ENVIRONMENTAL EDUCATION

RESEARCH BULLETIN

ABOUT THE RESEARCH BULLETIN

The *Environmental Education Research Bulletin* is a project of Dr. Nicole Ardoin and her team at Stanford University, with support from ChangeScale, NatureBridge, and ee360, a cooperative project of the U.S. EPA and the North American Association for Environmental Education (NAAEE). The bulletin is designed to inform environmental and sustainability educators about recent relevant research, with a primary emphasis on informal, field, and residential settings, as well as stewardship behavior, conservation, and related topics. Although other environmental educators and those in related fields might also find this bulletin useful, it does not—nor is it intended to—cover all aspects of environmental and sustainability education. This Research Bulletin, as well as past issues, is available online through the NatureBridge (https://naturebridge.org), ChangeScale (www.changescale.org), and Social Ecology Lab (https://nmardoin.people.stanford.edu/research/eerb) websites, as well as on the NAAEE website (https://naaee.org/eepro/research/eerb).

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INTRODUCTION

Dear Colleagues,

Stanford University researchers have collaborated with NatureBridge, ChangeScale, and the North American Association for Environmental Education (NAAEE) to create this 14th and final issue of the *Environmental Education Research Bulletin* (EERB). Since 2011, we have written more than 200 environmental education research summaries, which are accompanied by bottom-line applications for practice. We undertook this endeavor with the intention of helping talented environmental educators bridge the research-and-practice gap. We endeavored to enhance the accessibility of recently reported research by highlighting ways for practitioners to apply research findings to their work.

In each of the 14 issues, we focus on a range of topics pertinent to on-the-ground environmental educators, including environmental literacy, equity and inclusion, connection to place, professional development, and evaluation. We appreciate the support of our project advisors and collaborators, whose additional strategic emphases have informed our work. For example: NAAEE's focus on civic engagement, the intersection of environmental education and conservation, and early childhood ensure those issues remain front and center in these bulletins; NatureBridge has encouraged an ongoing emphasis on the intersection of social-emotional learning and environmental education; and ChangeScale's focus on developing tools and practices at the nexus of informal environments with K–12 learning settings have continued to inform the EERBs.

This final EE Research Bulletin includes summaries of research articles published between July and December 2017. They have been drawn from of a number of environmental education-related journals, including the *Journal of Environmental Education, Environmental Education Research, Applied Environmental Education & Communication, South African Journal of Environmental Education, International Journal of Science Education, Journal of Interpretation Research, Journal of Environmental Psychology,* and *Visitor Studies.*

For ongoing dialogue around the research-and-practice interface, we encourage you to participate in the research and evaluation discussion group of eePRO, NAAEE's professional development community. You can join eePRO at https://naaee.org/eepro/groups/research-and-evaluation. Also be on the lookout for the course under development through the Stanford Social Ecology Lab, in partnership with NAAEE and ee360, on leveraging resources such as the EE Research Bulletins and other research-and-practice resources. If you have comments or questions about these summaries, email socialecology@stanford.edu. In particular, we would love to hear your inspiring stories and ideas about how you have infused ideas from research into your practice. We believe, truly and deeply, that this open dialogue is essential to enhance the effectiveness of our work and, in the end, will make the world a better, more sustainable, thriving place, now and in the future.

See you in the field!

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EQUITY AND INCLUSION IN ENVIRONMENTAL EDUCATION

GENDERED DIFFERENCES IN EDUCATION FOR SUSTAINABLE DEVELOPMENT

Are girls more sustainability conscious than boys? Studies of how environmental education outcomes differ across genders have long indicated that girls demonstrate greater knowledge, more pro-environmental behavior, stronger preferences for the preservation of nature, and more positive environmental attitudes than boys. Given those prior results, this paper tackles the question of whether Education for Sustainable Development (ESD)—which combines social, environmental, and economic elements—yields the same gender differences as environmental education. The authors were particularly motivated to undertake this study because some research has suggested that ESD may actually prevent gender gaps in education. The authors of this study differentiate between the terms *sex* (that is, the biological term used to differentiate between men and women, or boys and girls) and *gender* (which is defined as socially constructed and may influence identities and differences between sexes); the latter term is the focus of their study.

To assess the potentially gendered aspects of ESD with regard to sustainability consciousness, the researchers posed three questions: (1) Do differences exist between boys and girls with respect to sustainability consciousness? (2) Does the effect of gender on sustainability consciousness change between grades six, nine, and twelve? and (3) How do ESD-certified schools impact gender differences? The authors designed the study so that each of the three lines of inquiry helped illuminate the economic, social, and environmental dimensions of sustainability consciousness.

To address the research questions, researchers engaged a sample of 2,413 students in grades six (ages 12–13), nine (ages 15–16), and twelve (ages 18–19) from schools across Sweden. They examined 26 ESD-certified and 25 noncertified schools of different sizes from both rural and urban areas all over the country. For the purposes of this study, researchers chose to focus solely on two student-

identified sexes—boy and girl—to directly compare the two groups. The study did not include gender nonbinary categories for methodological reasons, as part of the study relied on methodology that required the researchers to separate participants by sex into two groups in order to understand gender effects.

Each student in the study responded to a 50-item, Likert-type survey, which addressed knowledge, action, and behavior aspects of the environmental, economic, and social dimensions of sustainability consciousness.

Researchers arrived at several key insights through analyzing the results of this questionnaire. Most notably, they found that the gap between girls' and boys' sustainability consciousness widens as students age, with girls becoming proportionally more sustainability conscious over time.

Girls consistently received higher mean scores in each category of the survey, with the exception of sixth graders in the economic dimension of sustainability consciousness. Girls also scored higher if they attended ESD-certified schools, whereas there was no measurable difference between boys who did and did not attend ESD-certified schools. Finally, and perhaps most critically for this study, students who attended ESD-certified schools exhibited greater gender differences than students in non-ESD schools.

These results led the researchers to wonder whether the purportedly inclusivity-focused structure of ESD cannot mediate or negate whatever normative social forces are at play with respect to gender, at least in Sweden. The authors suggest that more transformative pedagogical approaches may provide a potential solution to this disparity and an avenue for future research on the gendered impacts of ESD.

THE BOTTOM LINE:
As international norms and expectations continue to develop around Education for Sustainable Development (ESD) through the United Nations and other

organizations, educators and schools should be aware of the limitations of ESD curricula, particularly related to gendered differences in sustainability consciousness. Although ESD may actually amplify the disparity between girls' and boys' sustainability consciousness rather than close the gap, some programmatic elements may assist in addressing this gap. To decrease the gender gap for boys and girls in ESD-certified schools, educators may need to approach the sustainability curriculum in transformative ways that push back against social norms of masculinity and femininity.

Olsson, D., & Gericke, N. (2017). The effect of gender on students' sustainability consciousness: A nationwide Swedish study. *The Journal of Environmental Education, 48*(5), 357–370.

BEHAVIOR

HOW DISCIPLINARY MAJOR AND COLLABORATIVE CONTEXT IMPACT ENVIRONMENTAL DECISION-MAKING

Deeper knowledge of environmental issues—in particular, their root causes, possible solutions, and alternatives—can encourage positive environmental behaviors. Cooperative, as compared to competitive, settings can likewise encourage people to act less selfishly. This study considered how university students made decisions in simulations of farmer irrigation to explore how knowledge and cooperative cues interact. The authors assumed that environmental science students had deeper knowledge of environmental issues, while educational science students had less of this knowledge. The article suggests that either deep knowledge or cooperative settings is sufficient to encourage similar levels of pro-environmental behavior.

To examine this assumption, the authors recruited as participants 61 environmental science majors and 46 educational science majors (107 students total) from Spain's University of Cordoba. The authors did not disclose recruitment methods. Students played a farmer irrigation simulation game, choosing how to irrigate each of their 10 fields every "year," for 10 years. The three options ranged from the most pro-environmental but least revenue-accruing (rain fed) to the most selfish (groundwater use), with river water irrigation falling in the middle.

Groups of three students, all from the same major, were randomly assigned to either cooperative or competitive "villages." Cooperative-condition participants could discuss strategy at three stages and were told to maximize both their own and the village incomes. Competitive-condition participants could not communicate, were given information on the other participants' income at three stages, and were told to maximize only their own income.

The authors quantified the "selfishness" of irrigation choices as the number of groundwater-fed fields minus the number of rain-fed fields. The authors found that environmental science majors were significantly less selfish than educational science students, and that cooperative condition students were significantly less selfish than competitive condition students. The major finding, however, considered the interaction between a student's discipline

and cooperation on behavior. Environmental science students were less selfish whether they were in cooperative or competitive conditions, while education students were less selfish only in the cooperative group. Participants who were educational science majors and in the competitive condition were significantly more selfish. In other words, a cooperative setting alone or being an environmental science student alone appeared sufficient to encourage pro-environmental behavior.

The authors interpret these results as a call to encourage cooperative context setting and for more education on environmental issues. However, the results support the former (collaborative context setting), but not the latter (more education). The authors used students' majors as a proxy not only for knowledge but also interest. Because the authors did not measure underlying levels of environmental concern, they cannot conclude that the difference between majors is due to a difference in knowledge, as opposed to one of interest or of some other factor.

THE BOTTOM LINE:

With college-aged students, being an environmental science major and working within a collaborative context can both be elements that encourage positive environmental behavior. Professors, especially those who teach outside of environmental studies departments, should encourage their students to collaborate when dealing with environmental issues. To encourage collaborative thinking, they should also emphasize the importance of community or societal goals.

Cuadrado, E., Tabernero, C., García, R., & Luque, B. (2017). The interactive effect of pro-environmental disciplinary concentration under cooperation versus competition contexts. *Environmental Educational Research, 23*(6), 797–811.

IMPACT OF COMMITMENT ON ENVIRONMENTAL EDUCATION OUTCOMES WITH TEENS

Although research has long indicated that knowledge gained from environmental education (EE) does not produce lasting pro-environmental action on its own, combining knowledge with other interventions may spark and sustain behavior changes among EE participants. In this study, the authors examined how combining commitment interventions with EE could influence water and energy conservation among teenagers in Portugal. They assessed whether students who received EE instruction and publicly committed to saving resources would ultimately conserve more water and energy at home than students who did not receive the instruction or make the commitment.

To test this, the authors first used previous research to establish criteria for creating effective commitments. The elements that the researchers studied included ensuring that commitments were public, voluntary, and adequately challenging, as well as designed to activate students' pre-existing personal norms, which the authors treated as an offshoot of identity. The researchers also designed the EE initiative used in the study, which included a visit to the Lisbon Botanic Garden (an experiential element) and two classes on energy and water conservation at students' schools (a knowledge delivery component). The study's 418 participants ranged from 11 to 15 years old and attended four schools across 21 classes.

Researchers split the students into two groups. Group 1 consisted of 248 students, all of whom received EE instruction and committed to water and energy conservation publicly, privately, or not at all. Group 2 (170 students) served as the control, receiving no EE programming but still signing a conservation commitment publicly, privately, or not at all.

To measure energy and water savings for each student, the researchers collected electricity and water meter readings at home from an average month and from the

month when students participated in the conservation challenge. They also administered pre and post surveys that gathered information on self-reported conservation attitudes, conservation intentions, conservation behavior, ecological self-identity, and personal norms around water and energy use.

Analysis of the direct data from meter readings indicated that water savings did not vary between the group with EE and the group without EE (control group), and that students in the EE group saved more energy than those in the control group. This analysis also revealed that students who signed public commitments saved more water than those who signed private or no commitments, but only among students already in the EE group. This indicates that commitment alone may not influence behavior.

In analyzing the questionnaires, researchers found that EE had a measurable effect on students' self-reported ecological identity as well as on their water saving attitudes and behavior. With respect to energy, researchers saw among those in the EE group an increase in feelings of guilt, which was part of the personal norms category. Commitment did not impact either group.

These findings indicate that ecological self-identity and personal norms related to guilt about not conserving more energy may be important predictors of conservation behavior. Making commitments may activate aspects of self-identity and personal norms, which can ultimately lead to behavior change. Researchers, therefore, suggest that making conservation commitments should occur in conjunction with experiential delivery of EE programs, such as that done in the Lisbon Botanic Garden.

THE BOTTOM LINE:

In isolation, neither EE initiatives nor resulting, purported conservation commitments are enough to ensure sustained positive changes in conservation behavior among teenagers. Combining public commitments with EE initiatives, however, may encourage more significant

effects on students' energy and water savings. Ensuring that EE programs conclude with a public commitment to a specific conservation behavior/action may enhance teenagers' self-reported ecological identity and personal norms related to conservation. If practitioners and educators aim to provide EE programming related to topics such as energy and water to help enhance students' ecological self-identities and activate their personal norms, more successful outcomes of public conservation commitments may follow.

Barata, R., Castro, P., & Martins-Loução, M. A. (2017). How to promote conservation behaviours: The combined role of environmental education and commitment. *Environmental Education Research, 23*(9), 1322–1334.

THE EFFECT OF SCHOOL DESIGN ON STUDENTS' ENVIRONMENTAL ATTITUDES

To reduce their environmental footprint, many schools have begun to incorporate sustainable design elements, such as solar panels and water-collection tanks. Evidence also exists that sustainable school design may impact students' environmental attitudes. Yet, while many researchers have explored the influence of recreational space design on children's environmental attitudes, few have considered the effect of learning space design.

Following ResourceSmart AuSSI Vic, an environmental education action plan that gives a five-star rating to schools achieving the highest level of sustainable design, the researchers used a randomized process to select three sustainably designed schools and four conventional schools in Victoria, Australia. All seven schools were public elementary schools that followed the same national curriculum. The researchers then selected students at random from the fourth, fifth, and sixth grades at each school to complete an environmentally related questionnaire. The questionnaire was designed to assess the students' environmental attitudes in three areas: human-nature interaction, environmentally sustainable design (at school), and human-versus-nature

hierarchies. The researchers also provided questionnaires to the students' parents and teachers to control for any influence the parents' and teachers' environmental attitudes may have had on the students. The study ultimately included 143 students who attended conventional schools and 132 students who attended sustainable schools.

The researchers compared students' environmental questionnaire responses, dividing the sample by those at conventional schools versus those attending sustainably designed schools. Using a series of multiple regressions, the researchers also examined whether the environmental attitudes of parents and teachers, and/or the absence of sustainable-school-design features, influenced the students' attitudes in each of the three areas of interest.

The researchers found that parents, teachers, and sustainable-school design influenced students' attitudes toward human-nature interaction, with teachers' environmental attitudes being the strongest predictor. School design was the strongest predictor of students' attitudes toward environmentally sustainable design; teachers' environmental attitudes also had a significant effect. Finally, the researchers determined that none of the measured factors had a significant effect on students' attitudes toward human-versus-nature hierarchies.

These results suggest that sustainable-school design can encourage students to have positive attitudes toward sustainable elements of the built environment. It may also foster an understanding of the connection between the built environment and the natural world.

THE BOTTOM LINE:
Sustainable school design can support students' positive attitudes toward a sustainably built environment, as well as foster a connection between the built environment and the natural world. Those positive attitudes may, in turn, contribute to pro-environmental behavior. One way that educators and schools can enhance children's pro-environmental attitudes is to invest in sustainable-design features, such as solar panels, daylighting, gardens, and water tanks, in their schools. Those features will not only reduce students' resource consumption, they will also help students

see value in sustainability efforts in the built environment. If schools already have sustainably built features, teachers can enhance the value by drawing attention to those features and emphasizing their importance.

Izadpanahi, P., Elkadi, H., & Tucker, R. (2017). Greenhouse affect: The relationship between the sustainable design of schools and children's environmental attitudes. *Environmental Education Research, 23*(7), 901–918.

OVERESTIMATION OF PERCEIVED RECYCLING SKILLS BASED ON PERSONAL DISPOSITIONS AND BELIEFS

The degree to which people think they are good at recycling is an important component of recycling behavior, as perceived skills are related to feelings of self-efficacy, which in turn have been shown to increase the chance that people engage in environmental behaviors. People's self-evaluations of their recycling skills, however, cannot always tell us how good they actually are at recycling. Often people overestimate the skills they possess; this overestimation is caused by a number of related factors, such as social norms, expectations of ability, and dispositional traits.

This study's authors hypothesized that the need for cognitive closure, one such dispositional trait, would be especially related to the overestimation of perceived skills. This term refers to people's needs for firm answers rather than feeling comfortable with ambiguity or situational openness.

The researchers explored this relationship between perceived and actual recycling skills, as well as some of the motivational, dispositional, and behavioral factors surrounding these constructs. The research involved enrolling 281 participants in Italy, who were given an initial survey and then asked to engage in a simulated recycling task. The survey included items related to perceived recycling skills, such as, "All in all, I think I am able to correctly perform household waste recycling." The

survey also included questions on five other constructs: recycling attitudes, social norms, perceived control over their recycling, need for cognitive closure, and typical household recycling behavior. The study's "simulated recycling task" element attempted to measure recycling skills by providing 20 pictures of common objects and asking participants to describe how they would dispose of the items using their local recycling procedures.

The researchers explored the patterns of association among these constructs using basic correlations. They also tested a formal model of prediction for perceived and actual skills. That is, the researchers tested whether the constructs of social norms, need for cognitive closure, and perceived control predicted perceived recycling skills and whether perceived skills—alongside household recycling behavior—predicted actual recycling skills.

Results of the survey demonstrated that perceived recycling skills were significantly correlated with all other motivational and dispositional factors, as well as with actual skills. This relationship between perceived and actual skills, however, was only of "moderate" strength (correlation value = .33). In addition, actual recycling skills were significantly related to attitudes, social norms, and household recycling behavior, but not to perceived control nor to the need for cognitive closure. This last relationship is of particular interest because it supports the researchers' hypothesis that the need for cognitive closure would be related to perceived skills but not actual skills. The authors suggest that the need for cognitive closure may explain this: such a need may motivate people to assert and self-inflate their existing recycling abilities and, as a result, not continue to improve those skills.

THE BOTTOM LINE:

People's perceived and actual recycling skills are closely related to each other as well as to other psychological components of recycling behaviors. They are, however, different, measurable constructs. People tend to overestimate how good they are at recycling, and this overestimation may be related to their need for cognitive closure, potentially because it encourages them to hold a positive view of themselves without continuing to develop their recycling knowledge. Other factors that contribute to this relationship may be key points for intervention for practitioners and educators, including how complicated people think local recycling procedures are and the availability of reliable feedback on correct recycling performance.

Passafaro, P., & Livi, S. (2017). Comparing determinants of perceived and actual recycling skills: The role of motivational, behavioral and dispositional factors. *The Journal of Environmental Education, 48*(5), 347–356.

RECIPROCAL TRUST AND SAFETY IN RESIDENTIAL EE SETTINGS

Research suggests that building trust may be instrumental in supporting broader intended outcomes of environmental education (EE), such as fostering personal growth, encouraging civic engagement, and contributing to pro-environmental behavior. Few EE studies to date, however, have characterized, operationalized, and measured trust particularly as it occurs in informal settings.

Therefore, this study set out to examine whether and how peer-to-peer trust develops among youth participants in a field-based residential EE program using a mixed-methods approach. The researchers selected classes from two schools with sixth-grade-level students (ages 11–12) who participated in NatureBridge, a residential, outdoor EE program at Golden Gate National Recreational Area, California. School 1 was a small, private school whose one sixth grade class of 28 students participated in the study, while School 2 was a larger public school whose three sixth grade classes of over 40 students total participated. Many of the students in School 1 had known each other since kindergarten, while some students in School 2 had not met prior to arriving at NatureBridge. During the NatureBridge programs, classroom teachers organized their students in hiking groups of 12–15 individuals, and, for the most part, students remained in those groups throughout the week. Students spent multiple

days with their primary instructors and hiking group—sharing meals, sleeping in the camp dorms, and engaging in cooperative group work in outdoor settings led by field educators.

This study examined the development of trust within these hiking groups. Specifically, the authors evaluated whether and how trust relationships among members of hiking groups changed during the NatureBridge program, and how group dynamics within hiking groups changed. The authors also explored how ideas about trust might differ in residential EE settings, such as the NatureBridge setting, versus formal classroom settings. The researchers drew upon validated quantitative measures of peer-to-peer trust in classroom settings and Social Network Analysis (SNA) requirements to design a structured survey related to trust among NatureBridge participants. The survey asked questions about each member of a student's hiking group: whether the student considers that person to be a friend; how often that person keeps promises; likeliness that the student would disclose something personal to them; likeliness that the student would go to them with a problem; and whether they trust the student. The researchers administered the survey to all participants the week prior to the program and immediately after. The researchers complemented the survey with open-ended items, field observations of students' interactions and daily discussion with field science educators during the program, as well as student focus groups with one school three weeks after the program ended. The researchers conducted statistical and network analyses of the survey data and thematically analyzed the qualitative data from focus groups and open-ended survey items. They used observations and informal daily discussion to contextualize findings.

The authors found that, during the NatureBridge program, trust increased among individuals within hiking groups. Survey results showed that, following the program, there were increases among different aspects of the trust relationship, including the friendship, promise, disclosure, problem, and reciprocal dimensions of trust.

School 2 participants reported a greater increase than School 1, as many students in School 2 did not know each other prior to attending the program. Social network analysis results indicated that the interactions while at NatureBridge encouraged net positive increases of hiking group members that participants trusted. Further, the SNA data indicated that, apart from one School 1 hiking group, every other hiking group showed signs of becoming closer. Hiking group structures were less fragmented and more cohesive at the end of the program as peer-to-peer trust developed and/or strengthened among hiking group members over the multiple days.

Focus group findings indicated that, although dimensions of trust identified in classroom studies, such as friendship and reciprocal trust among students, applied to the NatureBridge setting, "keeping safe" as well as reciprocal trust with field science educators were particularly salient in the field-based residential context. Qualitative data suggested that the NatureBridge setting and structure, outside of school routines and norms, allowed participants to explore new roles and make new connections with their peers. Field science educators were instrumental in supporting this process as they facilitated novel experiences, allowed participants freedom to explore, and ensured their emotional and physical safety.

The authors identified limitations of the study. The small number of participants meant that some individuals (with low or high scores) may have skewed the network analysis results. Additionally, the structured survey measured individual relationships, whereas group-level metrics may be more appropriate to understand trust in group settings. Further, the study surveyed participants immediately before and immediately after the experience, whereas a longitudinal approach may be useful for assessing changes in trust over time. Finally, this study did not investigate the links between trust and intended program outcomes, such as personal growth and interpersonal skills. Yet, the authors believe that the findings suggest opportunities for developing and testing new tools and measures that explore distinctive dimensions of trust in field-based

residential settings rather than classroom settings. The findings also suggest that social network analysis is conceptually promising for studying trust in informal EE settings, such as this one.

THE BOTTOM LINE:

Immersive, multiday residential environmental education programs, which remove participants from their typical routines and norms, offer unique settings and structures that allow peer-to-peer trust to form, develop, and change, even within a short time. Such settings can provide safe spaces in which students can take on new roles and make new connections with their peers. Educators play a crucial role in facilitating and supporting the trust-development process by curating such novel experiences, encouraging independent exploration, and ensuring that participants' emotional and physical safety are supported within group and outdoor contexts.

Ardoin, N. M., DiGiano, M. L., O'Connor, K., & Podkul, T. E. (2017). The development of trust in residential environmental education programs. *Environmental Education Research, 23*(9), 1335–1355.

TEACHING METHODS

USING SOCIAL MEDIA TO LEARN ARGUMENTATION WITH SCIENTISTS

Educators, formal and informal alike, are focusing less on knowledge acquisition and more on the construction and application of scientific ideas in context thanks to the Next Generation Science Standards (NGSS). This notion of practice-based learning suggests that students should construct scientific concepts by engaging in the practices of science. It also suggests that students should understand how scientific knowledge is generated through scientists' everyday practices, such as argumentation.

To further explore how students developed scientific argumentation skills through practice-based learning with experts, this study explored a partnership between scientists and students who interacted on a social-media platform. Focusing on a six-week climate change module within a yearlong life sciences curriculum, the students performed fieldwork, analyzed professional data sets, and used computer modeling to understand the impacts of climate change. They also developed infographics to communicate their findings. Throughout the module, the students used a social media platform that connected them to expert scientists who periodically provided feedback on the students' work. Three ninth-grade classes from two schools participated, with 49 students in total. Researchers used qualitative coding to analyze students' infographic drafts, as well as scientists' feedback.

Through cycles of feedback with expert scientists, students improved their infographics, according to an assessment rubric that the researchers developed. Changes included adding text, adding graphs or figures, reorganizing information, and removing elements. Students improved their infographics by adding more evidence or increasing their depth of explanation, often by adding mechanistic explanations, consisting of why, what, and how something was happening. Although initial infographics were typically simplistic, they tended to grow in complexity over time.

The researchers claim that experts' feedback, in which the experts modeled complex scientific argumentation, encouraged students to seek out additional evidence. Often, in seeking out more evidence, students engaged in additional scientific practices, such as asking

questions and using mathematical thinking. According to the researchers, scientists' feedback pushed students to engage in scientific practices more holistically, as doing one practice often involved incorporating many other practices. Also, researchers described the infographics and the data sets that students used as boundary objects through which students could learn in partnership with scientists. The work provided a connection point where students could construct personally relevant ideas and engage in practice-based learning alongside scientists. This finding suggests that practice-based science learning should include publicly available and professional data sets, as those data sets provide a window for students into scientists' everyday practices.

THE BOTTOM LINE:

Experiences in which students work with expert scientists can support more holistic engagement in scientific practices. Working through cycles of feedback with scientists pushes students to incorporate different scientific practices as they construct evidence-based arguments. Educators should encourage students to use publicly available professional data sets when studying science. This exercise will help students engage in authentic scientific practices in a way that is personally relevant and allows for a meaningful connection point between students and scientists.

Walsh, E. M., & McGowan, V. C. (2017). "Let your data tell a story": Climate change experts and students navigating disciplinary argumentation in the classroom. *International Journal of Science Education, 39*(1), 20–43.

HOW PRESCHOOLERS JUDGE ANTHROPOGENIC HARM

One promising avenue for improving early-childhood environmental education is to consider how children develop moral judgments about human behaviors that impact the environment. Over time, research and practice have consistently documented that school-aged children view the environment as having moral standing; that is, they consistently interpret behavior that harms the environment as morally wrong. It is less clear, however, how young children morally judge behaviors that harm the environment.

To address that question, researchers conducted two parallel empirical studies on moral reasoning with 3- to 5-year-old children: In the first, they showed 24 children between the ages of 3 and 5 simple drawings of a child doing one of three types of actions (12 total drawings, with 4 per category). The three types of actions were: harm to the environment, such as throwing a candy wrapper out of the car; harm to another person, such as pushing another child; and nonharmful personal choices, such as eating carrots for a snack. Researchers then asked the participating child to sort each picture into one of three categories of increasing severity, indicated by the images for each category: "a smiley face" (indicating "OK" behaviors), a "slight frowny face," and an "exaggerated frowny face."

Children in all three age groups (3-, 4-, and 5-year-olds) predominantly selected the *nonharmful personal choice* actions as the least negative of the three, confirming they were likely distinguishing the actions based on moral harm. Additionally, the study uncovered an important age-based difference: the 3-year-old children did not differentiate between the *harming environment* and *harming person* actions, but the 4- and 5-year-old children did. They consistently ranked *harming person* as much more negative than *harming environment*, while still ranking *harming environment* as worse than *nonharmful personal choice*.

These results suggest that children's sensitivity to actions that harm people increases around 4 years, whereas environmental actions that do not have a clear "victim" do not. One implication of this is the importance of indicating clear and identifiable agents that suffer harm (environmental or personal) when discussing consequences of actions with young children. The researchers present these results as compelling evidence that connecting environmentally harmful behaviors to moral judgments is an ability that develops early in

young children and precedes socialization by formal education. In other words, children as young as 3 and not yet in school are indeed sensitive to behaviors that harm the environment.

In the second study, researchers asked 30 children to conduct the same sorting activity as in the first study. However, before doing so, they asked the children to complete a "perspective-taking task." Researchers read the children a picture-book story and then asked the children to put themselves in the shoes of one of two groups of characters from the story: either the characters who undertook some kind of environmentally harmful behavior, or the characters who suffered as a result of such behavior. The second study's results showed that completing the perspective-taking task did not change responses for the *harming person* or *nonharmful personal choice* categories, but did change children's responses to the *environmental harm* category. Children who took the perspective of the environmental harm perpetrator later judged environmentally harmful actions *less* harshly, while children who took the sufferer's perspective later judged such actions *more* harshly. These results, while preliminary, suggest that empathizing with characters who either cause or suffer from environmental harms influences young children's moral judgments of actions directed toward the environment.

THE BOTTOM LINE:

The preschool years are foundational for early-developing environmental attitudes. It is therefore valuable for educators to recognize and leverage children's belief that harming the environment is intuitively wrong, even if children cannot fully articulate why. Educators can also recognize the increasing importance of empathy at this age and use specific, tangible examples of organisms or agents that suffer from environmental harm (while maintaining a hopeful perspective). Acknowledging concrete examples of organisms that suffer harm from environmental damage, combined with positive, actionable ideas on how to minimize that harm, can help to reinforce the developing moral beliefs of young children in relation to environmental stewardship.

Hahn, E. R., & Garrett, M. K. (2017). Preschoolers' moral judgments of environmental harm and the influence of perspective taking. *Journal of Environmental Psychology, 53*, 11–19.

THE POTENTIAL OF A NEW APPROACH TO URBAN ENVIRONMENTAL EDUCATION

Environmental education has traditionally emphasized environmental awareness through focusing on issues such as pollution, degradation, population growth, and natural-resource depletion. However, the authors of this paper argue that such a broad focus is not flexible enough to meet the needs of diverse communities. Therefore, they argue for a more transformative urban environmental education that recognizes the experience of youth in urban settings. They call this approach Critical Urban Environmental Education Programming (CUEP).

The authors hope that CUEP can combat what they see as the negative effects of neoliberalism. They define neoliberalism as the resurgence of extreme free market capitalism, and they emphasize that neoliberalism is a dominant force shaping urban environments. They believe that this dominant ideology has resulted in the trivializing of individual rationality and responsibility, causing harm to people, communities, and the environment. The authors cite the process of gentrification as one example of neoliberalism's harmful effects. They argue that CUEP helps deconstruct neoliberalism, thus addressing its negative effects.

The CUEP approach has three components: First, students use participatory methods to create a narrative on environment, social position, and identity about a particular place. Second, students work with instructors to understand how social, political, and economic forces interact within the status quo. Third, students are taught to critique the status quo based on what they find in their research.

To analyze the program, the authors relied on their personal experiences during five years of teaching, curriculum development, and participatory research experience with diverse communities in New York City. They examined their own recollections of the program, conversations with participants, and primary sources such as curriculum documents to explore the impacts of CUEP.

Citing examples mainly from the student narratives, the authors concluded that involving students in a participatory approach allows them to produce knowledge rather than simply accept what they are told. They contextualize this finding by describing how students asked new questions in response to their learning. The researchers also observed that the questions often raised inherently political issues and that the students' narratives often raised issues of socioeconomic inequality.

THE BOTTOM LINE:

To help students more effectively grasp the dynamics of sociopolitical and environmental systems, educators should help students actively participate in the learning process, analyze the power dynamics to understand the status quo, and critically engage with learning materials. These approaches can help students connect their lived experience with theoretical knowledge, build critical awareness, and generate knowledge.

Bellino, M. E., & Adams, J. D. (2017). A critical urban environmental pedagogy: Relevant urban environmental education for and by youth. *The Journal of Environmental Education, 48*(4), 270–284.

DEVELOPING CRITICAL-THINKING SKILLS THROUGH AN ENVIRONMENTAL SCIENCE CURRICULUM

An often-cited goal of higher education—and of education in general—is to help students develop critical-thinking skills. However, there remains much debate as to how to best do this. This study explored a curriculum design that focused on teaching critical-thinking skills with undergraduate students enrolled in an environmental science course at a university in South Africa. Using the Socratic method and inquiry-based learning as design principles, the researchers created the curriculum with the aim of helping students negotiate the complexity of environmental problems as well as differing perspectives that students are likely to encounter in the world.

The researchers, including the professor of the course, implemented the curriculum within the two-week environmental science course in which 53 undergraduate students participated. To understand how and in what ways the curriculum supported critical-thinking skills, the researchers undertook a qualitative study in which they analyzed several data sources, including individual student evaluations, a focus group discussion, lecturer reflections, and summative assessment results. Using discourse and content analysis, the researchers examined the data sources to clarify opportunities for critical-thinking skills development and perspective-taking within the curriculum.

The curriculum focused on Citizen Science (CS) and was built around the guiding questions of "What is CS? What are the challenges and opportunities associated with CS? How can quality data be ensured with CS projects?" The curriculum used two pedagogical strategies: Socratic inquiry and "Thinking Hats." In Socratic inquiry, the teacher provokes discussion and offers disruptive ideas. With Thinking Hats, students are asked to take various perspectives as a way of building their understandings of both the content and their own way of thinking. Three main learning activities constituted the curriculum. In the first, students researched examples of CS, or "opportunities" for which they wore an "optimistic hat." The second task included a collaborative debate about the problematic aspects of CS in which students wore a "negative hat." In the third task, groups produced mind maps in response to the guiding questions, with consistent feedback from peers and facilitators. At the end of the class, researchers used a summative written assessment to capture students' ideas about CS.

Through qualitative data analysis, researchers found that Socratic inquiry interwoven with the Thinking Hats approach supported students' development of critical-thinking skills. These pedagogical techniques helped students bridge the cognitive and affective domains and negotiate their own differing perspectives. The researchers pointed out that the safe, supportive environment of this classroom helped students use their developing critical-thinking skills to navigate the uncertainty inherent in the environmental science field.

THE BOTTOM LINE:

Environmental science curricula that integrate the Socratic method with activities designed to foster student perspective-taking can help students develop critical-thinking skills. Helping students acknowledge and understand others' perspectives, as well as their own, can help them learn how to navigate the uncertainty inherent in environmental science. Creating a safe, supportive environment within the classroom is important in fostering student learning through the strategies of Socratic method and perspective taking.

Belluigi, D. Z., & Cundill, G. (2017). Establishing enabling conditions to develop critical thinking skills: A case of innovative curriculum design in Environmental Science. *Environmental Education Research, 23*(7), 950–971.

LEVERAGING ONLINE DISCUSSIONS WITH A MARINE SCIENTIST TO ENHANCE STUDENTS' OCEAN LITERACY

The ocean is an ecosystem that encompasses most of the living space on Earth. It plays a crucial role in supporting the health of the planet as well as the livelihood of humans. Currently, about a third of the carbon dioxide (CO_2) emitted by human activities dissolves in the ocean and makes the seawater more acidic—a phenomenon referred to as ocean acidification (OA). If humans do not respond to this environmental issue by rapidly and drastically decreasing CO_2 emissions, OA will have

dramatic consequences for marine ecosystems and all that depends on those systems. Raising people's awareness of and knowledge about such issues, or enhancing their ocean literacy, is essential if they are to understand the impact of their behaviors on the ocean, as well as the ocean's impact on them.

This study explores how an online discussion about OA between a marine scientist and high school students could promote ocean literacy in an instructional setting. The researchers focused on the questions that the high school students asked the scientists in order to better understand the possibilities for enhancing students' ocean literacy in school through such activities. Since formulating a well-crafted, insightful question is a demanding task involving transforming existing experiences and knowledge in the light of new ideas, the researchers contend that the students' questions can be indicators of their knowledge and reasoning about a certain topic.

Three high school classes in two U.S. schools (61 students total) participated in this instructional activity as part of their regular class. First, the instructors introduced the students to the marine environment and the issue of ocean acidification through a virtual laboratory. The students went through a simulation to virtually grow sea urchin larvae in water with two different levels of acidity, and they compared the urchin larvae's growth rate. In the second activity, the students watched an online lecture (hosted on the VoiceThread platform) by an OA researcher. During the lecture, the scientist framed the results of the virtual experiment using a social and economic context. Finally, students and researchers engaged in an asynchronous discussion based on the students' questions.

The researchers found that the students' questions provided insights into how students combine their pre-existing experiences and insights with new information from the online lecture while reasoning about OA. The study also provided insights into how the students integrated their previous knowledge with what they encountered during the instructional activity.

This activity offers a relatively simple, affordable way to bring to the classroom valid, up-to-date science, which is often missing in school science curricula as well as from the expertise of classroom teachers. Scientists have relevant, cutting-edge knowledge about their fields; they also have a deep understanding of and experience with how their fields emerged as well as what kinds of studies have contributed to current knowledge. Facilitating direct contact between students and scientists, regardless of the teachers' levels of expertise, allows students to participate in relevant scientific discourse and culture.

Because scientists may not have time to visit schools and/or be able to spend time in student-focused discussions on a schedule convenient to the students, this research suggests that a virtual platform for facilitating asynchronous interactions between students and scientists could provide similar benefits. VoiceThread, for example, allows scientists to prepare and record one online lecture, which can be distributed widely. The scientists, or research team members, can address the students' questions when they have time. This interactive online lecture format also has the advantage of providing more time for the students to become acquainted with the topic during the time that they craft questions and reflect on their responses.

THE BOTTOM LINE:

Virtual instructional platforms and activities, such as VoiceThread, offer an affordable way to bring relevant, timely marine science to the classroom through firsthand interaction with a marine scientist. Because the interaction is asynchronous, students have more time to watch the marine scientist's lecture and then contextualize and mobilize their pre-existing knowledge while crafting questions for the scientist. The holistic expertise of the marine scientist allows students to explore and reason around ideas and aspects of natural sciences that go beyond the range offered in traditional school settings.

Fauville, G. (2017). Questions as indicators of ocean literacy: Students' online asynchronous discussion with a marine scientist. *International Journal of Science Education, 39*(16), 2151–2170.

HANDS-ON LESSONS FROM GREEN SCHOOL DESIGN TO FOSTER SUSTAINABILITY THINKING

Green schools are designed to reduce environmental resource consumption and facilitate learning. However, to date, limited research has examined the role of green schools in promoting education for sustainability (EfS). This study addressed this gap by exploring the relationship between green building design and EfS in the context of a university-middle school partnership.

The partnership in this study was created in response to the redesign of a Colorado public middle school that was working toward the Leadership in Energy and Environmental Design (LEED) certification. The partnership, which took place over the course of a semester, was formed between an undergraduate sustainable planning and design university class (15 students) and a middle-school applied science elective class (25 students). University students visited the middle-school class weekly to conduct hands-on lessons about water, living and sustainability systems, and design projects. The semester was divided into modules: In the first, middle-school students created a small-scale TerrAqua Column in plastic bottles to study the connections between terrestrial and aquatic ecosystems. In the second, students worked in small teams to design and build a larger-scale TerrAqua system using recycled materials collected during a visit to a local scrapyard. The third and final module focused on the middle school's green school design. Separate groups examined the new green roof, garden, and schoolyard.

In the author's role as instructor for the university course, she recorded field notes during the semester to capture university students' experiences and reflections, as well as her own reflections. She focused on perceptions of facilitating connections between the green school design and EfS through the partnership.

In this context, she found that undergraduate university students reflected on the importance of group cohesion and active applied learning approaches to hold middle-

school students' attention and engage them in the overall design process. University students found that the middle-school students had diverse personalities and demonstrated a range of learning interests that, at times, made the collaboration challenging. University students adapted their approach and decided to assign each middle-school student a different role that leveraged their interest and strengths. In one group, for example, one student became "the artist" and another "the negotiator." This fostered an appreciation of what each person could bring to the activity, a smoother collaborative working process, leadership, and the active participation of all students in the design-thinking process.

To guide the design process, university students created a Design Thinking Process Board for teams to use at each step: discovery, interpretation, ideation, experimentation, and evolution. This interactive process allowed for creativity, brainstorming ideas, group decision-making to solve problems and identify solutions, and shared learning both among middle-school students as well as between middle-school and university students through reflection, discussion, and action. Middle-school students were eager to participate in hands-on activities and use tools to build their own systems, and university students found that mixing discussion with action helped retain students' attention and keep them actively engaged in the process.

As a result of the partnership, university students expressed a greater awareness and appreciation of the value of students' active participation in the design of their own school environment. Through their experiences, university students came to appreciate that EfS is more than learning facts about green building or sustainable systems: it is also a process of learning to work with others, solve problems, find solutions, and apply sustainability thinking in decision-making.

After reading about exemplary green schools as part of their university course, university students identified two areas of missed opportunities for the new middle-school green building to promote EfS. First, the university students noted that no curriculum had yet been developed that specifically connected the new sustainability features with classroom learning. Second, the univeristy students noted that the new green features were not yet being leveraged to support interaction and learning; the middle school students were not allowed to access the green features and had to view them through a window. Based on the univeristy students' experiences, they suggested that giving students access to the green features and other interactive experiences would generate heightened interest among the middle-school students. For example, allowing student access to the green roof and more unstructured time in the garden would facilitate student connection with nature. These findings led the university and applied science middle-school student teams to develop specific recommendations for modifying some of the school spaces such as the new garden, in the hope of creating more opportunities for the green middle school to teach EfS.

THE BOTTOM LINE:

University-school partnerships that promote participatory design processes offer constructive avenues toward designing and building green schools that actively promote education for sustainability. Such partnerships provide opportunities for K–12 school students and university students to jointly learn about sustainability in instructive, engaging ways using school buildings and grounds as the learning pathways. Findings and outcomes from such partnerships can be empowering because they can be applied in a timely matter, with real-world consequences and benefits for the participants.

Derr, V. (2017). Teens, power tools, and green schools: Education for sustainability through a university design program and middle school partnership. *Applied Environmental Education and Communication, 16*(3), 129–138.

SENSE OF PLACE AND NATURE CONNECTION

FOSTERING NATURE CONNECTEDNESS THROUGH OUTDOOR ENVIRONMENTAL EDUCATION

On a planet facing numerous environmental issues, encouraging environmentally responsible behavior is more important than ever. However, many people are disconnected from nature, making it difficult to encourage environmentally responsible behavior. In this study, the authors considered the effects of one-day and five-day outdoor environmental education programs on students and how such programs can help individuals reconnect with the natural world.

Researchers recruited schools in Singapore through the mail and then randomly selected classes to participate. In total, the study had 601 participants, ranging in age from 7 to 18. The researchers then assigned the classes to one of four groups. Two experimental groups participated in an outdoor education experience, and two control groups completed an ecology unit in school. During both the indoor and outdoor interventions, participants learned about the rainforest ecosystem and conservation through hands-on activities. Before, directly after, and six weeks after the intervention, the authors administered the Inclusion of Nature in Self (INS) scale, which asks students to choose circles labeled "nature" and "me" that overlap to different degrees in order to measure nature connectedness. The researchers then used statistical analyses to see whether any difference occurred between students' connectedness with nature before, directly after, and six weeks after the program.

The authors found that participants in the experimental group showed significant increases in their level of nature connectedness, particularly in the five-day case. The control group students did not have significant increases in their connectedness to nature. Both experimental groups had significant increases in their connectedness to nature in the long-term (six-week) follow-up. Additionally, students in the experimental group with low baseline connectedness scores reported much higher scores post-intervention, and those with high baseline scores remained at that high level. Seven- to nine-year-old participants in the five-day experimental group showed

the largest increase in their nature connectedness, which is consistent with the idea that nature connectedness manifests itself as a trait in early years.

THE BOTTOM LINE:

Outdoor environmental education programs can have a significant positive impact on students' sense of connectedness to nature. The element of immersion inherent in such programs can create a markedly different experience from everyday school experiences, and such differences can facilitate a sense of nature connection. As such, integrating one-day (or longer) residential environmental education programs into curricula from a young age can facilitate a connection to nature and sustained connectedness to nature.

Braun, T., & Dierkes, P. (2017). Connecting students to nature—how intensity of nature experience and student age influence the success of outdoor education programs. *Environmental Education Research, 23*(7), 937–949.

UNDERSTANDING CHILDREN'S VISIONS OF NATURE AND THEIR ROLE IN PROTECTING IT

Environmental experiences are often central to children's knowledge of their local communities. Building these experiences, and consequently children's knowledge, has the potential to create a strong sense of community belonging for children and positively impact their degree of civic engagement. To help children grow into citizens connected to their community, they need opportunities to connect with nature and engage in local environmental issues. However, children are spending less time in natural spaces and have few opportunities for political involvement. This study, conducted at four schools in Portugal, used group discussions to highlight children's views on the environment, thereby emphasizing the active role that children play in their own learning and the potential role that they could have in environmental decision-making.

In Portugal, environmental education (EE) is considered a part of citizenship education, although it does not have a specific curriculum. As a result, various primary schools and preschools have developed their own strategies for EE. This study focuses on children from four schools with different pedagogical approaches. The authors held a group discussion at each of the four schools with student volunteers. The discussions, which were recorded and filmed, involved 31 children total, ages 4 to 10. After introducing herself as a researcher, one of the authors asked children to close their eyes and go to a place in nature, guiding their imaginative thoughts with imagery and ambient music. She followed with questions about their views on nature and experiences with learning about the environment. After transcribing the focus groups, the authors used the data and their knowledge of existing theories to conduct inductive and deductive qualitative coding and analysis of the responses.

The results revealed that children have broad views of nature, witnessed countless environmental problems, and experienced many environmental learning opportunities through time spent with their families and at school. During the imagination activity, some children went to local areas, such as gardens or forests; others went to distant places, such as the Amazon. The imagined places included both real and mythical creatures, which protected these natural spaces and the plants within them. The researchers suggest that this protective instinct resulted from the environmental awareness of children and their emotional connection with nature, which made them highly critical of human actions that hurt their imagined landscapes.

THE BOTTOM LINE:

Children—even those without direct exposure to traditional natural environments—are fond and protective of nature, but lack opportunities to participate in discussions that shape the future of the natural world. Although family and school experiences enable children to develop a sense of community belonging and learn about the environment, traditional environmental education curricula rarely promote political action. It is critical

that educators make space for emotional and experiential learning, as well as political discourse, in traditional environmental education, therefore acknowledging the importance of inclusion with nature and the right of children to influence decisions about the environment by voicing their concerns.

Rios, C., & Menezes, I. (2017). "I saw a magical garden with flowers that people could not damage!": Children's visions of nature and of learning about nature in and out of school. *Environmental Education Research, 23*(10), 1402–1413.

IDENTIFYING SUSTAINABLE ELEMENTS IN CHILDREN'S DRAWINGS OF THE URBAN ENVIRONMENT

Children's drawings can provide vital insight into their understanding and awareness of important issues that might not otherwise be articulated in an interview. Researchers have used drawings to measure children's knowledge and attitudes about environmental issues, revealing that children are conscious of environmental issues and often sympathetic toward nature. However, few studies have examined children's representations of the urban environment and how they relate to sustainability goals.

The researchers in this study sought to explore how children relate to sustainability and urban environments. The researchers selected 104 fourth- and sixth-grade students from a town in northern Greece, which is surrounded by a diverse physical landscape. The participants were evenly distributed between fourth and sixth grade, and there were equal numbers of boys and girls. To explore children's perspectives of the ideal urban environment, and how consistent those views are with sustainable development efforts, the researchers asked students to draw two pictures of their town: one as it is currently, and one as if the town were made "better for living" in the future. All participants completed both drawings within one two-hour session.

The researchers then identified key elements in each of the students' drawings and compared them to a predefined set of sustainability indicators in the categories of environment, economy, and society. The researchers also looked for significant differences between each students' pre and post drawings to see if any sustainability elements were added in the improved version of their town. Finally, the researchers looked for differences between the fourth- and sixth-grade students' drawings to see whether age influenced the students' perceptions.

The researchers found that the greatest total number of indicators represented in the drawings came from the environment category. The most popular environmental indicators were plants, animals, and the sun. Many students also represented air pollution and waste in their drawings of the current state of their town. The greatest total number of students included elements from the society category, and the most popular social indicators were roads and cars. The most popular economic indicators were residential buildings.

The student drawings did not include depictions of sustainable energy production or local economic development, such as agriculture or industry. In general, older students (the sixth graders) included more sustainability indicators than younger students (the fourth graders), and younger students included more apartment buildings, while older students focused on single-family houses, which are less resource efficient. These results suggest that students see clean air and clean streets as representing elements of "better living," but may not recognize the nuance of sustainable energy generation and waste disposal.

THE BOTTOM LINE:
Children's drawings related to the environment and environmental issues can convey aspects of their knowledge and perception, while also reflecting cultural dimensions and trends. Depending on the prompt, drawings may

reveal children's understanding about the local context, notions of human/environment interactions, and aspects of a desired future state. Educators and practitioners might, therefore, consider using drawing exercises to understand what children know and think about environmental issues, as well as how children might envision a desirable future. Such exercises could help educators and practitioners identify ways to further communicate how sustainable development can address local community needs.

Stokas, D., Strezou, E., Malandrakis, G., & Papadopoulou, P. (2017). Greek primary school children's representations of the urban environment as seen through their drawings. *Environmental Education Research, 23*(8), 1088–1114.

TECHNOLOGY IN ENVIRONMENTAL EDUCATION

COMMUNITY MEMBERS ACCURATELY EVALUATING WETLAND HEALTH

Wetlands are important environments that provide vital ecosystem services to millions of people worldwide. Unfortunately, many wetlands have been destroyed or damaged, so more effective management is needed to protect these places. Although wetland scientists can easily determine wetland health, little research has been done to see whether community members can be trained and empowered to effectively monitor and understand the health of local wetlands. This study examines whether, and under what conditions, community members can be trained to use an environmental health tool to evaluate wetland health.

Taking place in South Africa, this study focused on two wetlands: the Siphumelele wetland in Howich and the Ixopo Golf Course wetland in Ixopo. Researchers developed a monitoring tool to allow nonspecialists to develop an accurate estimate of wetland health. To assess the tool's utility and accuracy in practice, 56 participants were trained during daylong workshops, with 10 working at the Siphumelele wetland and 46 at the Ixopo wetland. The participants represented different groups of citizens who might use the wetland tool, including landowners, government officials, and university students.

The research had three objectives: (1) to see whether participants could use the tool to accurately assess wetland health, (2) to explore the possible variability between wetland health scores, and (3) to understand participants' attitudes toward the health tool. The mixed methods study gathered data in a number of ways. The researchers collected the scoresheets from the wetland health tool and gave participants a questionnaire with Likert-scale-type questions to assess participant attitudes. They also held focus groups to discuss the participants' experiences using the wetland health tool.

The data from the wetland health tool was analyzed using Levene's variance comparison. For the Siphumelele wetland analysis, where participant scores were compared with those of an expert wetland scientist, researchers found no significant difference in the scores.

For the Ixopo wetland analysis, participant scores were compared against Participant 5 from the previous assessment as the control, as this participant had previous wetland-monitoring experience. The analysis also found no significant difference between scores. Additionally, the results showed that all participants, whether or not they had experience with the wetland health tool, could determine wetland health accurately. In terms of perceptions, 84% of the participants said they would use the wetland tool in the future; 70% thought it was easy to use; and 88% thought the tool helped them understand wetlands better.

THE BOTTOM LINE:

Trained community members using a rapid-assessment wetland health tool can evaluate the state of wetlands in a manner similar to that of a trained scientist. Such tools may be used for both wetland monitoring as well as for general environmental education opportunities. Practitioners using such environmental health assessments should involve a range of the public, bringing in people with varying levels of education and different backgrounds. Not only will these tools encourage wider-scale wetland monitoring, but they also will help enhance local residents' understanding of wetland health and the significance of such ecosystems.

Dumakude, N., & Graham, M. (2017). Assessing wetland health using a newly developed land cover citizen science tool for use by local people who are not wetland specialists. *Southern African Journal of Environmental Education, 33*(1), 71–83.

ZOO, AQUARIUM, AND SCIENCE CENTER EDUCATION

THE IMPACT OF IMMERSIVE EXHIBITS ON CONNECTION TO NATURE AND ENVIRONMENTAL RESPONSIBILITY

As museums, zoos, and other science institutions are increasingly trying to promote connection to nature and environmentally responsible behavior, there has been a recent shift away from interpretive nature exhibits to constructed immersive nature experiences. However, the impact of this new form of nature experience on visitors' connection to nature and behavior has not been well studied. Accordingly, the researchers investigated how the experience of visiting an immersive free-flying butterfly exhibit impacted feelings of connection to nature and environmentally responsible behavior.

Researchers designed a questionnaire to measure connectedness to nature and environmental responsibility and administered it at the Florida Museum of Natural History's Butterfly Rainforest in Gainesville, where visitors can walk through the butterfly habitat, among the butterflies. Over four randomly selected days (one weekend day and three weekdays), the 426 visitors who completed the survey represented a range of gender, education, ethnicity, income, age, and group composition. The researchers used a posttest-only experimental design to examine the effect of the butterfly exhibit visit: Of the surveyed visitors, 257 were in the treatment group and given the survey only *after* they visited the butterfly exhibit. The other 169 visitors comprised the control group and were given the questionnaire only *before* they went into the exhibit.

The questionnaire measured connectedness to nature with the 14-item Connectedness to Nature Scale (CNS). Two indices of environmentally responsible behavior were measured with 11 items created by the researchers. Because the exhibit encouraged backyard wildlife-friendly behaviors, the survey also asked questions about human behaviors that might attract backyard wildlife using four survey items. The survey also included an open-ended item asking about the visitor's overall experience in the Butterfly Rainforest.

For all three measures (connectedness to nature, environmentally responsible behavior, and likelihood to engage in behavior that attracts backyard wildlife), there was a significant difference between the treatment group and the control group. The treatment group was higher on all three measures than the control group, suggesting that visitors were positively impacted by the exhibit. However, environmentally responsible behavior intentions were variable even in the treatment group, which could be explained by connectedness to nature. Visitors would already have had varying levels of connection to the environment, which would have then resulted in variable intentions toward pro-environmental behavior.

Forty-six percent of visitors also responded to the open-ended question about their experience. Qualitative analysis revealed that these responses could be divided into four themes: appreciation for the beauty of nature, feelings of awe, restorative feelings, and feelings of oneness. Such themes suggest the positive impact that the short, but unique and memorable, experience had on visitor attitudes.

THE BOTTOM LINE:
Connectedness to nature and intentions to undertake environmentally responsible behavior can be positively influenced through immersive nature-based exhibits in places such as museums, nature centers, aquariums, and zoos. This finding is especially relevant for environmental educators in urban areas or places with fewer opportunities for immersive nature-based experiences outdoors. Environmental educators in such places can leverage rich nature-based exhibit experiences to enhance visitors' sense of connection to nature, which may also increase their intentions to adopt environmentally responsible behaviors.

Pennisi, L., Lackey, N. Q., & Holland, S. M. (2017). Can an immersion exhibit inspire connection to nature and environmentally responsible behavior? *Journal of Interpretation Research, 22*(2), 35–49.

THE DISCONNECTION BETWEEN EDUCATOR PERCEPTIONS AND AUDIENCE EXPECTATIONS OF CLIMATE CHANGE EDUCATION

Education staff at zoos, aquariums, nature centers, museums, parks, and other informal learning venues regularly face the complexity of communicating about climate change as they promote understanding and action among their visitors. Visitors enter these venues with prior experiences, understanding, and attitudes that drive what they expect, notice, and ultimately take away. These factors also influence how and what informal educators communicate with their visitors. Beyond general theories, little is known about the educator-visitor relationship in the context of climate change communication. This study compared informal educators' perceptions and visitors' expectations with regard to climate change education programming.

Adults who visited at least one of 10 informal education institutions in two mid-Atlantic states completed an online survey focused on their attitudes about climate change and related education efforts. Of the 530 participating adult visitors, most were teachers or school contacts, the median age was 52, about two-thirds were female, the majority were white or non-Hispanic/Latino, and many had advanced degrees; they reported being repeat visits to the institutions that distributed the survey. Sixty education staff members working at informal education institutions in these same two Mid-Atlantic states completed a different, but complementary, online survey on their climate change education programming. The educators averaged 13 years of teaching and interpretive experience; they were not necessarily educators at the institutions that posted the visitor questionnaire. Researchers analyzed the survey responses looking for trends in responses from the two questionnaires.

The study findings point to two disconnections. First, most respondents to the educator survey indicated a belief that their institutions should offer climate change

education, viewing it as aligned with their institutional mission and creating no tension with funders or other conservation messages. Additionally, all of the educators reported being alarmed or concerned about climate change and generally believed that their visitors were interested in this topic. Despite strong beliefs and perceived lack of barriers, however, they described only limited climate change-related programming at their institutions. These findings align with other similar studies, which suggest minimal amounts of climate-change education and interpretation in such settings. This recognition of urgency, yet paucity of education, may be driven in part by lack of training and resources (as highlighted by surveyed educators) as well as the topic's complexity.

Second, available climate change-related programming primarily targets K–12 students and teachers, with a topical focus on addressing misconceptions while providing cursory information. Visitor respondents, by contrast, indicated that their interest in and motivation to learn about climate change comes from a leisure perspective, rather than a professional perspective. (That is, most visitors are not teachers and, as such, are not seeking K–12-related professional development and/or teaching-related materials.) Furthermore, in contrast to educators' perspectives, visitors indicate general acceptance of human-driven climate change—a finding that aligns with other general-public surveys related to climate change. Visitors also indicate a desire for programming focused on concrete ways they might respond to this environmental crisis, a finding that also aligns with other climate change-related polls.

Visitor and educator perceptions align in their agreement that informal learning institutions are appropriate and trusted venues for climate-change education. The two disconnections, however, suggest that current programming efforts are based on inaccurate perceptions of visitors' interests and, therefore, may not advance visitors' understanding of and action in response to climate change.

THE BOTTOM LINE:

Informal education institutions represent trusted and critical venues to learn, discuss, and promote action in response to climate change. Yet such programming remains limited at these institutions, and what is available may not align well with visitors' desire for concrete ways to respond to climate change. Education staff need to review and update outcomes of their current offerings and explore ways to expand those offerings. This should be coupled with resources and support that help educators develop and deliver high-quality, action-oriented climate change programming. By expanding their offerings in these ways, educators can better advance and guide visitors' understanding of climate change while also providing ideas for actionable ways to respond to climate change.

Stylinski, C., Heimlich, J., Palmquist, S., Wasserman, D., & Youngs, R. (2017). Alignment between informal educator perceptions and audience expectations of climate change education. *Applied Environmental Education & Communication, 16*(4), 234–246.

USING OPEN-ENDED QUESTIONS IN EXHIBIT LABELS TO ENHANCE VISITOR METACOGNITION

Solutions to the most pressing environmental problems of our time rest on a well-informed citizenry capable of understanding, analyzing, and thinking critically about ethically fraught social and environmental issues. Engaging in critical thinking requires metacognition—the ability to recognize, reflect on, and understand one's own thought processes. Inquiry-based exhibits at science museums are highly appropriate, well-structured contexts for fostering metacognition as they can provide emotionally safe spaces for visitors to reflect on their own beliefs, thoughts, views, and biases.

In this study, researchers studied metacognition in visitors who engaged with social science exhibits at the Exploratorium, a large science center based in San

Francisco, California. Specifically, researchers examined whether a simple metacognitive strategy—question asking—enhanced visitors' metacognitive talk.

Question asking, often used by teachers in formal classroom settings, is a well-known research-based strategy for enhancing metacognition among learners. Although it has been studied extensively in formal education, few such studies exist in informal learning contexts. In this study, researchers examined the use of open-ended questions in exhibit labels as a metacognitive tool in a science museum. They developed and tested two kinds of questions that would stimulate metacognitive talk, namely: (1) exhibit-specific questions (EQ), which prompted visitors to discuss their mental strategies specific to an exhibit, and (2) real-world questions (RQ), designed to elicit conversations about broader metacognitive strategies that visitors found applicable in their own lives. The questions were open-ended and incorporated into flip labels at a social science exhibit. The EQs were under a first flip label and the RQs under a second flip label below the EQs. The social science exhibit was housed in a "laboratory" off the main museum floor in order to minimize external noise and distractions.

The researchers used a quasi-experimental research design with three conditions: baseline, EQ, and RQ. The researchers' goal was to examine whether the treatment (question-asking in flip labels) had any effect on visitors' metacognitive talk. The baseline served as the control, while the EQ and RQ were the treatment conditions. The exhibit was designed so that the visitors would first engage with the elements of the exhibit without the questions (baseline), then they would open the first flip label to engage with the EQ, and then they would open the second flip label to engage with the RQ. This allowed the researchers to measure the effect of EQ, and then the additive effect of RQ, on visitors' metacognitive talk.

Study participants consisted of 59 dyads (adult-adult or adult-teen pairs) recruited from the main museum floor through a combination of random and purposive sampling. The researchers used video coding and analysis to measure metacognition; they identified metacognitive talk and quantified its duration. The videos were coded for two levels of metacognitive talk: (1) All Metacognitive Talk (A-MCT), where the visitor demonstrated a basic awareness of their own or someone else's thinking (e.g., "you are lying" or "your partner knows"), and (2) Stringent Metacognitive Talk (S-MCT), where the visitor demonstrated stronger metacognition that goes beyond awareness (e.g., "I was trying to pick what I thought you would pick").

Results from ANOVA showed that the proportion of time spent by visitors in A-MCT went from 13% (baseline) to 43% (exhibit-specific questions, or EQ) to 42% (real-world questions, or RQ). Similarly, proportion of time spent by visitors in S-MCT went from 5% (baseline) to 26% (EQ) to 25% (RQ). In other words, participants spent significantly more time engaging in both basic and stringent metacognitive talk after the exhibit-specific questions were introduced. Furthermore, the effect sizes were large for the EQ—a threefold increase in all metacognitive talk, and fivefold increase in stringent metacognitive talk. The RQ maintained this increased metacognitive talk but did not enhance it any further.

THE BOTTOM LINE:

Metacognition, or the ability to reflect on one's own mental processes, plays a key role in our understanding of complex social and environmental issues. Social science exhibits in museums can provide safe contexts for learners to engage in reflection and metacognition about their own ideas, beliefs, and social interactions. Asking open-ended questions in exhibit labels, whether specific to the exhibit or linked to real-world scenarios, can successfully promote metacognition among adult and teen museum visitors; therefore, museums or practitioners should consider adopting this simple, low-cost, and easy-to-implement strategy to enhance visitor metacognition.

Gutwill, J. P., & Dancstep, T. (2017). Boosting metacognition in science museums: Simple exhibit label designs to enhance learning. *Visitor Studies, 20*(1), 72–88.

USING "BUGS" TO UNDERSTAND BIODIVERSITY

Zoos and aquariums have the potential to be powerful settings for environmental education. Researchers and practitioners are still learning about the visitor experience and how it can be designed to maximize achievement of key outcomes around conservation. This study considers an exhibition at the London Zoo called Biodiversity Underpinning Global Survival, or BUGS. The study's purposes are threefold. First, the researchers investigated how the exhibition influenced conservation knowledge, beliefs, and perception of pro-environmental actions. More specifically, the researchers considered how the exhibition connected to visitors' everyday lives and visitors' perceptions of the concept of biodiversity. Second, the study examined visitors' attitudes toward invertebrates, a focal group for the exhibition. Third, the study examined how pre-visit conversations with the researchers might influence, or prime, visitor learning and experiences in the exhibition.

This study used a mixed-methods approach. One of the primary tools for data collection was Personal Meaning Maps (PMM), used in the study's third element. A total of 100 adult visitors, divided into two groups (Sample A and Sample B), were asked to complete the PMM. Sample A completed the PMM as part of pre- and post-exhibition interviews, whereas Sample B completed the PMM as post-only interviews. During the PMM interviews, researchers gave visitors the word "biodiversity" as a prompt. With that word in the middle of a blank sheet of paper, researchers asked visitors to write and draw what came to mind. Upon completion of the PMM, researchers asked visitors follow-up questions to explain their maps. Researchers supplemented the PMM with an exit questionnaire, including demographic questions and self-report data related to environmental concern. Researchers analyzed PMM results according to four dimensions: concept (the number of concepts directly related to biodiversity), elaboration (the number of words used to describe each concept, scored on a 1-to-6 scale), degree of emotion (number of emotive phrases used, positive or negative), and degree of expertise (appropriate use of vocabulary, quality of understanding, scored on a 1-to-5 scale).

The second tool for data collection was a cognitive world map. Researchers used this tool to understand how visitors think about biodiversity. For this exercise, researchers asked visitors to mark on a world map the places that first came to mind when they thought about biodiversity.

Findings from the studies, overall, suggest that the exhibition improved visitors' knowledge of and attitudes toward biodiversity. These findings, however, were only in the group that received pre-visit priming from interacting with the researchers. Without priming, the effects were small. Furthermore, the exhibition was well received by visitors, who found it to be entertaining and fascinating. Yet the researchers determined that the exhibition did not succeed in being relevant to visitors' everyday lives, nor did it increase visitors' confidence that they could contribute to biodiversity conservation. Visitors often perceived biodiversity as being synonymous with "exotic," meaning that they perceived biodiversity to be a concept relevant to faraway places, leaving little room for personal action.

THE BOTTOM LINE:

Many zoo exhibitions seek to bring about changes in visitor knowledge, attitudes, and behaviors related to biodiversity conservation. Those goals may be effectively achieved in two main ways: First, practitioners and educators might explore using pre-visit priming, or having conversations with visitors to spark their initial thinking about the concepts that they will encounter in the exhibition. Second, practitioners and educators should focus on connecting biodiversity and conservation concepts with visitors' everyday lives and local ecosystems. These strategies can be paired with specific messages about meaningful individual actions that benefit the local environment.

Chalmin-Pui, L. S., & Perkins, R. (2017). How do visitors relate to biodiversity conservation? An analysis of London Zoo's "BUGS" exhibit. *Environmental Education Research, 23*(10), 1462–1475.

FAMILIES LEARNING WITH STAFF AT MATHEMATICS EXHIBITS

Staff facilitators and educators are a vital yet overlooked educational resource in museums, science centers, and other informal educational spaces. Little research has been done assessing how staff can impact visitors and/or help them learn from exhibits. To explore this knowledge gap, researchers studied unstructured conversations between staff and visitors interacting with a museum exhibit.

The researchers partnered with the Oregon Museum of Science and Industry (OMSI) and Oregon State University (OSU) to develop a model for staff-facilitated learning in museums and then test this model with visitors. The project, called Researching the Value of Educator Actors on Learning (REVEAL), focused on visitors improving their algebraic thinking. The study was grounded in two theories: The first, interactional sociolinguistics, says that defining relationships and negotiating roles in the conversation often occurs even before people start communicating information. The second, asset-based education, is the broad idea that people with different cultural backgrounds can learn differently and bring unique knowledge to an interaction. The researchers asked two major questions: (1) What strategies can staff use to help families learn at museum exhibits that account for existing family learning and culture? and (2) What social factors influence staff-facilitated learning within families?

Using a design-based research approach, the researchers collected data at a science center in Portland, Oregon, over the course of 5 months. The researchers used video, surveys, and observational sessions to gather the data. Two major types of analyses were performed on the data during the study. For the first type, iterative refinement, the researchers looked at and talked about how educators interacted with visitors on a weekly basis. The second type, retrospective analysis, occurred after data collection was complete. This analysis continued to refine the educational model used by staff, while also examining the video data, coding, and discussing it in light of the existing model.

Five main strategies emerged related to how staff could help families learn while interacting with exhibits: orient, challenge, provide explanation, show appreciation, and establish visitor ownership. "Orient" involved staff introducing and/or providing families with an overview of the exhibit. "Challenge" had staff presenting a challenge that families could solve at the exhibit. For "provide explanation," staff shared mathematical information with families. "Show appreciation" had staff encouraging families in interacting with the exhibits. Finally, "establish visitor ownership" involved staff encouraging visitor agency during their visit.

In terms of social factors that influenced learning, five factors also emerged from the data: exhibit, size of group, age of children, visitor social goals, and adult visitor roles. "Exhibit" meant that the type of exhibit influenced visitor interaction. "Size of group" related to how smaller families interacted with exhibits in ways that were different from larger families' interactions. For "age of children," younger children often interacted differently with exhibits than older children. For "visitor social goals," families had different intentions when interacting with exhibits, such as building mathematics knowledge versus having fun. Lastly, "adult visitor roles" referred to adults adopting different roles, including facilitator, collaborator, or supporter, which impacted the way the staff interacted with adults and guided the experience.

THE BOTTOM LINE:

Staff facilitators and educators can help families learn more from museum exhibits by giving them information about exhibits, as well as by concurrently challenging and encouraging visitors in their interactions with exhibits. Additionally, staff should balance museum goals, such as improving mathematical reasoning, with visitor goals, such as having fun at the museum. Finally, staff should take into account the unique social factors that influence every family, including aspects such as family size, age of children, and the desire for help.

Pattison, S. A., Randol, S. M., Benne, M., Rubin, A., Gontan, I., Andanen, E., Bromley, C., Ramos-Montañez, S., & Dierking, L. D. (2017). A design-based research study of staff-facilitated family learning at interactive math exhibits. *Visitor Studies, 20*(2), 138–164.