gap by examining the design and implementation of a national capacity-building model for outdoor science programs. Specifically, this study examines a capacity-building model (developed by the Better Environmental Education, Teaching, Learning, and Expertise Sharing [BEETLES] Project) and the ways in which it supports the development of human capacity (e.g., knowledge, familiarity, practices about teaching

and learning) and critical reflection and changes within organizational systems and resources that shape what teaching and learning look like. By drawing on BEETLES, this study contributes to the discussion of how to improve the quality of OSPs and the professional learning available to OSP professionals as a means to build capacity and sustainable practices.

THE BEETLES PROJECT AND CAPACITY-BUILDING MODEL

The BEETLES Project aims to build the capacity of OSPs to improve the quality of science learning experiences they are offering in ways that position them to play a key role in supporting schools to implement Next Generation Science Standards (NGSS) and contribute to youth science and environmental learning. The BEETLES Project is informed by a theory of change (see Figure 1) that holds that in order to achieve desired learner outcomes (i.e., learner success and engagement in science and environmental literacy), organizations must offer uniformly high-quality instruction. To accomplish this, organizations must provide high-quality research-based curriculum and consistent professional learning, which are dependent on the continual development of organizational capacities: a shared vision and understanding of the current reality, distributed leadership, supportive priorities and policies, understanding of contextual

conditions, curriculum, professional learning, and equity. Subsequently, BEETLES aims to not only provide materials and resources that support high-quality research-based curriculum and professional learning experiences, but to also support organizations in thinking about the underlying "improvement infrastructure" that supports or inhibits shifts in practice.

Within this study, we focus on aspects of the BEETLES capacity-building model that consists of leadership institutes, professional learning (PL) sessions for leaders to conduct with field instructors, exemplary student activities, observation tools, instructional planning guides, a set of how-to videos for OSP leaders and field instructors, and a Guide for Program Leaders intended to help leaders improve organizational systems and their improvement capacities. Previous evaluation study results indicate that BEETLES is effective at improving the design of professional learning experiences, science learning experiences for learners, instructors' perceptions of teaching and learning, and pedagogical practices throughout organizations (Romero et al., 2021), allowing this study to focus on capacity building.

The BEETLES model is built upon five design principles. People learn outdoor science best when they: (1) engage directly with nature, (2) experience instruction based on how people learn, (3) are invited/supported to think like a scientist, (4) participate in equitable and culturally relevant learning environments, and (5) learn through discussion. Each BEETLES PL session emphasizes a learner-centered, nature-centered, and inquiry-based approach to outdoor science education. The BEETLES model is systematically shared through five-day intensive residential Leadership Institutes and is more widely disseminated through the project website, publications, short workshops, webinars, and conference presentations. This paper focuses on participants' experience during and subsequent to the Leadership Institutes in which program leaders experience and learn about the PL sessions, student activities, and other capacity-building materials and resources. Program leaders develop a plan to use BEETLES resources in their own unique contexts to meet their specific organizational goals. Using the uptake and adaptation of the BEETLES model as a case study, we examine how a nationally disseminated model can support the human and organizational capacity building of OSPs.

Study Overview

The BEETLES Project and The Research Group, both at the University of California, Berkeley's Lawrence Hall of Science, embarked on a five-year broad implementation project aimed to improve the quality of the science learning experiences at OSPs across the United States and beyond. We used a mixed-methods approach to examine the extent to which a multicomponent capacity-building model focused on how to promote learner-centered and nature-centered science learning experiences can support programmatic and pedagogical improvements across a range of outdoor science programs. We identified research-to-practice gaps in the implementation of professional learning across varied outdoor science programs. This paper examines the potential role and value of professional learning and organizational capacity building in outdoor science education. This paper addresses the following questions:

· Which components of the BEETLES capacity-building model were implemented?

· What were the perceived impacts of BEETLES materials and resources on program practices, structures, and capacities?

· What challenges did programs face in implementing materials and resources?

Future papers will address the impact of BEETLES on learner outcomes, including STEM dispositions and environmental literacy.

Methods

SAMPLE

The BEETLES Project supported broad implementation of the BEETLES capacity-building model through 5 weeklong, intensive, residential BEETLES Leadership Institutes that took place from August 2017 to August 2019. This study was conducted with 68 of the organizations that participated in the first 3 Leadership Institutes: August 2017 (n=24), December 2017 (n=22), and August 2018 (n=22). Organizations were in 29 different states and Washington, DC, with 39% of programs based in California. Here we describe some of the features of these organizations to provide insight into the range of organizations that participated in

the study. A total of 127 program leaders from 68 programs participated in the study.[1]

- **Program Type.** Just over half (53%, n=36) of the programs in this study were primarily nonresidential programs, including both single and multiday programs, while the rest (47%, n=32) were primarily residential programs (i.e., youth stay overnight for between 1 and 5 nights).

- **Staff Configurations.** On average, programs employ 13 staff members per year (median= 13; mean=21.36, range=0-200). Among the 62 programs providing data on staff characteristics, nearly all programs employ long-term staff (93%) who, on average, make up about half (48%) of staff members within programs. The majority of programs (82%) also employ interns or shorter-term staff who, on average, comprise about 37% of their total staff. Less frequently, programs employ graduate students (13%) or "other" staff types (11%), such as guest instructors. About one-third of programs (32%) engage volunteers who comprise an average of 7% of their total staff, though their prevalence ranges up to 80%.

- **Professional Learning Characteristics.** Over the course of a year, about one-third of the organizations (34%, n=15 out of 44) reported offering 21–40 hours of professional learning, one-quarter (25%, n=11) offered 41–80 hours, and a little over one-third (36%, n=16) offered 80 or more hours of professional learning to their staff. Typically, professional learning is either conducted at the beginning of the programmatic year (40%, n=14) or sporadically, as the need arises (40%, n=14). Others provided professional learning at scheduled time points throughout the year (20%, n=7).

- **Learner Characteristics.** 61 of the 68 programs provided data on the number of learners served. Overall, the 61 programs reported serving over 700,000 learners annually, including over 600,000 youth learners (high school or younger), with an average of 4,970 youth learners annually. The majority of programs serve youth from elementary school (89%, n=54) and/or middle school (77%, n=47), with 67% (n=41) serving high school youth and 41% (n=25) serving early learners (kindergarten or younger). The majority (87%, n=52) also reported serving classroom teachers directly.

Programs served diverse audiences. About 45% of programs served youth from urban areas, 35% served youth from suburban areas, and 30% served youth from rural areas. Program leaders (n=51) estimated that 56% of participating youth qualify for free/reduced lunch and/or come from low-income backgrounds. According to the 43 program leaders able to provide an estimate, approximately one-third (mean=30%, range=0-90%) of youth served were emergent multilingual learners. In general, programs reported that they do not systematically track demographic data related to race, ethnicity, gender, or other factors.

DATA SOURCES

This paper draws on several data sources to answer our research questions.

- **Post-Institute Survey.** The Post-Institute Survey was designed to gather program leaders' perspectives about the Institute and their programmatic practices and goals. The survey also included retrospective-pre questions around perceptions of science learning and teaching. A total of 127 program leaders from 68 programs responded to the Post-Institute Survey (42 from August 2017 Institute, 44 from December 2017 Institute, and 41 from August 2018 Institute).

- **End-of-Year Program Leader Survey.** One year after attending the Leadership Institute, program leaders were invited to complete a survey about (1) their program's use of BEETLES materials and resources, (2) the impact of the materials and resources on their instructors' pedagogical practices, and (3) their reflections on how well the Leadership Institute prepared them for implementing the materials and resources and for building organizational capacity. Only 1 respondent from each program answered this survey as the representative for their program. A total of 54 program leaders completed the survey: 17 from Institute #1, 22 from Institute #2, and 15 from Institute #3.

- **Program Leader Interviews.** Eight case sites were purposefully selected to reflect the geographic and programmatic diversity of the broader sample. Program leaders (n=14) at these sites were interviewed one year after the BEETLES Leadership Institute about their approach to implementing the BEETLES materials and resources and in what ways it impacted their programs' capacity to engage

learners in high-quality science learning experiences. In this paper, we draw from four of the case sites for the vignettes presented in the Discussion section (beginning on page 16).

- **Implementation Plans.** During the Institute, program leaders identified professional learning and capacity-building goals and constructed an implementation plan for using BEETLES materials and resources within their organization. Seventy-nine percent of participating OSPs (n=54) submitted a plan.

Results

INSTITUTE IMPACT ON SCIENCE PERCEPTIONS AND PLANNING

Program leaders reported about their familiarity with and the perceived relevance of science pedagogical concepts before and after participating in the Leadership Institute. A summary of their responses on the Post-Institute Survey is presented in Table 1 (below).

Table 1. Program Leaders' Familiarity with and Perceptions of Relevance of Concepts in Science Pedagogy, Before and After the Leadership Institute						
	Familiarity Mean Rating*			Relevance Mean Rating**		
Science pedagogical concepts	Pre*** (SD)	Post (SD)	Cohen's d	Pre*** (SD)	Post (SD)	Cohen's d
Discussion-based instruction	2.48 (0.85)	3.63 (0.52)	1.41	2.54 (0.79)	3.79 (0.45)	1.64
Learning culture (e.g., reflection on practice)	2.45 (0.77)	3.59 (0.58)	1.63	2.59 (0.95)	3.88 (0.33)	1.39
Learning cycle instructional method	2.25 (0.96)	3.59 (0.51)	1.66	2.70 (1.02)	3.88 (0.32)	1.21
Questioning strategies	2.74 (0.81)	3.79 (0.43)	1.42	2.80 (0.93)	3.91 (0.28)	1.22
Scientific habits of mind (e.g., how scientists think)	2.63 (0.86)	3.54 (0.55)	1.19	2.67 (0.86)	3.72 (0.49)	1.30
Nature of science (e.g., science as a process)	2.79 (0.90)	3.58 (0.53)	1.03	2.78 (0.90)	3.77 (0.45)	1.19
Practices of science (e.g., what scientists do)	2.91 (0.89)	3.65 (0.50)	0.93	2.83 (0.91)	3.75 (0.45)	1.10
Culturally relevant teaching (e.g., cultural humility)	2.34 (0.74)	3.16 (0.65)	1.14	2.98 (0.92)	3.82 (0.43)	1.00
Learner-centered instruction	2.88 (0.86)	3.83 (0.38)	1.16	3.22 (0.86)	3.95 (0.22)	0.87
Inquiry-based instruction	3.08 (0.85)	3.80 (0.43)	0.91	3.32 (0.80)	3.90 (0.30)	0.76

  *4-point scale: 1=No idea what this concept is, 2=Somewhat familiar, 3=Familiar, 4=Very familiar
 **4-point scale: 1=Not at all relevant, 2=Somewhat relevant, 3=Relevant, 4=Very relevant
***Items were measured using a post/retrospective pre-survey format.

Table 2. Program Leaders' Sense of Preparedness: Post–Leadership Institute				
How prepared were you . . .	Very or somewhat unprepared (1 + 2)*	Somewhat prepared (3)	Very prepared (4)	Mean**
to teach field instructors about how to make observations about the natural world?	2%	19%	77%	3.77
to find and access materials via the BEETLES website?	6%	30%	64%	3.58
to teach field instructors about how to ask good questions to promote student learning?	5%	38%	58%	3.52
to implement BEETLES student activities?	2%	46%	52%	3.5
to teach field instructors about science?	8%	45%	46%	3.39
to encourage a learning culture amongst my staff?	6%	47%	47%	3.4
to coach field instructors?	8%	43%	47%	3.4
to teach field instructors about how to probe for evidence-based explanations?	8%	52%	39%	3.31
to lead BEETLES PL sessions?	9%	63%	27%	3.19
to have conversations about NGSS with my staff, classroom teachers, or others?	18%	45%	33%	3.18
to lead conversations about equity and inclusion at my program?	18%	57%	24%	3.03
to lead capacity-building conversations at my program?	20%	61%	19%	2.98

*n=124–127 per item
**4-point scale: 1=Very unprepared; 2=Somewhat unprepared; 3=Somewhat prepared; 4=Very prepared

A series of paired samples t-tests showed that program leaders reported significant changes in familiarity and relevance across all 10 content areas. Though all effect sizes were large, the largest effect sizes for Familiarity were seen in the learning cycle instructional method and learning culture among staff (Cohen's d=1.66 and 1.63, respectively), while the smallest effect sizes for Familiarity were seen in inquiry-based instruction and practices of science (Cohen's d=0.91 and 0.93, respectively). For Relevance, the largest effect size was for discussion-based Instruction (Cohen's d=1.64), and the smallest was for inquiry-based instruction (Cohen's d=0.76).

Program leaders were also asked to evaluate their sense of preparedness to implement the BEETLES capacity-building model and lead PL sessions for their instructional staff. A summary of their responses is included in Table 2 (on page 8).

Most program leaders reported feeling very prepared to teach their field instructors how to make observations about the natural world (3.77), how to ask questions to promote learner thinking (3.52), and how to find and access materials in the BEETLES Project website (3.58). They felt the least prepared to lead conversation in their organizations about equity and inclusion in their programs (3.03) and about capacity building (2.98).

INSTITUTE IMPACT ON PROGRAM GOALS

Institute participants were invited to identify goals related to (1) professional learning and (2) capacity building and to construct an implementation plan identifying strategies, including BEETLES materials and resources, to achieve these goals. We collected those plans and performed thematic coding analysis. Our coding rubric was informed by the BEETLES model design principles (e.g., promoting and supporting PL and research-informed teaching practices) and

Table 3. Goal Categories and Frequency of Goals Expressed by Programs		
Category/Code	**Description: actions/goals focus on . . .**	**% programs**
Instructors' professional learning	improving the professional learning of instructional staff.	83% (n=43)
Instructional resources or learner experiences	improving learner activities or program offerings.	77% (n=40)
Theoretical grounding for learner experiences	connecting research to practice in instructional materials or program offerings.	54% (n=28)
Theoretical grounding for instructors' practices	connecting research to practice in professional practices or norms of instructional staff.	67% (n=35)
Organizational changes	changing mission statement, leadership structures/ priorities, or staffing roles.	40% (n=21)
Equity and inclusion	supporting equity, inclusion, and cultural relevance institutionally and programmatically.	35% (n=18)
Connections to local community	establishing/strengthening social relationships and communication with local community.	21% (n=11)
Field-wide changes	pursuing changes in political/social relationships, practices, or norms at a broader level (beyond their site/organization).	15% (n=8)
Evaluation	developing/improving measures and processes to evaluate their program.	12% (n=6)

themes that emerged from the data (program self-evaluation and organizational changes).

Program leaders articulated a variety of goals of a range of specificity. Most programs (n=48, 91%) articulated between 2–8 goals (mean=3.96), although 3 programs articulated more goals with much higher specificity (15, 32, and 37 goals). Most programs (83%, n=43) expressed at least 1 goal that had to do with the professional learning of instructional staff and at least 1 goal that had to do with instructional resources and learners' experiences (77%, n=40). Our findings are summarized in Table 3 (on page 9).

USE OF BEETLES MATERIALS AND RESOURCES

All (100%) responding program leaders reported using BEETLES materials and resources. Most (83%) reported using at least one of all types of materials/resources: PL session, student activity, and other resources (e.g., how-to videos, Guide for Program Leaders). Patterns of usage by type of resource are explored in Table 4 (below). For this paper, we focus on PL sessions and student activities due to space limitations.

Professional Learning Sessions. Overall, 87% of program leaders implemented at least 1 of the 8 PL sessions that were available at the time of the study[2], with an average of 3.11 (*SD*=2.06) sessions per program (range=0-8). Program leaders were most likely to implement sessions related to engaging learners in observations, explorations, and discourse. They were least likely to implement sessions with more of an academic or research focus, such as the *Nature and Practices of Science* (22%) and *Constructing Understanding* (11%).

Program leaders were asked to rate each PL session they implemented on its level of impact on their instructors' practice, using a 4-point scale (1=No impact, 2=Small impact, 3=Significant impact, 4=Transformative impact). Overall, program leaders reported that the

Table 4. Professional Learning Session's Usage and Reported Impact on Program					
Percent of programs that used PL session*		**No impact**	**Small impact**	**Significant impact**	**Transformative impact**
Making Observations	76% (n=41)	0%	7%	54%	39%
Questioning Strategies	65% (n=35)	0%	29%	37%	34%
Teaching and Learning	43% (n=22)	0%	27%	59%	14%
Promoting Discussion	37% (n=19)	0%	16%	58%	26%
Field Journaling with Students	31% (n=18)	6%	33%	33%	17%
Evidence and Explanations	28% (n=16)	0%	25%	63%	13%
Nature and Practices of Science	22% (n=13)	8%	23%	39%	31%
Constructing Understanding	11% (n=6)	0%	0%	67%	33%

*n=54

PL sessions had a significant impact on their program's approach to teaching. The overall mean across 170 ratings of the 8 PL sessions was 3.05 out of 4, suggesting that program leaders found the PL sessions to be impactful on their organization's approach to teaching.

The highest rated session was *Constructing Understanding*, with 100% of leaders reporting it had a transformative or significant impact on their instructors' practice, although the sample size was small (n=6). The next highest rated session was the most widely used session, *Making Observations* (n=41), which was rated as having a transformative or significant impact by 93% of program leaders. In an interview, one program leader reflected:

> *The most valuable [PL session] to my staff—it kept coming up over and over and over again the whole summer—was the one with the "I Notice, I Wonder, It Reminds Me Of" introduction, which I think was the Making Observations session.*

> *[S]eeing how much that was the lightbulb moment for them of really understanding [...] how to get students into that process, and how they would do it, and why that was valuable, so they kept coming back to "I Notice, I Wonder, It Reminds Me Of" all summer—it just blew my mind.*

The lowest reported impact, although still highly rated, was for *Field Journaling with Students* (n=18), which was rated as transformative or significant by 61% of implementing program leaders, but small impact by 33%, and 6% of whom said it had no impact.

Student Activities. Overall, 100% of programs implemented at least one of the 29 available student activities, with an average of 6.48 (*SD*=4.04) student activities per program (range=1–21). Overall, programs were most likely to use activities centered around general exploration and discussion routines and less likely to use activities focused on specific content areas.

Table 5. Student Activities' Usage and Reported Impact on Program				
Activity category	**Number of activities available**	**% of programs using one or more**	**Average number of activities being used (*SD*)**	**Mean level of impact***
Exploration routines	4	100%	2.20 (0.88)	3.25
Discussion routines	5	96%	1.81 (0.78)	3.13
Focused explorations	6	54%	1.04 (1.35)	2.84
Assessment and reflection	2	33%	0.39 (0.60)	3.00
Night Sky–focused	5	24%	0.33 (0.67)	2.68
Investigations	1	24%	0.24 (0.43)	3.31
Energy and Matter–focused	4	18%	0.33 (0.87)	3.00
Adaptations–focused	3	18%	0.26 (0.59)	2.39

*4-point scale: 1=No impact, 2=Small impact, 3=Significant impact, 4=Transformative impact

All program leaders reported using exploration routines, with the most widely used activity being *I Notice, I Wonder, It Reminds Me Of*. Similarly, 96% of program leaders reported using discussion routines, with the most prominent activity being *Thought Swap* (formerly known as *Walk & Talk*). Less used activities were those related to specific content areas (i.e., Adaptations; Energy and Matter; Night Sky). See Table 5 (on page 11).

In addition to being the most commonly used, the exploration routines and discussion routines were reported to have had some of the highest impacts on instructors' practice. On a scale of 1 (No impact) to 4 (Transformative impact), program leaders rated the exploration routines they used as 3.25 and discussion routines at 3.13. One program leader shared that using exploration routines, such as *Discovery Swap*, highlighted the impact that observations can have on learners' experiences and resulted in them changing the sequencing of their lesson:

> *[W]e changed the field trip experience to [the river]. We initially go there so that the kids can see [the river] before they see [the creek], so they can do the stream comparison. And we kinda let the [students at the river] just do whatever they do, but after seeing the Discovery Swap and recognizing how more authentic their learning and attachment to the subject would be if we just let them explore, [it] led to us using the Discovery Swap and moving the field trip experience to earlier in the unit instead of introducing it in another way that's more boxed or canned.*

The investigations activity was also rated highly at 3.31, despite its relatively low frequency of use (24%; n=13). The Adaptations-focused and Night Sky–focused activities were among the least used and lowest rated in terms of impact.

IMPACT OF RESEARCH-BASED MATERIALS ON PROGRAM PRACTICES

On their implementation plans, program leaders identified a range of goals related to how they intended to implement BEETLES in support of capacity-building efforts. Most OSPs (70%) identified goals that were focused on instructional resources and learner experiences. That is, OSPs intended to use BEETLES as a means toward connecting theory to practice

through the use of BEETLES professional learning modules and student activities. Here we explore the reported shifts in pedagogical practices, program structure, and organizational capacity.

Shift in Learner–Centered Approach. By the end of the Institute, program leaders reported shifts in their familiarity with and perceived relevance of a range of BEETLES-aligned pedagogical approaches aligned with the BEETLES design principles[3] (see Table 1 on page 7). To gain additional insights into how these principles translate into praxis, we examined changes in pedagogical practices associated with these approaches, categorized into 3 main areas: (1) learner–centered practices, (2) directly engaging learners in investigations of the natural world, and (3) culturally relevant teaching. Program leaders were presented with a list of practices and identified how well they felt their educational staff employed them with learners. A paired-samples t-test comparing the overall mean rating across all 20 items at the end of the Institutes and 1 year later[4] indicated a statistically significant increase in program leaders' perceptions of the quality of instructors' pedagogical practices ($t(46)=9.90$, $p<0.01$; Cohen's $d=1.46$). See Table 6 (on page 13).

With regard to individual practices, program leaders reported the largest changes with learner–centered best practices related to promoting learner discussions. The largest effect size was *Ask learners to add on to other's thinking* (Cohen's $d=0.91$). Such shifts in practice mirror program leaders' shifts in perspective about the value of discussion-based instruction reported after participating in the Leadership Institute. Program leaders reported the least change in practices related to culturally relevant teaching, including *Check for group understanding* (Cohen's $d=0.11$) and *Create an environment where it's okay for students to use their home/native language if they prefer* (Cohen's $d=0.21$). While we did not see as large of a shift in practices related to engaging learners in exploration and investigations of the natural world, program leaders often noted in interviews that BEETLES supported them in thinking about the importance of engaging learners with the natural world. One program leader shared that over the course of implementing BEETLES, they have observed educators "doing a great job with engaging [learners] directly with nature [and] explicitly [connecting opportunities] into the lessons to think like a scientist." There was a recognition among program leaders that change was slow but still being observed.

Pedagogy category	Pedagogical practice	Post–Institute Mean* (SD)	End-of–Year Mean* (SD)	Cohen's d**
	Table 6. Program Leaders' Ratings of Instructors' Pedagogical Practices: Post-Institute and One Year Later			
Overall Mean		**1.86 (.32)**	**2.35 (.27)**	**1.46**
Learner–centered discussions	Ask learners to add on to other's thinking.	1.56 (.59)	2.20 (.63)	.91
	Apply the learning cycle to instruction and curriculum design.	1.33 (.56)	1.89 (.65)	.84
	Provide opportunities for peer discussion.	1.89 (.71)	2.51 (.59)	.77
	Create an environment where it's okay to disagree and change minds.	1.88 (.77)	2.10 (.85)	.67
	Use broad questions to facilitate learners' discussions and exploration.	1.82 (.69)	2.36 (.57)	.64
	Probe for questions from learners.	1.98 (.58)	2.41 (.62)	.63
	Prompt learners to recall prior knowledge.	2.18 (.65)	2.53 (.55)	.44
	Provide opportunities for learners to connect activities to a theme or big idea.	2.09 (.67)	2.33 (.56)	.32
Directly engage learners in investigations of the natural world	Prompt learners to provide evidence for explanations.	1.51 (.66)	2.09 (.63)	.67
	Ask for rationale behind learners' thinking.	1.59 (.73)	2.11 (.54)	.60
	Provide opportunities for learners to explore the environment.	2.36 (.65)	2.78 (.47)	.58
	Ask learners to make and record detailed observations.	2.04 (.76)	2.48 (.62)	.51
	Select and emphasize important science and academic language/concepts throughout the field experience.	2.00 (.79)	2.33 (.71)	.44
Culturally relevant teaching	Provide [learners] time to think and reflect.	1.67 (.64)	2.38 (.65)	.77
	Encourage learners to make connections with prior experiences from family or community.	2.15 (.73)	2.48 (.66)	.49
	Create an environment where it's okay for learners to use their home/native language if they'd prefer.	1.88 (.73)	2.10 (.71)	.21***
	Check for group understanding.	2.26 (.61)	2.35 (.60)	.12***

*3-point scale: 1=Needs improvement, 2=Okay but with room for growth; 3–Area of strength
**All changes are statistically significant at the *p*<0.01 level, except as noted in the last two rows.
***This effect was not statistically significant (*p*>0.05).

At the end of the year, program leaders rated their educators lowest on *Apply the learning cycle to instruction and curriculum design* (mean=1.89). Interestingly, program leaders often reported that they, and their education staff, would redesign curriculum or specific activities using the learning cycle; yet, by the end-of-year survey, program leaders noted that this continued to be an area that needs improvement. This might reflect the complexity of curriculum redesign and the extent to which program leaders may need to support staff in understanding the intent behind the various stages of the learning cycle. Lower ratings could also reflect the fact that it is program leaders, not educators themselves, who often led the redesign of curriculum.

CHALLENGES IN CAPACITY BUILDING

In the end-of-year survey, program leaders reported challenges that they encountered during the study and/or anticipated challenges related to long-term sustainability of implementing the BEETLES materials and resources. Within the BEETLES Project, there is a recognition that shifts in organizational systems and practices take time and require resources. Simultaneously, one of the goals within BEETLES is to support organizations in examining the underlying systems and practices required to build greater capacity to implement learner-centered and nature-centered learning experiences. With this in mind, we took a deductive thematic approach[5] to examine the ways in which program leaders' reported challenges aligned with the BEETLES organizational capacities (as previously described in Figure 1 on page 4). Here we discuss challenges that program leaders reported over the course of the study and then discuss challenges anticipated in the future. In the discussion, we share insights on the implications of these findings.

The most prominent challenge that program leaders reported was related to structures and practices related to professional learning (n=17). Program leaders shared that the PL sessions as designed need a lot of time—generally, the BEETLES sessions are designed to be 2–3 hours long—and within their existing structures, it was difficult to find time to accommodate the sessions. One leader shared:

I think the biggest challenge to implementing these materials is finding time in the schedule. PL [sessions] need a long block of time dedicated to them, and we very rarely have more than 1.5 hours that we can dedicate to training.

The second most reported challenge was related to program policies and practices (n=13). Program leaders shared reflections related to pre-existing policies and structures that had implications for consistent professional learning opportunities and/or implementing BEETLES in student learning experiences. First, program leaders noted that there are challenges related to limited funding that impact the number of hours that are allocated to professional learning. In addition, staffing structures (e.g., varying types of full-time and part-time positions) and hiring processes impact the ability for organizations to have consistent staff-wide professional learning. Lastly, within this category, there were two program leaders who discussed the impacts of the amount of time with learners in their program and the impacts on the extent to which they can leverage some of the BEETLES student activities—as designed. For example, one program leader shared, "We have a fairly limited amount of time with our kids, and our teachers come with fairly specific goals. Not a lot of time for other student activities that do not directly support those goals." Notably, the challenges that were coded as contextual conditions (n=3) were double coded as program policies and practices. Here, we see that guiding policies that shape OSPs (e.g., funding streams) directly impact the policies and practices that subsequently shape opportunities for professional learning.

The third most reported challenge was related to curriculum and instruction (n=9). Program leaders often described that when working with learner groups, there can be constraints around the time that they have with youth and the learning goals and priorities, which has implications for the extent to which program leaders (and educators) may feel positioned to integrate BEETLES materials and resources (e.g., student activities). A few program leaders also noted that they had to be cautious about not overwhelming educators with too many new changes. In addition, program leaders noted that often when implementing student activities with learners, lessons did not go as planned, and materials required some level of adaptation. It is important to note that two program leaders reported that their organizations have a lot of autonomy in designing their programs, which, they shared, seemed to support implementation:

Fortunately, we have the freedom to design and teach our own programs, so we have been able to incorporate BEETLES materials without any significant challenges, other than time to plan and add them to existing programs.

Program leaders' reflections also indicated a point of tension related to organizational goals and priorities and BEETLES—a challenge related to vision and reality (n=6). In this regard, organizations noted that their programs have specific goals that required carefully integrating BEETLES. One organizational leader shared that because their organization was "not explicitly [environmental education]," they needed to think about how to adapt BEETLES materials and resources. In addition, another organization shared that there was some resistance among staff because they felt "it [was] too much to change the way we conduct our programming."

Program leaders also pointed to a challenge related to leadership (n=5). Within this category, challenges largely were associated with the level of confidence that program leaders felt in facilitating the BEETLES PL session and supporting staff. One program leader also noted that they do not have a lot of capacity (e.g., bandwidth) to lead BEETLES PL sessions because they are often asked to facilitate other sessions, which intersects with challenges related to goals and structures related to professional learning.

CHALLENGES RELATED TO LONG-TERM SUSTAINABILITY

When we asked program leaders about anticipated challenges moving forward, we saw very similar patterns of challenges emerge. For instance, the top two categories of challenges were related to professional learning (n=13) and program policies and practices (n=13). Vision and reality was the next highest reported challenge (n=10), followed by curriculum and instruction (n=7), contextual conditions (n=6), and leadership (n=2). As we looked at the anticipated challenges, it's important to note that many of the organizational capacities overlapped. For instance, challenges related to program policies and practices often intersected with challenges related to professional learning or vision and reality. With this in mind, we describe some of the themes that emerged across these categories that have particular implications for sustainability.

One theme that emerged was related to existing staffing structures—that is, within organizations there are varying staffing structures consisting of part-time and full-time positions and seasonal positions that directly impact the organization's ability to hold consistent professional learning for all staff. Relatedly, this presents a challenge related to turnover, where program leaders are thinking about how they may onboard new staff members without having to retrain all staff. Program leaders also highlighted a challenge related to turnover of leadership, wherein they had to think about creating a plan that would support and sustain changes if, and when, program leaders left the organization and/or shifted to different roles and responsibilities.

Another observed theme was related to thinking about the long-term structures and policies that would need to be in place to support ongoing professional learning and time for reflection and continuous improvement. Program leaders noted that they needed to think about how to build in time for the PL sessions, what sequencing would be most appropriate, and/or how to adapt and modify the PL sessions or student activities to better fit within existing structures. Program leaders also noted long-term planning requires thinking about professional learning goals in juxtaposition to other goals and priorities and may warrant some negotiation and refinement of organizational priorities—which largely resonates with the vision and reality capacity.

The last theme to highlight here is a challenge related to the extent to which the organization is able to support staff in shifting practice. Program leaders often cited that implementing BEETLES is a shift in mindset and practice for many educators and, therefore, requires time and support. One organizational leader noted "overcoming folks' habits of teaching non-BEETLES ways for so long is a challenge, even among those who want to adapt to BEETLES methods." In this way, we can see evidence of organizations having to think about what their shared vision and goals are for their organization (vision and reality), for professional learning, and for curriculum and instruction as a means toward supporting educators in growing their knowledge and skills to design and facilitate learner-centered and nature-centered learning experiences.

Discussion

In this study, we conducted interviews with program leaders at eight case study sites to gain a richer understanding of how OSPs were approaching capacity-building efforts. To further illustrate some of the main themes in the discussion, we have constructed five vignettes from four case sites to illustrate the complex and dynamic nature of capacity-building efforts. Table 7 (below) highlights some of the features of these case sites.

The present study investigated the implementation of an organizational capacity-building model to support improved science instruction at outdoor science programs across the United States. Overall, findings suggest that the Leadership Institute and implementation of BEETLES materials and resources promoted shifts in program leaders' perceptions and organizational practices to promote learner-centered and nature-centered learning experiences. With that said, findings also highlight the ways in which variation in the use of BEETLES materials and resources can affect the potential impact of capacity-building efforts.

In interviews with program leaders, one of the prominent challenges cited was time, as illustrated in Vignette 1: Having "Enough" Time (on page 17). However, in this report, we argue that time is symptomatic of broader systemic and structural issues. In this discussion, we illustrate how such factors can impact capacity-building efforts, as illustrated in the vignettes.

EASE OF IMPLEMENTATION VS. TRANSFORMATIVE IMPACT

Overall, program leaders reported high rates of implementation of PL sessions and student activities, with notably higher use of resources that supported learner exploration of the natural world and discussions. Yet, findings also pointed to less use of resources that focused on investigations or were related to specific science content (e.g., Night Sky activities or Matter and Energy activities). One potential explanation for lower use could be due to the context-specific activities. For instance, if you don't have access to lichen, you will be less likely to use *Lichen Exploration*. Or if you don't have overnight programs, you might be less likely to use *Moon Balls* (which must be conducted in a very dark room).

Table 7. Case Site Characteristics				
Program	**Program type**	**Region**	**Education staff**	**Learner characteristics**
Branch Nature Center	Nonresidential	Southeast	12, mostly seasonal and part-time	Pre-K–college, 15,000 learners/year
Creek Nature Center	Nonresidential	Northeast	7 staff, mostly volunteers and interns	1st–5th graders, 500 youth/year
Leaf Outdoor School	Residential	Northwest	15 educators, majority seasonal	4th–6th graders, 100,000 youth/year
Lichen Outdoor School	Residential	West	12 educators, all full-time	4th–8th graders, 3,200 youth/year

The names of organizations and program leaders have been changed and do not reflect the identities of the individuals quoted in the vignettes.

VIGNETTE 1: HAVING "ENOUGH" TIME

The Branch Nature Center is a nonresidential city government–affiliated nature center offering various outdoor programming to youth via a city park network in the Southeastern region of the United States. Lee (one of the program leaders of The Branch Program), like many others across the BEETLES network, identified time, both for training and contact with youth participants, as their biggest challenge. Lee mused that more time during their program would allow for richer experiences.

...time to plan, time to train staff and volunteers, time with students, yeah...I would love to have a half-a-day experience where we could have students here for three or four hours, and we have actually increased our time. It used to be an hour and a half and now we've convinced some teachers to stay for two hours. But if you try to get them to come for more, ...there's all these reasons they can't. And if we had kids here all day or half day, I think we just would have even more amazing things happening. And, because we do a lot of other things here and our staff [members] are expected to do more than just field instruction, they don't have as much time to really learn this as deeply as maybe I would like, or for us to spend a lot of time on some of the reflection.

The challenges that Lee points to are not unique to the organization, nor to endeavors of transformative change. However, the constraint of time is symptomatic of larger issues that organizations like this one are facing. Nonresidential programs must often work within the bounds of what field trips allow (usually 2–4 hours) and teachers' expectations and goals. In this example, we can see how the program leader and staff were beginning to push against these boundaries—expanding the time they have with learners so as to provide richer learning experiences. Furthermore, Lee described how having more hours devoted to professional learning would enable staff to further develop their skills, but the varying expectations, roles, and workload of educators is a very real constraint and nearly a constant point of tension.

Other residential program leaders also raised concerns about having enough time for professional learning. Alex, the program leader of the Leaf Outdoor School, recognized that the way professional learning is structured has an impact on the frequency that all staff can come together to engage in professional learning.

I think we are struggling to find a time where we can get everybody to come back for continued professional development ... [currently, we] offer the most professional development ... on [occasional] Friday afternoons where we get like half of the staff ... [for only an hour] ...

In this example, we continue to see the constraints of negotiating the reality of organizational workload and expectations of staff with a desire to create structures that can support the growth and learning of staff.

While this may hold true, findings suggest that some of the underutilized activities were highly impactful. For example, investigation activities were only reported to be used by 24% of organizations, yet were rated to be transformative in impact. This raises a critical point that program leaders, and staff, must consider what types of activities may be more impactful as opposed to solely focusing on activities that may be easier to implement.

When we look at use of PL sessions, findings highlighted that *Constructing Understanding* was one of the least used sessions while being the highest rated in terms of impact. While *Constructing Understanding* was not presented during the Leadership Institute in its entirety, elements of it were incorporated throughout. This is notable because if program leaders were to implement this session, it would take more time and intentional effort to learn and implement it. Yet, *Constructing Understanding* is one of the sessions that provides a foundational understanding of how people learn and the theoretical underpinnings for pedagogical practice, which align with goals that program leaders

VIGNETTE 2: EASE OF IMPLEMENTATION VS. TRANSFORMATIVE CHANGE

Our conversation with Lee, the program leader of the Branch Nature Center, offered an important perspective on the challenges that program leaders face as they balance the need for ease of implementation with the longer-term goal of making deeper changes. Lee shared that overall, their staff held little familiarity or previous experience with education theory, so they wanted to focus on the sessions and activities that would support immediate shifts in practice. Accordingly, their approach to implementing BEETLES materials was rooted in a desire to make immediate changes:

While we were still in California at the BEETLES [Leadership Institute], [we thought about] what we could integrate into field trips almost immediately, […] And so we started with those professional learning [sessions] for the staff and volunteers that would best fit with, kind of, early adoption of routines into things. And then, [we chose to implement] some of the more theoretical things like nature and practice of science, we did those later on. We still haven't done the teaching and learning cycle, that's the big one that we're gonna do this winter.

Lee also noted that when educators started to implement BEETLES routines with learners, they began to see how effective the strategies were and how youth were engaging in different ways. They hoped that this process would lead to deeper change over time.

Lee's insights highlight the need to carefully consider the point of entry so as not to disproportionately burden education staff. This example speaks to the careful considerations and trade-offs program staff must account for when working toward institutional change. Program leaders and staff seek the best way to impact their program but must do so within the realities of their program, such as time and the prioritization of goals. The ease of implementing materials that they can "plug and play" into their programs may come at the cost of implementing materials that will have the highest impact on teaching and program experiences.

identified in their implementation plans (i.e., theoretical grounding for instructional practice and learner experiences). Further, research has shown that when educators are exposed to the underlying rationale or theory of pedagogical practice or curriculum, there is an increased likelihood of it being taken up in practice (Randi & Corno, 2007), highlighting the importance of sessions such as *Constructing Understanding*. Collectively, the observed patterns of usage of BEETLES resources point to the complex choices that program leaders face in deciding where to focus their efforts. On one hand, program leaders can focus on resources that are easy to implement with minimal reorganization or restructuring of their programs; however, this simplicity may come at the expense of truly transformative changes. On the other hand, program leaders can focus on resources that can cultivate more substantial and long-lasting changes, such as developing a shared understanding of the organizational vision (vision and reality) and approach to teaching and learning (curriculum and instruction); however, these changes can be a more arduous process that requires substantial commitment, time, and leadership.

IMPACT ON SCIENCE LEARNING

As we've described, BEETLES is designed to build organizational capacity to provide high-quality science teaching and learning. BEETLES has designed a model with associated materials and resources that supports learners to engage with nature, experience instruction based on how people learn, think like a scientist, experience equitable and culturally relevant learning environments, and learn through discussion. Overall, study findings point to the positive impact that the BEETLES capacity-building model has had on these goals. In particular, findings demonstrate that through participation in the Leadership Institute and implementation of BEETLES materials and resources, program leaders reported a shift in organizational priorities and practices that promoted learner-centered learning and authentic engagement through observations and discussions. For instance, program leaders reported a high usage of PL sessions, such as *Making Observations* and *Questioning Strategies*, that placed learners' funds of knowledge at the center of learning experiences. In this way, program leaders and instructors were pushed to think about the expansive

ways they can engage learners' experiences, interests, and knowledge as a means toward making meaning of the natural world and science content. Subsequently, there are more opportunities for youth to make more meaningful connections and see the value of science. This shift in practice can reframe the role of the instructor to be more of a facilitator that can ultimately promote a greater sense of agency amongst learners. Findings also suggested that the BEETLES capacity-building model supported program leaders in redesigning activities and lessons using the learning cycle. Program leaders reported the largest gains in their familiarity with the learning cycle (Cohen's d=1.99), and those that implemented the learning cycle found it to have a substantial impact on their organization's practice. By leaning into the learning cycle, program leaders and instructors were better positioned to design learning experiences that provided multiple points of entry and supported learners in making connections

between science content and their own interests and experiences. Within the context of this study, our focus is on understanding the impact of BEETLES on program leaders and organizational practices and, therefore, does not focus on the impact on learners. A concurrent research study extends this line of inquiry to explore the impact of OSP learning experiences on learner outcomes.

One of the challenges that the findings point to is related to shifting practices that might warrant larger organizational changes. For example, program leaders were less likely to report using materials and resources focused on journaling or notebooking. This type of shift in practice requires more intentionality behind understanding the purpose of notebooks and how to facilitate youth engagement and learning using notebooks, let alone buying notebooks or asking youth to bring notebooks from home; therefore, it

VIGNETTE 3: IMPACT ON SCIENCE LEARNING

The Creek Nature Center is a nonresidential program in the Northeastern region of the United States. This program is situated within a natural science and history museum, established over 150 years ago, and provides free science education programs to the public. The museum's education program, established about 25 years ago at the time of this study, is primarily designed to engage learners, pre-K through college, in a wide range of public programs that include community science, evening and weekend family programs, community outreach programs, and school-based programs that integrate science and art. As part of their participation in BEETLES, the education staff focused on applying BEETLES to their school-based experiences where educators will work with teachers over the course of 6–12 months to provide classroom-based and field-trip experiential learning. One of the goals for the program team was to think about how to make a meaningful, cohesive experience that connected the field-trip activities to the content that learners were learning in the classroom through a standards-aligned curriculum. In an interview, the program leaders shared that BEETLES provided them with a framework that supported staff in building a common language and vision for their program. One of the program

leaders shared that in one of their activities, they would engage youth in a stream exploration where they would let learners do whatever they wanted. Yet, through their participation in BEETLES, they drew on the activities such as *Discovery Swap* and were able to think about how engaging youth in questioning, discussions, and argumentation could allow for a more authentic learning experience. For instance, during activities that engage learners in observations of phenomena, there is more of an emphasis on supporting learners to share their ideas through writing, drawing, and talking. Pat, the program leader, shared that using strategies such as *I Notice, I Wonder, It Reminds Me Of* also provided a shared language that "[staff and learners] all understand as a practice of science, and I think that's really powerful to build up over time." Pat also shared that when they implemented BEETLES, youth were able to engage in science in a more meaningful way, and it "gave more meaning and purpose to what and how [educators] teach." In seeing this impact, Pat noted that the staff is now thinking about how to integrate BEETLES into other programs in the organization as well as with partner organizations. They hope that this will enable them to collectively work toward having a larger impact. However, Pat shared that "[it's] really hard to coordinate across programs."

might require more ongoing professional learning or additional resources. Similarly, while equity and inclusion was implicitly embedded within BEETLES materials and resources, shifting practice to cultivate culturally relevant learning experiences requires a dedicated investment in professional learning wherein program leaders and instructors can engage in critical reflection about ideologies and practices (e.g., implicit bias, power, and privilege) that explicitly aim to promote more equitable, inclusive, and culturally relevant experiences. With this in mind, these study findings suggest that BEETLES can have a positive impact on science learning experiences and also require organizations to think about what other organizational capacities beyond teaching and learning can support transformative change in practice (further discussed in the next section).

GOING BEYOND TEACHING AND LEARNING

As noted previously, BEETLES posits that to shift instructional practice, organizations must also tend to the capacities that can support changes in curriculum, professional learning, and instruction. Study findings highlighted that the vast majority of implementation goals were related strictly to teaching and learning— such as improving professional learning (85% of programs) or providing resources to support instruction and learner experiences (77%). Subsequently, we saw that organizations widely used PL sessions and student activities that were primarily designed to directly impact instructional practice with learners. While this is important and aligns with the intended use of these materials, one of the unintended consequences that the findings highlighted was the lack of focus on organizational capacities, such as assessing how

VIGNETTE 4: STRENGTHENING VISION AND COHERENCE

The Leaf Outdoor School is a residential program located in a Western U.S. national park that offers 3–5 daylong outdoor science learning experiences for youth. Like most program leaders in this study, Alex shared that the BEETLES Project provided rich materials and resources that positively influenced their learning experiences and educators' knowledge and skills. The Leaf Outdoor School had recently redeveloped their theory of action to align across their programming. This process allowed the Leaf Outdoor School to modify a number of the BEETLES-identified organizational capacities to strengthen their commitment to professional learning and high-quality curriculum. For instance, a theory of action provided a clear vision for the organization's approach to teaching and learning. In this process, the organization must also account for the factors (i.e., contextual conditions) that would influence professional learning, such as staff availability and workload expectations. Alex called attention to BEETLES' ability to support applying high-quality pedagogical practices to environmental education:

I think there can be a little bit of a disconnect between best teaching practices and environmental education [...] so I think BEETLES does a good job of

bridging that gap of bringing some simple yet effective pedagogical tools to people that might have a lot of outdoors experience and experience working with kids and are scientifically literate, but maybe don't have a deep pedagogical background.

For the program leader, drawing on BEETLES provided an opportunity to build the skills and practices of their educators, many of whom hold a wide range of experiences and familiarity with pedagogy. This case demonstrates that there is an opportunity for leaders to think beyond focusing solely on curriculum to attend to the structures and practices that enable organizations to expand their capacities for broader improvements. The Leaf Outdoor School offers occasional professional learning and has some structural systems for feedback that enable them to improve and integrate BEETLES materials more effectively. Beyond this, the program has sent individuals to multiple BEETLES institutes, reflecting their commitment to professional learning and use of high-quality curriculum materials. This case highlights that advancing teaching and learning happens within a larger context; programs need to look at multiple facets of a program in order to achieve a coherent approach to improving teaching and learning to realize their larger vision.

the organization's vision and reality are connected to professional learning or reflecting on how policies and practices can impact changes in practice. One of the most substantive challenges that organizations reported was related to the availability of staff to participate in professional learning. Yet, the structures around professional learning are directly impacted by contextual conditions (e.g., funding), program policies (e.g., hiring and staffing structures), and shared vision and reality (e.g., alignment of BEETLES to organizational mission). From the BEETLES perspective, while this can be a lengthy and arduous process, when organizations consider what capacities can support or hinder organizational transformation, the breadth of change extends beyond teaching and learning to organizational systems.

THE INTERSECTION OF EQUITY, INCLUSION, AND SCIENCE LEARNING

Overall, results pointed to highly positive outcomes of the capacity-building model. A common theme that emerged across data sources, however, was the need for more intentional support around equity and inclusion. Prior to the Leadership Institute, program leaders reported themselves to be least familiar with culturally relevant teaching among all the pedagogical approaches they were asked about. They also reported moderate levels of change in their familiarity with and the perceived relevance of culturally relevant teaching through their participation in the Institute. There is a similar trend related to individual pedagogical practices. One year after the Institute, program leaders thought their staff were implementing culturally relevant teaching practices, yet recognized that there was still room for growth. The strategy that had the lowest rating at both timepoints was related to encouraging staff to reflect on their own biases in relation to their instructional practice. Collectively, these findings suggest that participation in BEETLES had only a minor impact on the extent to which programs were able to implement culturally relevant teaching practices.

Culturally relevant pedagogy was not originally an explicit focus of the BEETLES capacity-building model;

VIGNETTE 5: THE INTERSECTION OF EQUITY AND INCLUSION

The Lichen Outdoor School is a residential multisite outdoor science program that aims to bring science to life for youth through hands-on, nature-based learning experiences. In their programs, youth experience science by connecting with nature and the outdoors and feeling what it means to be a scientist. The program leader, Devin, shared that through their participation in the BEETLES Leadership Institute, they reflected more critically and intentionally about the cultural relevance of their program offerings: "[It got us to] think about our activities and the way we speak to students and the environment that we provide with students for the week."

To this end, the program staff had cultivated a culture that supported collective dialogue and reflection about ways to address learners' needs. For instance, at the beginning of each week when groups arrive, educators talk with classroom teachers to share information about their learners. Over time, Devin observed staff sharing strategies for working with individual learners. "I see staff stopping and talking about different strategies and asking about how to connect with specific students." Devin noticed that this new practice helped shift how staff build connections with learners.

Devin also acknowledged that while, as a staff, they are beginning to engage in difficult conversations that may have once been taboo, including equity, inclusion, and cultural relevance, it continues to be an area of growth for them. The program leader noted that slowly, staff members are being challenged to reflect on how the design and facilitation of activities are uplifting learners' knowledge and experiences. Devin highlighted that while the BEETLES model supported them to begin more intentional work and reflection on how to connect with individual learners, further work is needed to support organizations and their staff to engage youth in equitable and inclusive learning experiences. Notably, the experience of the Lichen Outdoor School resonates with survey findings where practices centered around equity and inclusion (e.g., culturally relevant pedagogy) continued to be an opportunity of growth. Within the broader field of science and environmental education, we see similar trends (Romero, et al, 2019; Sheth, 2019) where leaders and educators are reckoning with how to center equity (e.g., racial, gender, ableism) within their programs.

rather, it was embedded throughout the resources. When BEETLES was initially conceptualized to engage learners in learner-centered and nature-centered learning experiences, one of the implicit assumptions was that these experiences would inherently be more equitable and inclusive. During the scope of this study, the BEETLES Project team recognized that it was inadequate to promote equity and inclusion implicitly and indirectly; rather, it was imperative that this be an explicit focus. Beginning in Year 3 of the project (i.e., following the collection of data used in this study), the project team began redesigning its model to incorporate sessions in the Institute that specifically focused on equity, inclusion, and cultural relevance. The team began to revise and republish student activities and PL sessions to call out the ways in which the BEETLES design principles connect to equity and inclusion.

LIMITATIONS

The present study was designed to offer insights to the field on how a capacity-building model can support programmatic changes and improvements in a wide variety of OSPs across the country. As a case study, however, this work is inherently connected to the specific model and programs that participated: the BEETLES capacity-building model and the sample of residential and nonresidential OSPs who applied to participate in the BEETLES Leadership Institutes. The findings of this study are specific to the context of OSPs that participated in the BEETLES Project and, therefore, may not be generalizable beyond this population. In addition, due to space limitations, the present study privileged the voices of program leaders, but they are just one of several stakeholders in capacity building at OSPs. Future work should explore how other stakeholders, particularly educators, experience and influence capacity building in OSPs.

Implications

Program Leaders and Funders. The present study holds a number of implications for professionals in the field of outdoor science and environmental education related to organizational capacity building. It showed that program leaders representing varied programs found value in incorporating research-based PL sessions and student activities to support

exploration, discussion, and improved learning. At the same time, findings highlighted the complexity of transformative change and the need to consider how underlying systems and structures, values, and contextual conditions can shape the possibilities of transformation. That is, implementing PL sessions and student activities without addressing the organization's mission and vision, financial resources, or programmatic structures can limit their impact. In addition, it may also be important to consider how to engage staff in goal-setting and decision-making as a means toward ensuring vision attends to reality. These capacity-building efforts in combination can, in turn, promote truly transformative impact. Situating these findings in the broader context of environmental education, this study affirms the need for funders to continue building capacity of environmental education organizations and the field at large.

Professional Learning and Curriculum Developers. The study offers several implications for professionals who develop outdoor science and environmental education professional learning materials or instructional materials. The present study found that a multicomponent capacity-building model was effective in supporting organizational change across a varied sample of programs nationwide. By engaging program leaders in an immersive leadership institute as the first step, the model ensured that leaders were motivated, bought-in, and prepared to return to their programs to initiate changes. A suite of capacity-building materials and resources from which programs could choose allowed program leaders and educators to select the sessions and activities that were most relevant to their staff and learners. What this highlights is the importance of having a flexible and adaptive model that can provide for varying points of entry depending on an organization's starting point. With that said, study findings suggest that transformative change that extended beyond teaching and learning was complex and difficult for program leaders. Over the course of this study, the program team refined the ways in which it was supporting greater capacity-building efforts. For instance, they redesigned materials and the Leadership Institute to explicitly address equity, inclusion, and cultural relevance; provided reflective tools so program leaders could assess the policies,

systems, and practices that would support or inhibit greater organizational capacity building; built structures and expanded a facilitation team that brought different voices and more nuanced ideas to support participants in expanding ideas for what transformative change can look like; and provided various sources of ongoing support (e.g., ongoing webinars, consultation via email or phone as requested to support organizations in persisting through challenges).

Implications for Future Research. The present study poses a number of implications for future research on outdoor science education. This study found that the broad implementation of the BEETLES capacity-building model was successful in that a national sample of programs (a) was able to implement the materials and resources back at their sites, and (b) reported positive impacts from the materials and resources. It was beyond the scope of the present paper, however, to understand patterns in implementation based on programmatic features. For example, were programs with particular professional learning structures better positioned to incorporate the BEETLES PL sessions? Similarly, were programs with particular staff profiles or backgrounds more likely to show improvements in their educators' pedagogical practices? Deeper analysis into these kinds of patterns would enable a better understanding of potential best practices for OSPs in order to promote instructional improvements.

Though this study found that participating in the capacity-building model enabled educators to make significant improvements in their pedagogical practices, it remains to be seen how these changes may, in turn, influence learner outcomes. The authors are currently analyzing data from a case study to examine the extent and ways in which OSPs support learner outcomes related to science and environmental literacy.

ENDNOTES

1. While there were a total of 127 program leaders that participated in this study, participation in each of the data-collection activities varied. We include the number of program leaders that completed each of the data-collection activities in the description of data sources.

2. The BEETLES Project has since created 3 additional professional learning sessions, for a total of 11 sessions. This study focused on the materials and resources that were available at the time of data collection.

3. With the program team, we designed a series of items that assessed program leaders' perceptions about the extent to which instructors drew on practices that were aligned with the BEETLES design principles. To make sense of these practices, we formed three categories—(1) learner-centered discussions, (2) directly engage learners in investigations of the natural world, and (3) culturally relevant pedagogy—to understand how practices can align with the BEETLES framework. However, we recognize that these practices are not mutually exclusive and connect to multiple categories. For instance, *Prompting learners to recall prior knowledge* promotes learner-centered discussions and also aligns with culturally relevant pedagogy. Therefore, in our discussion of patterns, we focus on an item-by-item analysis (i.e., looking at trends on individual items) to describe how BEETLES can support shifts in practices that may support a range of outcomes or goals.

4. Participants rated their educators' practice across 20 items on a 3-point scale, with 1 representing "needs improvement," 2 representing "okay but room for growth," and 3 representing "area of strength." Participants completed the survey at the end of the Leadership Institute (before they began capacity-building efforts back at their programs) and then again 1 year later.

5. Deductive analysis entails looking for evidence that supports the theory or guiding hypothesis. An inductive approach, on the other hand, would be identifying emergent themes to identify categories or build up a theory (Merriam & Tisdell, 2017).

REFERENCES

American Institutes for Research (AIR). (2005). Effects of outdoor education programs for children in California.

Ardoin, N. M., & Bowers, A. W. (2020). Environmental education and nature-rich experiences: Essential for youth and community well-being during the COVID-19 pandemic and beyond. Policy Analysis for California Education (PACE) Reports.

Ardoin, N. M., Bowers, A. W., & Gaillard, E. (2020). Environmental education outcomes for conservation: A systematic review. *Biological Conservation*, *241*. https://doi.org/10.1016/j.biocon.2019.108224

Ardoin, N. M., Bowers, A. W., Roth, N. W., & Holthuis, N. (2018). Environmental education and K-12 student outcomes: A review and Analysis of research. *The Journal of Environmental Education*, *49*(1), 1–17. https://doi.org/10.1080/00958964.2017.1366155

Avci, G, & Gümüs, N. (2020). The effect of outdoor education on the achievement and recall levels of primary school students in social studies course. *Review of International Geographical Education Online*, *10*(1), 171–206.

Barab, S., & Luehmann, A. (2003). Building sustainable science curriculum: Acknowledging and accommodating local adaptation. *Science Education*, *87*(4), 454–467

Barak, K. (2009). Environmental education: Camp as an alternative learning site. *International Journal of Learning*, *16*(11), 423–438.

Collins, M. A., Dorph, R., Foreman, J., Pande, A., Strang, C., & Young, A. (2020). A field at risk: The impact of COVID-19 on environmental and outdoor science education (Policy brief). Berkeley, CA: The Lawrence Hall of Science, University of California, Berkeley.

Collins, M. A., Pande, A., Strang, C., Foreman, J., & Dorph, R. (2021). Impacts from COVID-19: Resilient outdoor science programs need support as challenges persist. (policy brief). Berkeley, CA: The Lawrence Hall of Science, University of California, Berkeley. https://www.researchgate.net/publication/358937791_Impacts_from_COVID-19_Resilient_Outdoor_Science_Programs_Need_Support_as_Challenges_Persist

Collins, M. A., Young, A. Y., Romero, V. F., Laina, V., Pande, A., Foreman, J., Strang, C., & Dorph, R. (2022). *The disproportionate impact of outdoor science programs on BIPOC- and female-identifying youths' dispositions toward science and the environment*. Manuscript in preparation.

Coyle, K. J. (2010). Back to school: Back outside! How outdoor education and outdoor school time create high performance students. *National Wildlife Federation*, 1–41.

Cutter-Mackenzie, A., Clarke, B., & Smith, P. (2008). A discussion paper: The development of professional teacher standards in environmental education. *Australian Journal of Environmental Education*, *24*, 3–10.

Danforth, P. E., Waliczek, T. M., Macey, S. M., & Zajicek, J. M. (2008). The effect of the National Wildlife Federation's schoolyard habitat program on fourth grade students' standardized test scores. *HortTechnology*, *18*(3), 356–360. https://doi.org/10.21273/HORTTECH.18.3.356

Dorph, R., Bathgate, M. E., Schunn, C. D., & Cannady, M. (2018). When I grow up: The relationship of Science Learning Activation to STEM career preferences. *International Journal of Science Education*, *4*, 1034–1057. https://doi.org/10.1080/09500693.2017.1360532

Ernst, J., & Erickson, D. M. (2018). Environmental education professional development for teachers: A study of the impact and influence of mentoring. *Journal of Environmental Education*, *49*(5), 357–374.

Feille, K. (2017). Teaching in the field: What teacher professional life histories tell about how they learn to teach in the outdoor learning environment. *Research in Science Education*, *47*(3), 603–620.

Gonzales, P., Williams, T., Jocelyn, L., Roey, S., Kastberg, D., & Brenwald, S. (2008). Highlights from TIMSS 2007: Mathematics and science achievement of U.S. fourth- and eighth-grade students in an international context (NCES 2009–001 Revised). Washington, DC: National Center for Education Statistics, Institute of Education Sciences, US Department of Education.

Grimwood, B. S. R., Gordon, M., & Stevens, Z. (2018). Cultivating nature connection: Instructor narratives of urban outdoor education. *Journal of Experiential Education*, *41*(2), 204–219.

Karpudewan, M., & Mohd Ali Khan, N. S. (2017). Experiential-based climate change education: Fostering students' knowledge and motivation towards the environment. *International Research in Geographical and Environmental Education*, *26*(3), 207–222.

Kuo, M., Browning, M. H. E. M., & Penner, M. L. (2018). Do lessons in nature boost subsequent classroom engagement? Refueling students in flight. *Frontiers in Psychology*, *8*, 1–15. https://doi.org/10.3389/fpsyg.2017.02253

Lammert, J. D., Johnson, L., & Fiore, T. A. (2015). Conceptualizing capacity building. Rockville, MD: Westat.

REFERENCES (continued)

Li, Y., & Krasny, M. E. (2019). Practice change in environmental education: Lessons from professional development. *Environmental Education Research*, *25*(7), 1119–1136.

Liddicoat, K. R. & Krasny, M. E. (2014). Memories as useful outcomes of residential outdoor environmental education. *The Journal of Environmental Education*, *45*(3), 178–193. tandfonline.com/doi/abs/10.1080/00958964.2014.905431

Lieberman, G. A., Hoody, L. L., & Lieberman, G. M. (2000). California student assessment project (phase one): The effects of environment-based education on student achievement. Conducted by the State Education and Environmental Roundtable on behalf of the California Department of Education.

Mack, E., Augare, H., Cloud-Jones, L. D., Davíd, D., Gaddie, H. Q., Honey, R. E., Kawagley, A. O., Plume-Weatherwax, M. L., Fight, L. L., Meier, G., Pete, T., Leaf, J. R., Scout, E. L. F., Sachatello-Sawyer, B., Shibata, H., Valdez, S., & Wippert, R. (2012). Effective practices for creating transformative informal science education programs grounded in Native ways of knowing. *Cultural Studies of Science Education*, *7*, 49–70. https://doi.org/10.1007/s11422-011-9374-y

McLeod, B., & Allen-Craig, S. (2007). What outcomes are we trying to achieve in our outdoor education programs? *Journal of Outdoor and Environmental Education*, *11*(2), 41.

Merritt, R. D. (2018). Environmental Education. *EBSCO Discovery Research Starters*. EBSCO Information Services, Inc., 1–10.

National Project for Excellence in Environmental Education. (2010). Excellence in environmental education: Guidelines for learning (K–12). Washington, DC: North American Association for Environmental Education.

National Research Council. (2009). *Learning science in informal environments: People, places, and pursuits*. Washington, DC: National Academies Press.

National Research Council. (2010). *Surrounded by science: Learning science in informal environments*. Washington, DC: National Academies Press.

National Science Teachers Association. (2012). An NSTA position statement: Learning science in informal environments. Retrieved from nsta.org/nstas-official-positions/learning-science-informal-environments

Payne, P. G., & Wattchow, B. (2008). Slow pedagogy and placing education in post-traditional outdoor education. *Australian Journal of Outdoor Education*, *12*(1), 25–38.

Pearson, A. R., Ballew, M. T., Naiman, S., & Schuldt, J. P. (2017). Race, class, gender, and climate change communication. *Oxford Research Encyclopedias, Climate Science*.

Powell, R. B., Stern, M. J., Krohn, B. D., & Ardoin, N. (2011). Development and validation of scales to measure environmental responsibility, character development, and attitudes toward school. *Environmental Education Research*, *17*(1), 91–111.

Quibell, T., Charlton, J., & Law, J. (2017). Wilderness schooling: A controlled trial of the impact of an outdoor education programme on attainment outcomes in primary school pupils. *British Educational Research Journal*, *43*(3), 572–587.

Randi, J. & Corno, L. (2007). Theory into practice: A matter of transfer. *Theory into Practice*, *46*(4), 334–342.

Rickinson, M. (2001). Learners and learning in environmental education: A critical review of the evidence. *Environmental Education Research*, *7*(3), 207–320. https://doi.org/10.1080/13504620120065230

Rickinson, M., Lundholm, C., & Hopwood, N. (2009). *Environmental learning: Insights from research into the student experience*. Springer.

Rogers, E. B., Taylor, J., & Rose, J. (2019). Perceptions and experiences of diversity and inclusion of outdoor educators in higher education. *Journal of Outdoor Recreation, Education and Leadership*, *11*(2), 134

Romero, V., Chi, B., Snow, J. (2015). BEETLES: Better Environmental Education, Teaching, Learning, and Expertise Sharing. Final Evaluation Report: A Summary of Findings for Years 2–4: 2013–2015. Berkeley, CA: The Lawrence Hall of Science, University of California, Berkeley.

Romero, V., Foreman, J., Strang, C., Maybury, C., Pepito, E., & Rocca, C. (2019). Intentional hiring and recruitment through the lens of equity and inclusion: Insights and lessons learned from Crissy Field Center, Golden Gate National Parks Conservancy. Berkeley, CA: The Lawrence Hall of Science, University of California, Berkeley.

Romero, V., Foreman, J., Strang, C., Rodriguez, L., Payan, R., & Moore Bailey, K. (2019). Equitable and inclusive work environments in environmental education: Perspectives from the field and implications for organizations. Berkeley, CA: The Lawrence Hall of Science, University of California, Berkeley.

Romero, V., Snow, J. Z., Laina, V., Pande, A., & Chi, B.. (2021). BEETLES: An evaluation of a capacity building model to support outdoor science programs. Berkeley, CA: The Lawrence Hall of Science, University of California, Berkeley.

Sanford, C., & Sokol, V., (2017). Professional development: Targeted on-the-job trainings. In P. G. Patrick (Ed.), *Preparing informal science educators: Perspectives from science communication and education*. Springer International Publishing.

REFERENCES (continued)

Sheth, M. J. (2019). Grappling with racism as foundational practice of science teaching. *Science Education*, *103*(1), 37–60.

Snow, J., & Romero, V. (2014). Findings from National Residential Outdoor School Needs Assessment (Memorandum). Berkeley, CA: The Lawrence Hall of Science, University of California, Berkeley.

Stern, M. J., Powell, R. B., & Ardoin, N. M. (2008). What difference does it make? Assessing outcomes from participation in a residential environmental education program. *The Journal of Environmental Education*, *39*(4), 31–43.

Stern, M. J., Powell, R. B., & Ardoin, N. M. (2010). Evaluating a constructivist and culturally relevant approach to environmental education for diverse audiences. *The Journal of Environmental Education*, *42*(2), 109–122.

Stern, M. J., Powell, R. B., Hill, D. (2014). Environmental education evaluation in the new millennium: What do we measure and what have we learned? *Environmental Education Research*, *20*(5), 581–611.

Tai, R.T., Liu, C.Q., Maltese, A.V., & Fan, X.T. (2006). Planning early for careers in science. *Science*, *312*(5777), 1143–1144.

Tas, E., & Gulen, S. (2019). Analysis of the Influence of Outdoor Education Activities on Seventh Grade Students. *Participatory Educational Research*, *6*(2), 122–143.

Taylor, D. (2014). The state of diversity in environmental organizations: Mainstream NGOs, foundations, and government agencies. Washington, DC: Green 2.0 Working Group. https://diversegreen.org/wp-content/uploads/2021/01/FullReport_Green2.0_FINAL.pdf

Weinstein, M., Whitesell, E. R., & Schwartz, A. E. (2014). Museums, zoos, and gardens: How formal-informal partnerships can impact urban students' performance in science. *Evaluation Review*, *38*(6), 514–545. https://dx.doi.org/10.1177/0193841X14553299

Williams, D. R., & Dixon, P. S. (2013). Impact of garden-based learning on academic outcomes in schools: Synthesis of research between 1990 and 2010. *Review of Educational Research*, *32*(2), 211–235. https://doi.org/10.3102/0034654313475824

Wishart, L., & Rouse, E. (2019). Pedagogies of outdoor spaces: An early childhood educator professional learning journey. *Early Child Development and Care*, *189*(14), 2284–2298.

PHOTO CREDITS

All images used in this brief were provided by the BEETLES Project team.

SUGGESTED CITATION

Romero, V. F., Collins, M., Young, A., Laina, V., Dorph, R., Pande, A., Strang, C., & Foreman, J. (2022). Improving outdoor science teaching and learning: The implementation of a capacity-building model in outdoor science programs. Berkeley, CA: The Lawrence Hall of Science, University of California, Berkeley.

THE RESEARCH GROUP

The Research Group at The Lawrence Hall of Science delivers a full spectrum of research and evaluation services to provide evidence and insights that foster high-quality, innovative Science, Technology, Engineering, and Mathematics (STEM) learning experiences that are equitable, inclusive, and culturally relevant.

BEETLES™ (Better Environmental Education Teaching, Learning, and Expertise Sharing) provides environmental education programs nationally with research-based approaches and tools to continually improve their programs.

The Lawrence Hall of Science
UNIVERSITY OF CALIFORNIA, BERKELEY

Our Mission: Discover. Engage. Innovate.

To inspire and foster learning of science and mathematics for all, especially those who have limited access to science.

lawrencehallofscience.org