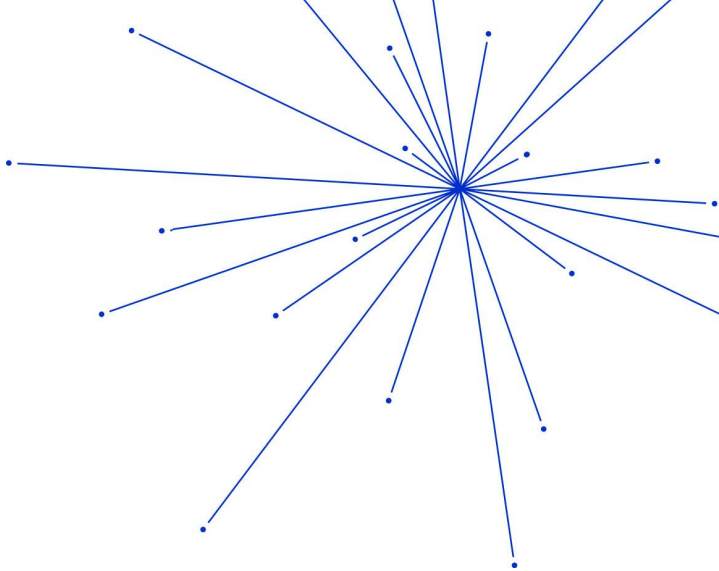
NGSS Science & Engineering Practices in Outdoor Science Programs



NAAEE 2020 Conference Presentation

Melissa Collins, Aujanèe Young, Valeria Romero, Vicky Laina, Aparajita Pande, Rena Dorph, & Craig Strang

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Our Team (Research + Program)

Aparajita

Aujanèe

Melissa

Craig, PI

Emilie

Valeria

Vicky

Rena, co-PI

Jedda

Kevin

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Context for our study

This work is part of larger NSF-funded study to research science education in outdoor science programs through the implementation of professional development model, The Better Environmental Education, Teaching, learning, Expertise Sharing (BEETLES; beetlesproject.org)

Program leaders from 68 outdoor programs attended BEETLES Leadership Institutes in 2017-2018

Context for our study

Over the course of five years the study aimed to

(1) build the capacity of OSP to increase the quality of their informal science learning experiences, and position them to play a key role in supporting schools to implement Next Generation Science Standards (NGSS), and

(2) contribute knowledge to the field of informal science education about the features of informal science learning experiences that support meaningful outcomes for youth.

Where we are right now

COVID-19 pandemic has been devastating to the field

- 11 million+ students missing EE programming by the end of 2020
- At least $600million in lost revenue
- 64% of programs unsure if they will reopen

Collins, Dorph, Foreman, Pande, Strang, & Young, 2020

OSPs are often been viewed as field trips-- i.e., a luxury--despite the enriching, powerful, and effective experiences they can provide. Now more than ever, we need to make sure these experiences are seen for their value and not viewed as dispensable .

Making space for science

Since 2002 (NCLB), elementary science education has been virtually dismantled. Elementary teachers in California, on the average, spend less than 60 minutes per week teaching science (Dorph, Shields, Tiffany-Morales, Hartry, & McCaffrey, 2011)

This has been exacerbated by the pandemic & remote instruction; 88% of teachers say their students are learning less science during the pandemic (WestEd, 2020)

In a week of outdoor science school, youth can receive the classroom equivalent of several months' worth of science exposure, with particularly rich opportunities for science and engineering practices and hands-on experiences that are difficult to implement in classrooms.

Promoting the Value of the Outdoors

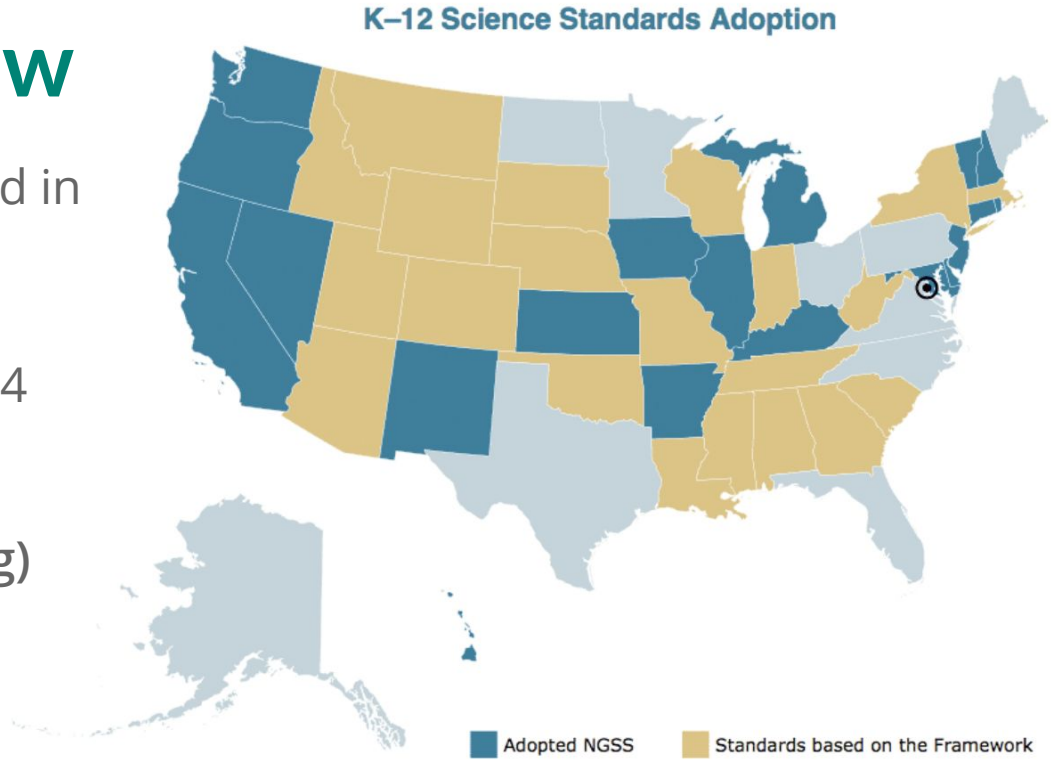
By its very nature, the outdoors also lends itself toward integrated, systems-based learning, and cross-cutting ideas described in the Next Generation Science Standards.

Intentionality around alignment with education standards could be the extra "boost" needed to keep schools engaging with OSPs. This would add value for school districts and improve the learner experience

NGSS - Overview

- Standards were released in 2013
- Adopted in 20 states
- Basis of standards for 24 more states

(ngss.nasta.org)



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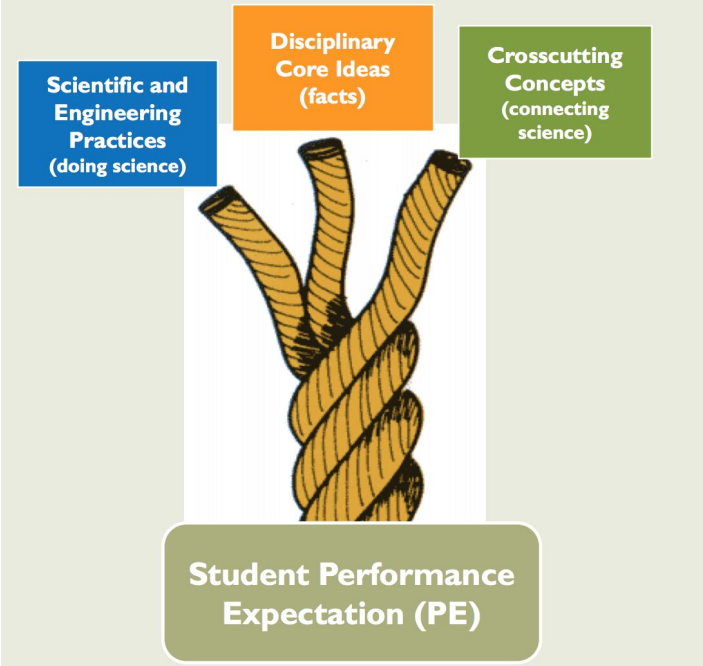
Three-Dimensional Science Learning



The BEETLES Project. “Nature and Practices of Science.”

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Three-Dimensional Science Learning

NGSS takes into account the major developments in research about science education by placing a priority on students doing science and critically reflecting on evidence.

The NGSS are written as Performance Expectations. There are three strands that weave together to create the performance expectations for the NGSS requires that students apply the three dimensions *in context.* The 3 dimensions are interconnected, and equally important. The idea is that all three dimensions should be interwoven during science instruction, not taught in isolation.

This is a new conception of science – even though the science practices are another version of previous concepts like inquiry skills, which were taught along with content. NGSS is promoting the idea that students should learn science content by engaging in the practices, and using the cross cutting concepts to make sense of the natural world – that's what is meant by using them in context, students are actively engaged in exploring phenomena and figuring things out.

Performance expectations do not provide info on how to teach, nor are they meant to be use as assessments.

NGSS Scientific and Engineering Practices (SEPs)

1) Asking Questions (science) and Defining Problems (engineering)
2) Developing and using models
3) Planning and carrying out investigations
4) Analyzing and interpreting data
5) Using mathematics and computational thinking
6) Constructing explanations (science) and designing solutions (engineering)
7) Engaging in argument from evidence
8) Obtaining, evaluating, and communicating information

Research Questions

How do outdoor science programs (OSPs) create opportunities for youth to engage in science and engineering practices (SEPs), as outlined by NGSS?

How can research-based curricular materials support the enactment of SEPs and 3-dimensional learning in OSPs?

Methods

Data sources

- Program Leader Surveys (range n=65 through n=127)
- Case Site Observations (n=8)

Study Participants

N= 59 programs attended Institutes
30/29 residential/ non-residential

Students served annually
10 less than 1k
35 between 1-10k
13 More than 10k

Range of grades (prek-12)
Range of contact hours (2hrs-5 days)

Case Sites

N= 8 programs

5 residential
3 non-residential

Similar to full sample in range of students served

All over 50% of time outdoors

Findings

Change of Perspective: OSPs & Science Relevance

BEFORE and AFTER engaging in immersive professional learning introducing research-based curricular materials

There is not always an agreement in the field about the role of science in outdoor programs. Before the Institute, views on the relevance of science were varied, and just 20% of leaders thought the nature and practices of science were very relevant to their program (see data on next slide).

After a week of immersive professional development, their views had changed substantially. Seeing the BEETLES resources in action shifted their perspectives on what science can look like and how it can be implemented in their programs. Program Leaders reported a really high perception of the relevance of science after participation in the institutes.

Change of Perspective: OSPs & Science Relevance

BEFORE and AFTER engaging in immersive professional learning introducing research-based curricular materials

	Nature of Science (e.g., science as a process)		Practices of science (e.g., what scientists do)	
	Pre	Post	Pre	Post
Not at all relevant	8%	1%	7%	1%
Somewhat relevant	38%	1%	32%	1%
Relevant	38%	23%	42%	24%
Very relevant	**18%**	**76%**	**20%**	**75%**

BEETLES Student Activities & SEPs

After seeing these high perceptions of the relevance of science, we next wanted to see which BEETLES student activities, if any, the program leaders chose to implement back at their programs, and which SEPs these activities promoted.

The first step was to analyze which activities promote which SEPs. Of the 36 student activities BEETLES has published, 29 promote NGSS SEPs (see next slide)

Overall, programs were most likely to use activities to promote *Asking Questions & Defining Problems* (97%) or *Obtaining, Evaluating, and Communicating Information* (94%).

They were least likely to use activities to promote *Engaging in Argument from Evidence* (12%).

BEETLES Student Activities & SEPs

Which SEP	# BEETLES activities available	% orgs using 1+
Constructing Explanations and Designing Solutions	15 activities	65%
Engaging in Argument from Evidence	4 activities	12%
Developing & Using Models	4 activities	28%
Asking Questions & Defining Problems	3 activities	97%
Obtaining, Evaluating, and Communicating Information	3 activities	94%
Planning & Carrying Out Investigations	2 activities	23%

No activities promoting:

- *Using Mathematics & Computational Thinking*
- *Analyzing and Interpreting Data*

PL Perceptions, BEETLES Student Activities & SEPs

Regardless of which SEP was being promoted by the BEETLES activities or the prevalence of the activity's usage, program leaders overall reported that using these research-based activities had a "significant" or "transformative" impact on their instructors' practice (see next slide).

PL Perceptions, BEETLES Student Activities & SEPs

SEP	Most frequently used BEETLES activity within SEP	% programs using	"Transformative" or "Significant" impact
Asking Questions	I Notice, I Wonder, It Reminds Me Of	97%	95%
Obtaining, Evaluating, & Communicating Information	Thought Swap (Walk & Talk)	94%	79%
Constructing Explanations	Lichen Exploration	31%	70%
Planning & Carrying Out Investigations	Exploratory Investigation	23%	100%
Developing & Using Models	Moon Balls	19%	67%
Engaging in Argument from Evidence	Argumentation Routine	8%	100%

Case Study Vignettes

After examining trends across program leaders, we wanted to gain a deeper perspective on how SEPs can be promoted through outdoor science programs.

For the following vignettes, we drew from our case site observations.

We selected three vignettes to serve as examples of the range of learning experiences we observed to highlight the different levels of SEP engagement and the different roles curricular materials can play.

Vignette #1 - Low curricular scaffolding

A group of 12 ninth grade students are visiting a coastal area. After a morning spent hiking through the intertidal zones and discussing the adaptations of intertidal creatures, they head into the lab. The educator does a brief lesson on plankton, beginning with an open-ended question to gauge their prior knowledge: "What do you know about plankton?" She then describes the differences between different varieties of plankton. The instructor encourages students to pose questions they would want to know about plankton--"How long do they stay plankton? Do they stay plankton forever?" but the students are reserved. Then they collect samples at the dock and return to the lab to look at samples under microscopes. The instructor encourages them to describe what they see, and then she gives them an identification key to identify the types of plankton in their samples. They then debrief the activity, sharing what they learned and any questions they have.

Vignette #1 - Low curricular scaffolding

- Very engaging experience, fostered curiosity, locally relevant
- At times was fact-heavy; Sage on the Stage
- Missed opportunities to engage in SEPs
  - Asking Questions (I Notice, I Wonder, It Reminds me of...)
  - Planning and carrying out investigations *(e.g., do types vary by region of the intertidal zone?)*
  - Analyzing and interpreting data *(e.g., comparing data from different samples)*
  - Constructing explanations *(e.g., using evidence to explain differences between samples)*
- BEETLES resources (e.g., Discovery Swap or Structures & Behaviors) could situate observing plankton samples within a more 3-Dimensional experience.

Vignette #2 - Medium Curricular scaffolding

On a late November morning, a group of 20 youth were learning about ecosystems and what animals need to survive in the wild. After having students reflect on their prior knowledge, the instructor taught about the roles of consumers, decomposers and other entities within an ecosystem. The students then discussed how they might identify what types of things live in the ecosystem of the forest they were in. After creating a list of potential evidence, the youth marked out an area of the forest floor with a hoop and looked for the evidence they had outlined before. After documenting their findings in their journals, the students went on a walk to share and compare what they found with a peer. The instructor explained why some of them had different findings; because some plants will grow in more sunlight and others need less. Students are asked to discuss differences in findings, constructing explanations and identifying patterns of what will grow where.

Vignette #2 - Medium Curricular Scaffolding

- Based loosely on BEETLES activities (Exploratory Investigation + Thought Swap), but heavily adapted
  - This can be positive, as it allows for instructor autonomy and local tailorization
- But, adaptations can also lead to missed opportunities for SEPs- e.g., ask *students* to give explanations for different findings
- Successful enactment of SEPs/3D learning depends on
  - Circumstantial events and on-the-fly decisions
  - Staff experience and expertise
- Success is vulnerable to staff turnover

Vignette #3 - High Curricular Scaffolding

A group of 16 sixth grade students are out on a hike in the woods on a sunny fall day. After some team-building exercises in the morning, the students are quite comfortable with each other and have developed a culture of talk. The instructor holds up a stick with a green, leafy substance on it, and asks the students "What do you think this is? What is your evidence?". Students give various answers and the instructor probes for evidence, using their observations on color, shape, texture, location, and connections to other things they have learned. The instructor then tells the group, "We're going to walk and see how many different kinds of this stuff you can see. I want to hear you talking!" Students explore the area with their magnifying glasses. They share when they find new kinds, talk about how features differ, and pose explanations for why ("Maybe it's a fungus. We keep finding it growing on trees"). The instructor helps them realize they've gathered evidence that it's a fungus and that it's a plant, and then introduces the concept of symbiosis and informs them that they've been looking at lichen. The group then uses a key to identify different types of lichen in their field journals.

Vignette #3 - High Curricular Scaffolding

- Immersive, engaging experience based on the Learning Cycle, a research-based model of how people learn
- 3-dimensional learning experience
  - SEP = Constructing Explanations
  - Content = LS2.A Interdependent Relationships in Ecosystems
  - CCC= Patterns
- Resilient to staff turnover due to existing documentation
- Provides enough scaffolding to support staff with a range of expertise
- Can be adapted to different flora/fauna, specific to site

Takeaways

- OSPs provide learning experiences that can be hands-on, engaging, and authentic to the program experience. These are rich opportunities for engaging participants in SEPs and 3D learning.

- Programs showed more readiness to incorporate some SEPs (Asking Questions and Communicating Information) than others

- Program leaders found research-based activities to have “transformative” or “significant “ impact on their instructors’ practice

- Research-based curricular materials can be a tool to prevent missed opportunities in implementing SEPs and 3D learning

Thank you!

For professional learning sessions, student activities, and other materials and resources, check out our website!

Beetlesproject.org

Research Questions: Melissa Collins macollins@berkeley.edu
Program questions: beetles@berkeley.edu

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