ABOUT THE RESEARCH BULLETIN

The *Environmental Education Research Bulletin* is a project of NatureBridge in partnership with Dr. Nicole Ardoin at Stanford University. The bulletin is designed to inform NatureBridge educators about recent relevant research, so the emphasis is on field science, stewardship behavior, residential settings, and related topics. Although other environmental educators might also find this bulletin useful, it does not—nor is it intended to—cover all aspects of environmental education. The research bulletin is available online through the NatureBridge website. Please send questions and feedback to Jason Morris, Executive Vice President, NatureBridge, at jmorris@naturebridge.org.

DEVELOPMENT TEAM

PROJECT LEAD
Nicole Ardoin, Stanford University

PROJECT ADVISOR
Jason Morris, NatureBridge

SENIOR WRITERS
Jess McNally
Christy Merrick

CONTRIBUTING WRITERS
Matt Biggar
Alison Bowers
Priya Fielding-Singh
Zahra Golshani
Kathayoon Khalil
Christina Maki Strong
Kathleen O'Connor
Whitney Stubbs
Madeline Weeks

NatureBridge

TABLE OF CONTENTS

SENSE OF PLACE

PROFESSIONAL DEVELOPMENT

OTHER RESEARCH

BEHAVIOR

INTERPLAY OF SOCIAL NORMS INFLUENCES ACTION

Behavior researchers have long understood that one important factor in moving people to action is the perception of approval from others. These "social norms" help indicate what is socially acceptable and can help motivate behaviors. Further research, though, has revealed that the way that norms affect behavior is not straightforward. In fact, there are different types of norms, and this research aimed to investigate what happens when different types of norms interact.

Specifically, this study focused on the interplay of injunctive norms (which indicate what people in the social group approve of or disapprove of, or, in other words, what people *should* do) and descriptive norms (which indicate what people in the social group are *actually* doing). These norms can either be aligned (in effect, what the group approves of and what they actually do are the same) or they can be misaligned (what the group approves of is different from what they actually do). The authors investigated how the alignment of norms affected university students' intentions to engage in energy-saving behaviors.

In a first experiment, the researchers presented 162 university students the results of a fictional study on energy conservation at the university, in which the details that indicate norms were manipulated: one condition (supportive descriptive norm) indicated that 82% of students engaged in energy conservation, another (unsupportive descriptive norm) indicated that 22% of students engaged in energy conservation, a third (supportive injunctive norm) indicated that 85% of students approved of students conserving energy, and a fourth (unsupportive injunctive norm) indicated 23% approval for energy conservation. The students were presented with these results in different combinations and then asked to rate their likelihood of engaging in energy conservation.

The results indicated that group approval for energy conservation does not motivate action unless it is paired with a similarly supportive descriptive norm, indicating that the group actually engages in the behavior. Likewise, learning that other students took energy conservation steps did not make the students more likely to act if they were also told that other students did not approve of that

behavior. The authors explain, "That is, it is not the case that descriptive and injunctive norms are simply additive. Although it is true that the strongest intentions are associated with having two sources of normative support for the behavior, if only one source of norm is supportive and the other source is not, this is equivalent to having no normative support at all for the behavior."

In a second experiment, the authors explored similar questions about the interplay of norms in different cultures. The researchers compared the results of a similar study in the UK, which represents an individualist culture, and China, which represents a collectivist culture. One might assume that social norms play a smaller role in motivating behavior in an individualist culture, where individuals are perceived to be more autonomous, than in a collectivist culture, which prizes conformity. Although the researchers did find some differences between the two cultures, there were not differences in how they responded to the manipulations of the norms. The authors conclude that "The findings suggest that, although cultural differences exist, responses to unaligned descriptive and injunctive norms do not necessarily vary by cultural context."

The researchers believe that the importance of having normative information aligned should not be understated. If people get conflicting messages about what their social group approves of and what they actually do, they will not be motivated to act. In fact, if normative messages are incongruent (that is, if one normative message is supportive and the other isn't), then the results are the same as if both normative messages are unsupportive. The researchers caution, though, that these experiments measured only the students intention to act. Further research could measure actual behaviors to better understand the interplay of norms and behaviors.

THE BOTTOM LINE: When crafting messages designed to inspire action, social norms play an important role. But you have to be careful how you convey normative messages. If injunctive norms (which

indicate what a group thinks one should do) are not in line with descriptive norms (which indicate what a group actually does), a person will not be motivated to act. For example, this research suggests that people will be utterly unmotivated by a statement like "Most of us think it's important to conserve energy, but few of us actually do it." Instead, normative messages must be aligned.

Smith, J. R., Louis, W. R., Terry, D. J., Greenaway, K. H., Clarke, M. R., & Cheng X. (2012). Congruent or conflicted? The impact of injunctive and descriptive norms on environmental intentions. *Journal of Environmental Psychology, 32*(4), 353-361.

PARENTS INFLUENCE CHILDREN'S RECYCLING BEHAVIOR

This study explores the role of parents in influencing their children's behavior, specifically the recycling and reuse of paper. The researchers were particularly interested in how parents may activate norms that lead to these behaviors in children. Citing various theories on human behavior, the authors differentiate between different types of norms: A personal norm is a personal moral obligation to take specific actions, while a social, or subjective, norm is influenced by others who are relevant to the individual. Social norms can be further broken down into injunctive and descriptive norms. Injunctive norms are based on what one thinks ought to be done, while descriptive norms are based on what others are doing.

Research has identified parent communication and behavior as potential variables that influence environmental norms and behavior among children. Parents can share knowledge of environmental problems and explain the consequences of individual actions to children. When parents praise or criticize their child's behavior, they create injunctive norms. A parent can also serve as a model of behavior through his or her behavior, providing a descriptive norm for the child. For this study, the variables of problem communication from parents

(related to both need for and consequence of action), sanctions from parents (injunctive norms), and parental behavior (descriptive norms) were analyzed in relation children's awareness, norms, and behavior.

Two hundred and six students, aged 8-10, from ten different schools in Cologne, Germany, were the subjects of this study. The age group of students was considered particularly relevant to this study's focus on parental influence with behavior norms, as children this age are considered in an early stage of moral development in which interaction with parents is particularly important. Each student and the parent identified as most responsible for each student's education in each household were provided a questionnaire that gathered information on communication, awareness, norms, and actual behavior related to paper recycling and reuse. Ninety percent of the parents in this study were mothers.

The specific behaviors the authors studied were the separation of paper waste for recycling and the reuse of paper through using both sides of the paper. With both paper reuse and recycling, the child's social and personal norms were predictive of their behavior. The parents' communication of the problem was shown to affect the child's personal norm and behavior through the child's awareness of the need for and consequences of reusing and recycling paper.

With paper recycling, the parent's recycling behavior was related to the child's norm and behavior. But the parent's sanctioning of paper recycling had little relation to the child's paper recycling norm or behavior. When it came to reusing paper, however, neither the parent's behavior nor sanctioning affected the child's paper reuse behaviors. The authors think parental behavior may matter more with recycling than reuse because paper recycling may be more visible and easier to control than using the back of a sheet of paper.

In summary, communication by parents related to both recycling and reuse, along with parental behavior in relation to recycling, seems to matter when it comes to a child's behavior. These findings suggest that what

parents say and do is important. When parents talk about environmental issues and involve their children in everyday pro-environmental behaviors, children respond. The authors also argue that, in addition to parental involvement, incorporating "practical training of pro-environmental behavior" in education programs can also help build environmental behavior in children.

THE BOTTOM LINE: Parents play a key role in the development of children's pro-environmental norms related to specific behaviors such as paper recycling. Parents' communication of the need for and the consequences of specific individual behaviors can affect what their children do. With some behaviors, such as paper recycling, the parent's own behavior can also influence the child's behavior. Parent sanctioning of behavior, such as through praise and criticism, has less effect on specific behaviors. Educators can apply these findings to their work with children and parents, keeping in mind that the implications of these findings may be most relevant to low-cost behaviors such as recycling and reuse.

Matthies, E. Selge, S., & Klöckner, C. A. (2012). The role of parental behaviour for the development of behaviour specific environmental norms—The example of recycling and re-use behaviour. *Journal of Environmental Psychology*, 32(3), 277-284.

NEW SCALE DEVELOPED TO MEASURE CHILDREN'S BEHAVIOR

Efforts to establish a reliable scale for environmentally responsible behavior (ERB) have been ongoing for decades. Many researchers, practitioners, and policy makers agree that ERB is one of the key outcomes of environmental education. Participation in ERB has been linked to personality, cognitive, demographic, and external factors, making this a complicated area to understand. Although research on ERB has increased since the 1990s, we still know relatively little about the motivations for and barriers to ERB in children. According to this paper's authors, the Children's Environmental Attitude and Knowledge Scale (CHEAKS) is "one of the few measures of ERB for

elementary students apparent in the literature." This scale is limited, however, in the types of action that it considers and the cultural context in which it can be applied. Since CHEAKS was developed in the United States, it may not be applicable in other counties. This study intended to introduce a new scale, Children's Responsible Environmental Behavior Scale (CREBS), developed for elementary school students in Turkey.

Through a review of the literature, the authors found that there are five major categories of ERB: eco-management, consumer/economic action, persuasion, political action, and legal action. For CREBS, legal action was omitted because it was not deemed appropriate or reasonable for the age group targeted by the study. Following this review, the researchers asked a group of 229 elementary school students (fourth and fifth graders) to generate an open-ended list of behaviors in each of these dimensions that they had done in the last two years or that they planned to do. The most common responses were used to generate the item pool for the main study. Education and curriculum specialists validated this item pool was to verify the items' age-appropriateness, comprehension, and clarity. The researchers pilot-tested the scale with a larger group of students. The final study included responses from 2,412 fifth-grade students in Turkey.

The authors found four statistically reliable factors in the data: (1) political action, (2) physical action/eco-management, (3) consumer and economic action, and (4) individual and public persuasion, confirming the results of prior studies. Thus this study contributes a validated tool for studying ERB in elementary-aged children. Although the study was done in Turkey, the authors assert that "CREBS might be used and slightly adapted for use in the countries with similar culture and educational systems."

Overall, CREBS offers a way of studying the "typical" behaviors of school-aged children in a different cultural context than served by CHEAKS. Further research is needed to determine whether this scale can be "used in a valid way with populations other than fourth and fifth graders in Turkey." The article provides a roadmap, however, for those interested in developing similar scales for other cultural and demographic populations.

THE BOTTOM LINE: Culturally relevant approaches to studying environmental behavior are critical to our understanding of human relationships with the planet and to how we approach environmental education. Although CREBS may only be directly applicable to a specific population, the methods used by the authors to develop and validate this scale can be repeated in a variety of cultural and social contexts. This will allow environmental researchers and practitioners to build more responsive and appropriate ways of promoting responsible environmental behavior.

Erdogan, M., Ok, A., & Marcinkowski, T. J. (2012). Development and validation of Children's Responsible Environmental Behavior Scale. *Environmental Education Research, 18*(4), 507-540.

ENCOURAGING ENVIRONMENTAL BEHAVIORS REQUIRES A TARGETED APPROACH

Research over the past 50 years has failed to provide evidence for a strong link between a person's attitudes toward the environment and his or her willingness to act environmentally. Yet most studies have tended to focus on individuals' general feelings toward the environment. This study focused, instead, on specific environmental attitudes and behaviors, with the aim of understanding environmental education's potential to increase individuals' willingness to undertake particular pro-environmental actions.

The authors surveyed 961 public school students between the ages of 11 and 16 in northwest England about their environmental attitudes and beliefs. Mirroring the UK adult population, about half of the students considered themselves to be environmentally friendly and believed in and expressed worry about global warming.

The questionnaire first asked students about their willingness to undertake specific pro-environmental behaviors. Students seemed willing to undertake different environmental behaviors to varying degrees. Students were most amenable to the direct action of switching off unused electrical appliances. About half the students were open to installing home insulation, recycling materials, and paying more for energy-efficient household appliances. Fewer expressed interest in planting trees, paying more for food grown without artificial fertilizers, or eating less meat.

The survey also inquired into students' beliefs about the possible benefits of particular behaviors in the context of one environmental problem: global warming. Students believed that some environmental actions would be more effective in addressing global warming than others. Most thought that making better decisions related to personal transportation, minimizing energy consumption, and recycling were important ways to address global warming. They were less likely to believe that growing food without fertilizers or eating less meat would have an impact.

The authors found important differences between males and females, students of different ages, and more or less concerned students. Females were more prepared than males to take action on certain issues, such as switching off unused electrical items, reducing car usage, and eating less meat. Similarly, older secondary students appeared to be more willing than younger students to change their behaviors in light of new knowledge about environmental issues. Finally, there appeared to be a positive relationship between a student's level of concern about global warming and their willingness to undertake some pro-environmental actions.

The authors conclude by identifying which actions might be effectively targeted through environmental education. Because of the host of personal and social incentives, disincentives, and norms associated with every action, the authors argue that altering a student's belief about certain issues will not necessarily have an effect on their willingness to act. For certain behaviors—such as using public transportation or reducing fashion purchases—increased education is unlikely to overcome the personal

disincentives for action. However, for other actions, there was a strong relationship between the extent to which an action was to be effective in reducing global warming and a willingness to undertake it. Increasing recycling, planting trees, installing home insulation, and using energy-efficient domestic appliances are just some examples of behaviors environmental educators may want to target.

That said, educators and researchers must continue to bear in mind the wide differences in students' attitudes, knowledge, and the potential for pro-environmental behavior. The authors note that, similar to adults, "students will not be uniform in their behavioural responsiveness to environmental education even about specific actions."

THE BOTTOM LINE: Young adults vary widely in their knowledge and attitudes towards environmental issues, as well as their willingness to change behaviors. For certain behaviors, altering a student's belief will have little effect on his or her willingness to act. However, for other actions—such as recycling, reducing energy consumption, and planting more trees—the benefits of education in changing practice may be more likely.

Boyes, E., & Stanisstreet, M. (2011). Environmental education for behaviour change: Which actions should be targeted? *International Journal of Science Education, 34*(10) 1591-1614.

URBAN FARMING SCHOOL PROMOTES CRITICAL REFLECTION AND ENVIRONMENTAL ACTION

To what degree is it appropriate for teachers to promote specific environmental actions and behaviors? This question is a contentious issue in environmental education. Scholars who support an "interpretive" approach argue that promoting specific actions—eating organic food, for example—is a form of advocacy, not education. Critical environmental education (critical EE), on the other hand, encourages critical thinking about the current social order, and aims to empower students to take action to create a world that is in line with their values. Critical EE emphasizes

a two-way discourse and egalitarian relationship between teacher and student, as a means of encouraging the student to deconstruct knowledge and question the status quo. This case study examines a critical EE approach developed at an urban farming school in New Orleans, Louisiana, called Our School at Blair Grocery (OSBG).

OSBG started in 2009, with the aim of using urban farming as a means to address environmental racism in an impoverished area of New Orleans called L9. The environmental racism that is of particular focus for OSBG is the lack of access to healthy food in L9; the only stores to purchase food offer convenience store items, and rarely fruits and vegetables. OSBG also hopes to make students aware of how the social and natural worlds are interconnected using critical EE. The mission statement of OBSG is: "We're here to engage in and build upon a model of urban farming and community organizing that can combat systematic and internal oppression both here and at home for all humanity." High school and college students come to OSBG in groups of about 10-20 and stay on average a few weeks, but some continue for up to four months.

The author collected data through interviews and participant observation in the program every weekend from January to May 2010. This included engaging in farm work with the students by day, participating in student meetings, and eating and staying in the student housing at night. Group interviews were conducted at student meetings. The collected data were analyzed for specific themes, such as "work," "stress," and "youth-centered culture."

The egalitarian ethic of the school—what the students called a "community of practice" ethic—was one of the primary factors that seemed to promote student learning and engagement. The community of practice was described as "a tight-knit community working together with a shared goal," which allowed the students and teachers to develop close bonds and work toward an egalitarian ideal, where neither teachers nor students were in charge. Decisions were reached by consensus, and teachers aimed to give students as much responsibility as possible, including organizing their daily schedule. However, this ethic was

challenging to maintain: In reality, the school wasn't perfectly egalitarian. For one, teachers often did less farm work than the students, which was noticed and perceived as a form of age inequity by the youth. The teachers were also often stressed by their responsibility of trying to find funding for the school, which prevented them from being fully engaged in the school's daily activities.

Another factor that seemed critical to meeting the goals of OSGB was its focus on engaging students in local, real-world environmental and social problems. In addition to working on the urban farm, students took up projects in the L9 community, including creating a small farmers market and doing a food accessibility survey. The farmers market initiative wasn't successful, but the food accessibility survey was found to be influential in students' learning. Specifically, the survey created an awareness about the food desert effect and made environmental racism tangible rather than simply a theoretical idea.

Overall, the author found that the students in the program developed greater awareness of their ability to enact pro-environmental actions as individuals and as a group. Several students also noted changes in their environmental behavior, such as changing their eating and purchasing habits.

The author noted several main challenges faced by the program, including maintaining the egalitarian ethic of the school and securing funding so that the teachers can focus on teaching rather than fundraising. The author points out that future research is needed to determine whether the critical EE model can be maintained in a more institutional setting.

THE BOTTOM LINE: Critical EE aims to empower students to think critically about the current social order and their role in creating change. Our School at Blair Grocery, an urban farming school in New Orleans, has had some success in implementing critical EE pedagogy through its program. Key to its success is creating an egalitarian ethic among teachers and students, which empowers students to question authority, take action, and feel compelled to change their own behaviors. Being involved in food accessibility issues in a community also engaged the students and helped them

develop a deeper knowledge and understanding of ecological and social justice issues.

Ceaser, D. (2012). Our School at Blair Grocery: A case study in promoting environmental action through critical environmental education. *The Journal of Environmental Education, 43*(4), 209-226.

COURSE DECREASES STUDENTS' LACK OF MOTIVATION TO ENGAGE IN PRO-ENVIRONMENTAL BEHAVIOR

As researchers work to understand the drivers of human behavior, an important application of their work is in environmental education (EE) settings, where educators work to encourage behaviors that promote sustainability. This paper applies a theory of human motivation to environmental motivation and presents a study designed to test whether an environmental biology course guided by this theory increases students' determination to engage in pro-environmental behaviors.

Self-determination theory (SDT) is a theory of human motivation. This theory has two essential parts: The first part says that the motivation behind human behaviors exists along a continuum, ranging from a lack of motivation to motivation that is self-determined. Researchers refer to a lack of motivation as *amotivation*. At the other end of the spectrum are *integrated regulation*, where a behavior has become part of one's identity, and *instrinsic regulation*, where performing a behavior brings one pleasure. According to SDT, behaviors that fall under integrated regulation and intrinsic regulation are most likely to be sustained, even when these behaviors are hard to do. These are known as self-determined behaviors.

The second part focuses on self-determination. The claim is that behaviors are most likely to become self-determined when the context in which they are valued meets a person's three basic psychological needs: *autonomy, competence,* and *relatedness*. The need for autonomy is met when one feels they have choices and that any rules are reasonable and well explained. The need for competence is met when a person feels that they are capable of achieving their goal. Relatedness comes about when a person feels that they belong in and are valued by a group. An EE context would fulfill all three of these basic psychological needs if students were able to choose and explain their own pro-environmental behaviors (autonomy), if the curriculum allowed for discussion and authentic problem-solving (competence), and if there were space for diverse perspectives and everyone's contributions were valued (relatedness).

The author hypothesized that an environmental course designed and taught with the explicit intention of providing students with a sense of autonomy, competence, and relatedness would foster self-determination toward pro-environmental behaviors more than a course without those specific goals. To test this, the author compared two sections of a community college environmental biology course, one of which was guided by the principles of SDT and the other of which was not. The two course sections covered the same topics and used the same textbooks. However, in the SDT-guided section, students worked collaboratively in small groups, chose local environmental issues to explore in depth, used their everyday knowledge to develop solutions to the problems, and engaged in reflective activities. To measure the degree of students' self-determination toward pro-environmental behaviors, the author administered a questionnaire to participants at the beginning of the course, immediately after the course, and six months after the course.

Although the author expected students in the SDT-guided section of the course to have higher scores on the items related to self-determined behavior, this was not the case. What the questionnaire did reveal, however, was that students in the SDT-guided section had a larger decrease in their levels of amotivation from the beginning of the course to the end than did the students in the comparison section. This suggests that designing and teaching EE courses with attention to students' autonomy, competence, and relatedness has the potential to decrease students' environmental amotivation, or lack of motivation to engage in pro-environmental behaviors. The author concedes that further research is needed to determine the specifics of how an SDT-guided course diminishes students' amotivation.

THE BOTTOM LINE: This study suggests that, if properly structured, education programs can reduce students' amotivation, or lack of motivation, toward pro-environmental behaviors. Specifically, the findings suggest that EE provides students with autonomy, competence, and relatedness and helps encourage pro-environmental behavior. When students are given some measure of choice over the issues studied, allowed to engage in authentic problem-solving, and see that everyone's contributions and perspectives are valued, they are more likely to become motivated to engage in behaviors that are good for the environment.

Darner, R. (2012). An empirical test of self-determination theory as a guide to fostering environmental motivation. *Environmental Education Research, 18*(4), 463-472.

EVALUATION

MORE RESEARCH NEEDED ON INTERPRETATION'S BEST PRACTICES

Because interpretation has grown as a field and now is relied upon as a critical tool in managing natural resources, it's important to understand which interpretive practices are most effective in reaching certain desired educational, behavioral, and conservation outcomes. To that end, this paper's authors compiled a list of interpretation's best practices from the field's most influential texts and searched the literature to find empirical support for the practices. Their research uncovered gaps in the evaluation literature regarding what we know about best practices in interpretation.

The researchers reviewed 18 "key sources" in interpretive training, including foundational sources such as Tilden's *Interpreting Our Heritage*, more recent sources such as Ham's *Environmental Interpretation*, National Park Service training modules, and other well-known interpretation guides. The authors identified 17 best practices, defined as follows:

- **Theme development:** Interpretation delivery system has a clear theme(s).
- **Link tangibles to intangibles to universals:** Interpretation makes a link between tangible and intangible concepts and objects and demonstrates the relationship to universal concepts.
- **Multisensory:** Interpretation delivery system is intentionally designed to engage one or more senses.
- **Actively engage audience:** Interpretation is designed to facilitate audience participation in the interpretive experience.
- **Multiple activities:** Interpretive experience consists of a variety of activities and opportunities for direct audience involvement.
- **Multiple delivery styles:** Interpretation delivery system employs a mixture of first-person interpretation, brochures, signs, exhibits, and so on.
- **Relevance to audience:** Interpretive delivery system communicates relevance of subject to audience.
- **Resource and place-based messaging:** Interpretive message focuses on relationship between visitor and the site/resource.
- **Physical engagement with the resource:** Interpretive delivery system intentionally provides direct physical experiences and interactions with the site/resource to build relationship between the visitor and the site/resource.

- **Tailored to the audience:** Interpretive delivery system is developed specifically for a predefined audience or user group (e.g., age appropriate).
- **Cognitive-based messaging:** Interpretation delivery system provides accurate, fact-based information as part of interpretation.
- **Affective messaging:** Interpretation delivery system provides affective messages.
- **Cognitive/affective messaging:** Interpretation delivery system has a combination of cognitive and affective messages.

The following best practices are specific to addressing behavioral outcomes:

- **Demonstrates benefits of action:** Interpretation delivery system uses messaging to present the potential results of desired actions.
- **Social norms:** Interpretation delivery system presents messaging focused on social norms regarding a particular behavior or desired action.
- **Ease of action:** Interpretation delivery system uses messaging to present the ease of visitors adopting desired actions.
- **Demonstrates action:** Interpretation delivery system provides examples of or opportunities for desired actions.

The authors searched for research articles published from 1996 to 2009 in major interpretation journals that demonstrated how interpretive programs affected at least one of the following visitor outcomes: attitudes, awareness, behavior, behavioral intentions, knowledge, or satisfaction. The research articles also had to provide enough detail about the interpretive programs to determine which best practices were employed. In all, the researchers selected 70 articles that met the criteria, and because each paper may have reported on more than one best practice and/or outcome, the researchers were able to pair practices with outcomes a total of 394 times.

The researchers found that in 84% of the pairings of a best practice with an outcome, the results were positive, which suggests that the best practices are effective at eliciting a range of positive outcomes. But, the authors raise a series of questions about the quality of the data. First, the sample sizes for many pairings were small. Second, the papers often did not fully describe the interpretive programs being evaluated, so it was impossible to judge the quality or quantity of a specific best practice in a program. Third, most papers reported only positive results, leading the authors to suggest that perhaps negative or null results are left unpublished. The authors also note that of the 111 instances of an outcome being evaluated in the papers, just five evaluations conducted a post-test more than six months after the interpretive program. The authors argue that long-term impacts should be measured more often. The authors also note that knowledge was the most-evaluated outcome. But, the authors argue that given interpretation's goal of "life-long change in understanding and action . . . short-term assessments of knowledge through pre-post tests appear to be of minimal significance."

The authors conclude that more focused research on interpretation's best practices is sorely needed. Future research should explicitly target best practices, compare practices across programs, conduct longer-term follow-ups, and report null and negative results when they occur.

THE BOTTOM LINE: Although the published research largely supports interpretation's best practices, there are many gaps in the research. In general, researchers have not explicitly tested specific practices, and often have not published negative or neutral evaluation results. And although most interpretive programs aim for long-term changes in their audience, short-term evaluations of knowledge dominate interpretation's evaluation literature. The field would benefit from more evaluations specifically investigating best practices, comparing them across programs to better understand if and how they are effective, considering their impact on a range of outcomes beyond knowledge, measuring their impacts over longer time periods, and reporting instances where they are not effective.

Skibins, J. C., Powell, R. B., & Stern, M. J. (2012). Exploring empirical support for interpretation's best practices. *Journal of Interpretation Research*, *17*(1), 25-44.

PLACE-BASED LEARNING LINKED TO IMPROVEMENTS IN ENVIRONMENTAL QUALITY

After years of measuring environmental education's impacts on knowledge, attitudes, behavior, student achievement, and other areas, researchers are increasingly considering how EE programs can directly affect environmental quality. This study's authors aimed to understand the environmental outcomes of education programs focused on air quality. They also wanted to know how place-based learning techniques affected the programs' outcomes.

The authors focused specifically on air quality education programs for several reasons. First, the authors believed that comparing all types of programs that influence environmental quality would generate too many variables to analyze effectively (for example, it would be difficult to compare programs that affect water quality, air quality, and invasive species). Second, they reasoned that air quality is an issue that impacts children's health. And third, they noted that numerous air quality education programs exist throughout the United States, ensuring that there would be a sufficiently large sample from which to select.

To identify the sampling frame, the authors compiled a list of air quality education programs throughout the United States by searching peer-reviewed literature and the popular press (including websites), as well as by reaching out through social networks. The search yielded 198 air quality education programs, and they were able to identify contact information for 190 of those. To those 190 programs, the authors sent a 45-minute survey inquiring about the programs' background, use of place-based learning practices, specific education activities, and program outcomes. To understand the degree to which the programs exhibited place-based learning, the survey included 18 practices and qualities of place-based learning

and asked the respondents to rate how strongly their programs exhibited those characteristics. Some of the practices and qualities included factors such as: the degree to which the program is personally relevant to learners, whether the program uses the local environment as a context for learning, and whether the program contributes to community needs.

In the end, the researchers administered the survey over the phone or email to 54 program representatives. Most of the programs were school based, and about half started the programs in response to poor air quality in the local area. In addition, the programs represented a diverse array of socioeconomic backgrounds in cities, suburban areas, and rural areas.

The survey revealed that 11% of the programs made no effort to take specific actions to improve air quality, but instead provided information only. Another 43% were more action oriented and attempted to measure air quality improvements or related air quality indicators, but were not able to demonstrate specific improvements. Finally, the remaining 46% of the programs—the largest group— measured proxy indicators (factors that are assumed to affect air quality, such as a reduction in car idling) or actual changes in air quality. Most of this group (19 of 25) measured proxy indicators, while six measured actual air quality.

In general, the program representatives reported high levels of place-based learning indicators, reporting that the programs either "somewhat" or "strongly" included many qualities of place-based learning. The authors grouped the programs into two groups of roughly equal size based on their scores for place-based learning, the "lower" place-based learning group whose scores were at the lower end of the spectrum and the "higher" group. Interestingly, three-quarters (a statistically significant portion) of the 25 programs that reported air quality improvements were part of the "higher" place-based learning group. And the authors explain that further analysis revealed that "the degree to which a program incorporated [place-based

learning] was the strongest predictor of improvements in physical or proxy [air quality] indicators."

The authors conclude that while there are various limitations to their approach, "Our findings provide preliminary evidence that education programs can be a viable approach for achieving measurable improvements in [environmental quality]."

THE BOTTOM LINE: This research suggests that certain types of air quality education programs—namely, place-based education programs that exhibit a certain set of characteristics—can have measurable impacts on either actual air quality or factors that are likely to improve air quality. This paper, however, represents just a first step in this line of research, and additional research is required to understand more about success rates, type, and scale of environmental benefits, the effectiveness of specific education approaches, and so on. And although measuring environmental impacts may be valuable in certain circumstances, by no means is it a necessary or appropriate evaluation for every environmental education program.

Johnson, B., Duffin, M., & Murphy, M. (2012). Quantifying a relationship between place-based learning and environmental quality. *Environmental Education Research*, *18*(5), 609-624.

COMPUTER-BASED CONCEPT MAPS EFFECTIVELY ASSESS SYSTEM THINKING

System thinking plays a central role in much of environmental education. Helping students understand how elements within a system are connected is a common—and often critical—teaching goal. Therefore, assessing whether students understand the structure and function of systems can be important.

The authors of this study focused on one way to assess system thinking: the concept map. Concept maps allow students to illustrate their mental models of how elements are connected by creating a visualization of concepts that depicts the interconnected "nodes," which are separate elements joined by lines that are then labeled to indicate the nature of the connection. This study's authors investigated whether a paper-and-pencil or computer-based map better assessed students' knowledge. The authors also evaluated the effects of the level of direction given to the students in developing their concept maps.

The authors randomly assigned 154 German fourth graders and 93 German eighth graders to one of three groups: highly directed paper-and-pencil mapping, nondirected paper-and-pencil mapping, and highly directed computer mapping. (The computer program did not allow for a nondirected mapping option.) In the directed group, students received suggested concepts and linking words to use in their maps; in the nondirected group, students received no such direction. The students received a series of lessons in their classrooms regarding ecosystem interactions in a local marine environment. After the lessons, they were asked to construct concept maps (either with pencil and paper or on the computer). The students also completed a questionnaire with multiple choice and open-ended questions that measured their system thinking.

The researchers found that both the fourth and eighth graders performed better with the computer-based concept mapping than the paper-based maps. The researchers believe that students probably found the computer easier to use than the paper and pencil. They explain, "We can assume that if a student has a tool at his disposal, and this tool facilitates the creation of maps that are more complex and easier to organize, he will perform better than with paper-pencil maps." The authors believe that the computer maps might simply be easier to organize and revise. The authors did not, however, find that one method was more valid than the other.

The authors conclude, "To summarize, we consider highly directed computer-based practices to be appropriate for system thinking measurement, particularly for fourth graders, who obviously benefit from support by providing

concepts and linking words that draw students' attentions more intensively towards the underlying system and facilitate the demand for conceptual knowledge."

THE BOTTOM LINE: This study points to the effectiveness of concept maps in assessing students' system thinking, which is a key concept in many environmental education settings. Highly directed assessments, in which students are given a set of concepts and linking words, can accurately reflect students' knowledge of how elements fit together. Although this study demonstrates that computer-based concepts maps are particularly effective for fourth-grade and eighth-grade students, paper-and-pencil maps, which may be more feasible in many environmental education settings, can still be valid assessments of system thinking.

Brandstädter, K., Harms, U., & Großschedl, J. (2012). Assessing system thinking through different concept-mapping practices. *International Journal of Science Education*, *34*(14), 2147-2170.

NEW DIAGNOSTIC TEST MEASURES MISCONCEPTIONS

Surveys and other close-ended questionnaires have been used extensively to identify misconceptions people have about environmental issues. We know, for example, that many people incorrectly believe that ozone-layer depletion causes global warming. Identifying misconceptions is important, because misconceptions often are difficult to change and, as a result, require specialized teaching approaches that are different from simply educating people about something that they don't know. It's also important to identify teachers' misconceptions because of the risk that they will pass these strongly held, but incorrect, notions on to students.

But, the authors of this paper argue, the tools we most often use to diagnose misconceptions are not refined enough to paint a clear picture of what people actually believe. Multiple-choice questions can result in guessing; through this process, a respondent might reveal a lack of knowledge by selecting the incorrect answer, yet he or she might not necessarily hold a misconception. That person, for example, might choose a response that indicates that ozone-layer depletion causes global warming. While that response could be interpreted as a misconception, it may be the case that the person might simply have guessed wrong or selected the wrong response for a reason other than holding a misconception.

To address this issue, researchers have developed two-tier tests that add a second question to clarify whether a person can identify a reason for his or her choice. In this study, the authors added another aspect: They included a third tier to measures an individual's certainty in his or her response. To be classified as a true misconception, a person must answer incorrectly on both the first and second question, and also be confident in their response.

After initial testing, the authors administered this new three-tier test—the Atmosphere-Related Environmental Problems Diagnostic Test (AREPDiT)—to 256 preservice teachers in their third or fourth year of a teacher certification training at a university in the American Southwest. The test included questions related to global warming, greenhouse effect, ozone layer depletion, and acid rain.

In general, the results revealed low levels of understanding of all four issues. Interestingly, although the preservice teachers' knowledge scores were low, their certainty scores were moderate, which the authors indicate aligns with previous research suggesting that people tend to be overconfident in assessing their own knowledge.

The results also indicated that the teachers held five prevalent misconceptions:

- Global warming is caused by ozone layer depletion
- Global warming will cause skin cancer
- Acid rain is a result of global warming
- The greenhouse effect is a totally harmful phenomenon for humankind

- Using public transportation reduces ozone layer depletion

But the three tiers proved valuable in analyzing the results. For example, 56% of the preservice teachers linked global warming and ozone layer depletion in their first-tier question, which is in line with previous research that has indicated similarly high levels of support for this incorrect idea. But when the authors looked at the first two tiers together, the misconception decreased to 40%. And when they accounted for all three tiers, just 18% of preservice teachers held the misconception. The authors then question whether "a wrong answer on a one-tier test truly [identifies] a misconception? The results in this study indicate that identifying misconceptions by one-tier or even two-tier tests overestimates the percentages of misconceptions."

The authors believe that this test can be used to assess misconceptions among preservice teachers, but also in-service teachers or high school students. They also urge educators to develop similarly designed three-tier tests to assess their students' misconceptions about other science topics.

THE BOTTOM LINE: Multiple-choice questions may reveal gaps in people's understanding when they select an incorrect response, but they do not necessarily reveal misconceptions. The authors of this paper argue that it's important to understand the difference between true misconceptions—which are typically strongly held beliefs about what is accurate—and a lack of knowledge, because they require different types of educational interventions to address. This paper demonstrates that a refined "three-tiered" instrument can more accurately diagnose misconceptions by measuring not just a gap in knowledge, but also a person's confidence in an incorrect idea. Anyone interested in assessing misconceptions about atmosphere-related environmental issues, such as climate change and acid rain, among teachers (preservice or inservice) or students in high school or above could use the assessment tool described here; however, other issues or audiences might require the development of a different three-tiered test.

Arslan, H. O., Cigdemoglu, C., & Moseley, C. (2012). A three-tier diagnostic test to assess pre-service teachers' misconceptions about global warming, greenhouse effect, ozone layer depletion, and acid rain. *International Journal of Science Education*, *34*(11), 1667-1686.

TEACHING METHODS

COMPUTER SIMULATIONS SUPPORT SCIENCE TEACHING

In 1998, the national ratio of students to computers with internet access was 12:1; by 2008, the ratio dropped to 3:1. Technology now plays a central role in many schools, and often there is pressure for schools to use technology even more. Computers are used in a variety of ways in the classroom, but perhaps the most promising application is in computer simulations, which the authors of this paper define as "computer generated, dynamic models of the real world and its processes." Animations, visualizations, and interactive laboratories are all examples of computer simulations, and they can be used by students individually, in small groups, or as a whole class.

The authors of this paper reviewed research published since 1972 on the effectiveness of computer simulations in K-12 and college science teaching. Their search yielded 61 articles that focused on how computer simulations promote content knowledge, science process skills, and conceptual change, along with issues surrounding how simulations are used in the classroom.

In general, the review indicated that computer simulations are often better than, or are almost always at least as good as, traditional science teaching. Most of the results (49 of 61) indicate that simulations produce better results that traditional teaching. Eleven studies showed the two approaches to be equal, and just one of the studies reviewed found traditional approaches to yield better results.

In particular, the authors found that the published research demonstrated that computer simulations were effective at boosting content knowledge and science process skills, but that guidance and support from the teacher were critical. In an example of interest to environmental educators, the authors describe one study in which two groups of college students participated in three educational sessions related to oceanography. Both groups experienced identical first and last sessions, but one group's second session occurred in the field while the other's consisted of a computer simulation. There was no difference in overall learning between the two groups, but the simulation group produced better sketches than the field group. The authors explain, "The researchers concluded that while the fieldwork provided an authentic experience, the simulated work provided a

model-based experience that also offered visualization opportunities not possible in the field."

The literature review also suggests that simulations can be used effectively with a cognitive dissonance model of education, in which students' initial beliefs about a subject are exposed and explored as they move toward adopting more scientifically sound understandings. The reviewed papers all showed that simulations help expose students' initial beliefs, but the papers also acknowledge that changing those beliefs over the long term is challenging.

Some of the papers reviewed explored how simulations are used in the classroom. The findings suggest that providing supplemental text and demonstrations, allowing the students the flexibility to explore ideas, and providing immediate feedback are effective design features. Whole-class use of simulations also proved effective. Most of the papers emphasized the important role of the teacher in guiding the students.

The authors conclude that three key themes emerged from the review. Computer simulations are most effective when:

1. They are used to supplement, not replace, other instructional modes;
2. Students are provided with high-quality support structures; and
3. They are used to promote cognitive dissonance.

The authors point to weaknesses in research conducted to date that might be addressed by other researchers and suggest directions for future research. They conclude that the results of their review are "quite encouraging," and explain:

> Knowing that it is just as effective for students to make observations and collect data about celestial objects from a computer simulation as it is for them to make observations in nature is important information for the teacher whose students live in places where night-

time observations are unrealistic or unsafe. In addition to being at least as effective as other traditional practices, computer simulations provide students with opportunities to be actively involved in the kind of inquiry-based, authentic science explorations called for by science education reform efforts. Furthermore, advantages such as time and cost efficiency, safety, and the ability to cater to differences among learners make computer simulations an attractive option for today's classrooms.

THE BOTTOM LINE: Research conducted over the past 40 years on the impact of computer simulations on science teaching indicates that this technology is effective. The research suggests that computer simulations are most effective when they are used to supplement other education techniques, when students receive guidance and support from their teacher, and when they help create cognitive dissonance by exposing students' initial ideas and moving them toward more scientifically sound ideas.

Smetana, L. K., & Bell, R. L. (2012). Computer simulations to support science instruction and learning: A critical review of the literature. *International Journal of Science Education*, *34*(9), 1337-1370.

WHOLE-CLASS DISCUSSIONS SEEN AS EFFECTIVE TEACHING TOOL

According to the author of this paper, whole-class discussions take up a much larger portion of classroom time than the current academic and professional literature might recommend. The emphasis in the literature is on inquiry-based approaches, with students working together in small groups to develop knowledge through experimentation. The author of this paper argues, however, that this kind of approach can sometimes present practical challenges and may not be appropriate when teaching certain topics in primary school settings.

To illustrate how whole-class discussions and demonstrations can serve as acceptable alternatives to inquiry-based approaches, and indeed even be appropriate and quite effective, the author used a case-study approach to closely follow two teachers at "typical" British primary schools as they conducted a science unit. The teachers were experienced and familiar with the recommended best practices in science education.

The author describes four types of communication approaches the teachers used:

- **Interactive-Dialogic:** Reciprocal conversations between students and the teacher, with different people's ideas interacting (e.g., teacher helps pool ideas and questions at the beginning of the unit, teacher leads a discussion of students' ideas, teacher helps guide students in a debate)
- **Non-interactive-Dialogic:** Reciprocal conversations between students and the teacher, without different people's ideas interacting (e.g., teacher presents certain student ideas to the class, students talk with each other but their ideas do not build on each other)
- **Interactive-Authoritative:** Teacher maintains control of the knowledge transmission, but students are involved and interact (e.g., teacher leads the students in a recap of what they've learned)
- **Non-interactive-Authoritative:** Teacher transmits the knowledge with little student involvement (e.g., teacher explains procedures for conducting a test)

The author argues that the teachers use each of these approaches to achieve different goals, and that each can be appropriate in certain circumstances. For example, the author describes how one of the teachers used the Interactive-Dialogic approach to pool students' questions at the beginning of the unit to discuss the meaning of terminology and to debate and apply ideas.

The author also describes how the Interactive-Authoritative approach can help students understand scientific concepts such as making generalizations. Through a whole-class discussion, the teacher walks the students through the process of applying knowledge gained in one context, such as an in-class demonstration, to other contexts they might encounter elsewhere.

Although there is value in inquiry, the author argues that these case studies demonstrate that whole-class discussions and in-class demonstrations of scientific concepts also have an important role to play in the classroom. The author believes that "overall, there was evidence that whole-class discussions can contribute to constructing a view of science as not only about experiencing the natural world but theorizing it and aiming to come to a shared understanding of it."

THE BOTTOM LINE: This study highlights the ongoing tension between inquiry-based teaching theory and practice. Although inquiry-based approaches in which students work in small groups are accepted as ideal in much of the education literature, this paper argues that whole-class discussions and demonstrations can also effectively build knowledge and skills. Interactive approaches that involve students, help them work together to build knowledge, and hand control of discussions over to students when they are ready can also be effective teaching strategies. This paper is based on a descriptive case study approach, however, rather than on a controlled experiment, making the results somewhat limited. Future studies that compare the two different approaches to determine which generates better results under what conditions would be helpful.

McMahon, K. (2012). Case studies of interactive whole-class teaching in primary science: Communicative approach and pedagogic purposes. *International Journal of Science Education*, *34*(11), 1687-1708.

UNDERSTANDING CLIMATE CHANGE REQUIRES HOLISTIC UNDERSTANDING OF THE CLIMATE SYSTEM

Research has revealed that there is a wide gap between the ways that scientists and students think about climate change. This paper's authors argue that to better understand climate change, students must first understand the climate as a system. They propose a climate system framework that can be used to teach about climate change. Their goal is to present this framework to inform both the design of climate change curricula and future research on climate change education.

The authors conducted a comprehensive review of research on secondary students' learning about climate change and identified six categories of topics that emerged from the review: (1) causes of global warming climate change, (2) greenhouse gases, (3) relationship of global warming and climate change, (4) relationship of climate and weather, (5) the carbon cycle, and (6) the impacts of global warming and climate change. For each of these categories, the authors describe research on the learning that has taken place, looking for sources of the misconceptions that secondary students have. For example, the authors highlight that students believe air pollution, such as acid rain and dust, causes climate change; carbon dioxide is not a greenhouse gas; and greenhouse gases exist as a "layer" in the atmosphere. When it comes to impacts, students are largely focused on the impacts of increasing temperatures, which they see as the cause of sea level rise due to ice melt they believe will be the cause of cause droughts and a loss of drinking water.

The authors use this analysis to construct a generalized model of secondary student conceptions of climate change, including their erroneous ideas. They then use well-accepted scientific models of the climate system to create their own climate system framework. The framework describes the Earth's climate system, including the external and internal causes of climate and natural and human-induced causes of climate variability. The authors juxtapose their climate system framework and the students' conceptual model to highlight what's missing from the student conceptual model. The authors' analysis reveals that students are missing several key concepts "that need to be addressed in order to develop students' conceptualizations of climate change within the context of a climate system." These concepts include:

- What is a climate system?
- Climate and weather
- The Earth and Earth's energy budget
- System feedbacks
- The sun (solar radiation)
- Atmosphere (troposphere)
- Ice and snow
- Oceans
- Land and vegetation

The authors believe that understanding these concepts will help students understand the climate system as a whole, and they believe it "challenges students' understanding of global warming and climate change as being driven by the greenhouse effect alone." This system understanding, the authors argue, helps put the variability in the Earth's climate into perspective. But, they acknowledge that teaching students about the Earth's climate is challenging, and more research about how students think about the climate system is needed. The authors have invited the formal and informal education community to provide comments and feedback about their proposed approach at an online discussion board at iclimate.org/ccc.

THE BOTTOM LINE: When teaching about climate change, the authors of this paper argue that the curriculum should emphasize climate change in the context of the climate system as a whole. They've developed a climate system framework that describes key concepts and linkages in the climate system. This approach focuses attention on fundamental climate science knowledge and develops students into critical thinkers who can use this knowledge to help interpret and understand climate change. But they acknowledge that teaching about the climate system is not easy, and more research is needed. The authors invite colleagues to weigh in on the challenges of climate education

and their proposed teaching approach at iclimate.org/ccc. Shepardson, D. P., Niyogi, D., Roychoudhury, A., & Hirsch, A. (2012). Conceptualizing climate change in the context of a climate system: Implications for climate and environmental education. *Environmental Education Research*, *18*(3), 323-352.

DRAMA INVIGORATES PRIMARY SCIENCE EDUCATION

As in the United States and many countries around the world, students in Britain are increasingly being "taught to the test," with heavy emphasis on content and vocabulary, and less time for creativity, questioning, and investigating in science instruction. This article reports on a pilot study to explore the use of dramatic techniques for promoting engagement and understanding of science among five- to seven-year olds. In addition, the study investigated whether using drama promoted the development of teachers' understanding of primary science.

The study focused on a group of 20 teachers of five- to seven-year-olds from 10 schools in the UK. Six workshop days were held between September 2009 and September 2010 (two workshop days per term). The workshops were organized and led by a team of three educators. In addition, the project had a steering group, which included the director of a local science center and a local drama advisor.

For each workshop day, the teachers were instructed in various dramatic teaching strategies and participated in interactive activities. As the project progressed, the teachers became more autonomous in devising the teaching strategies that they brought back to their classrooms.

Eight basic teaching strategies were developed through the project, each one allowing students to think about science in different ways. *On the table,* for example, developed observation and questioning skills as the students explored images of magnified objects and speculated about the objects' nature and possible uses. Another strategy, called *modeling*, provided a physical way for students to engage with learning by allowing students to use their bodies to mimic how something works. The strategies were applied in various contexts. One example was *toys*, where students were encouraged to discover what made toys move and work in different ways.

To evaluate the project, researchers collected quantitative and qualitative data to measure the teachers' and students' experiences. The qualitative data included reflective journals that the teachers kept throughout the process, video and audio recordings of the workshops and teachers in the schools, and field notes. The quantitative measures included questionnaires for the 20 teachers, asking them to reflect on how the project influenced their own teaching. A questionnaire for the 200 participating students examined their feelings and views about learning science through drama.

The qualitative data were used to compose "the teacher's learning story," which outlined the teachers' development over the course of the six workshops. Each workshop day was understood as a different phase in the teachers' development. The six phases were described as: (1) Becoming conversant and familiar; (2) Recognizing and realizing opportunities; (3) Drama can provide revelations!; (4) Succeeding despite challenges; (5) Becoming more confident and creative; and (6) The finale. One of the key findings from the learning story narrative was the teachers' realizing that inviting children to demonstrate their understanding of the subject through drama often illustrated an incomplete conceptual grasp, of which the teachers were otherwise unaware.

Another finding was that some of the strategies were much easier to apply than others. Particularly straightforward strategies were *miming movement* ("indicating what it might be like to be a 'something' or have something happening to them"), *freeze frame* (pausing-in-action), and *modeling*. Over the course of the project, the teachers became more comfortable and familiar with all of the strategies presented and found ways of implementing them despite initial hesitation. That said, some strategies continued to be used more frequently than others.

The teacher questionnaires also revealed that the dramatic techniques were effective for most of the science subjects covered in their classroom. Exceptions to these were teaching students how to plan an experiment and how to obtain and present evidence, where the teachers reported little improvement in both students' learning and enthusiasm for the material.

Overall, the teachers reported a great deal of enthusiasm from the students regarding the learning strategies. In fact, some of the students were so enthusiastic that they began acting things out when taught something new, not only in science class but in other classes as well. The student questionnaires echoed this positive response, with the vast majority of students reporting that using drama to learn science "is more enjoyable and fun," "helps me understand more difficult ideas," "helps because we act things out more," and "helps because we talk about things more."

THE BOTTOM LINE: This study demonstrated that dramatic techniques can be effective tools for teaching science to five- to seven-year-olds. Drama increases student engagement and enjoyment with science learning and also can help them understand difficult concepts. Having students act out scientific concepts also can help teachers better understand where students' conceptual gaps exist.

McGregor, D. (2012). Dramatising science learning: Findings from a pilot study to re-invigorate elementary science pedagogy for five- to seven-year olds. *International Journal of Science Education*, *34*(8), 1145-1165.

CERTAIN STUDENT BEHAVIORS HELP MOVE GROUPS FROM ARGUMENTS TO CONSENSUS

Science educators in general, and environmental educators in particular, often use techniques related to argumentation to teach science concepts. Argumentation allows students to apply their knowledge as they form and defend their own arguments and challenge others. Often, the goal is for students to reach a consensus about the topic at hand. But, for students, reaching a consensus can be challenging.

The authors of this study explain that a long history of research helps explain why it's often difficult for people to argue productively. For example, they point to "confirmation bias," in which people favor evidence that supports their ideas. The authors also cite the work of cognitive scientists Mercier and Sperber, who concluded that people are perfectly capable of objective reasoning "when they are after the truth rather than trying to win a debate." Other factors that can influence how students argue include how strongly the students hold their beliefs, students' perceptions of the people with whom they are arguing, and classroom norms and culture.

The authors observed fifth- and sixth-grade students as they engaged in an argumentation activity in which the students were asked to come to consensus about ecosystem interactions. As a part of the week-long lesson, the researchers tasked pairs of students with identifying the food source of an invasive species based on information and data supplied through a computer model of the fictional ecosystem. They asked the pairs to develop an argument to support their idea; then two pairs of students were joined and asked to discuss their arguments and come to consensus about the food source. In all, the authors observed ten groups of students in five classrooms in three different schools. One school was a suburban school in the Midwestern United States, another was in a small city in the Mountain West, and the third was an urban school in a major American metropolitan area.

The authors' analysis focused on one group that failed to reach a consensus and two groups that struggled but eventually did reach consensus. In the group that did not reach consensus, three students agreed but one did not, and the students in agreement challenged and dismissed their classmate's ideas quickly. The researchers believe that "the students were focusing on the persuasive aspects of argumentation," as evidenced by their exclamation at the conclusion of the discussion, "We win, we win."

In contrast, in the groups that ultimately found consensus, the students "seemed to find a way to legitimize one another's ideas—so they were not simply 'wrong' . . . ." In

one group, for example, a student had become disengaged in the discussion as the students argued about the invader's food source. Only after another student in the group acknowledged that her idea might be right did the disengaged student become reengaged, and the students found consensus. In the other group, the authors point to one student who held an opposing view but finally accepted the rest of the group's claim, by saying "'I still don't [agree], but yes.'" The student's acceptance of both ideas paved the way for the group to move forward from argumentation to consensus.

The authors believe that in addition to skills related to constructing, articulating, and revising arguments, students also need other skills to move to consensus. The authors explain, "In contexts like the schools participating in this study, some students will be more willing participants in consensus-building through argumentation if they feel that they are heard and that their ideas are valued." The researchers argue that teachers can foster this kind of social interaction by establishing classroom norms that support consensus by legitimizing other's ideas.

THE BOTTOM LINE: Environmental educators often use argumentation and consensus as teaching tools to help students understand the complex nature of environmental issues and to help build skills in addressing them. This research suggests that students may need support in effectively engaging in argumentation. It may require that teachers remind students that the goal of argumentation is finding *an* answer, not *the* answer. That is, students should not set out to persuade each other to their own way of thinking, but instead acknowledge each contribution as they move toward a solution. Teachers can accomplish this directly with reminders during an argumentation activity, but also indirectly through the creation of a supportive classroom culture.

Berland, L. K., & Lee, V. R. (2012). In pursuit of consensus: Disagreement and legitimization during small-group argumentation. *International Journal of Science Education*, *34*(12), 1857-1882.

CLASSROOM TEACHER MORE EFFECTIVE THAN OUTSIDE PRESENTER FOR CLIMATE CHANGE EDUCATION

Recently, there has been increasing interest in teaching young people about the causes and ramifications of climate change. Some non-governmental organizations (NGOs) have provided professional development opportunities and learning materials for classroom teachers, while others have sent outside presenters into classrooms to teach one-off assemblies or multipart units on climate change. This paper's authors sought to explore whether it makes a difference in student learning outcomes if the same climate change education material is presented by outside presenters versus regular classroom science teachers.

Four grade six classes in British Columbia, Canada, were selected for the study. All the classes were taught a unit on climate change science, designed by the researchers, over a period of two weeks. Two of the classes received this unit from their regular science teacher during their science periods, and the other class received the unit from an environmental educator working with an NGO over two one-and-a-half-hour sessions. Both interventions included the same total time on the task, the same content, and similar instructional strategies, as a way to examine whether the learning setting alone alters student learning. As a control, an additional classroom completed surveys but received no instruction (they received the climate change unit after the research was completed).

A survey collected data on students' knowledge of three fundamental topics within climate science: weather and climate; the carbon cycle and human impacts; and global warming and the greenhouse effect. The survey was administered before the unit (pre), immediately after the unit (post), and six weeks after the end of the unit (follow-up). In addition, the classroom science teacher was given a post-instruction teacher survey to gather information on their experience with the lessons.

The results showed that the classrooms that received the climate change unit from their regular science teacher were the only ones to show a statistically significant improvement in knowledge between the pre- and the post-test surveys. In terms of the three main topics covered, the highest gains in knowledge were in regard to the carbon cycle and the human impacts topics. The teacher and students alike had the hardest time with the topic of global warming and the greenhouse effect. None of the groups showed any difference in their rate of knowledge decline in the follow-up survey, suggesting that the intervention setting had no impact on the students' knowledge retention over time.

This study supports the idea that with the necessary background information and materials, the classroom teacher is more effective than outside presenters, who may have more education on the topic of climate change but less experience teaching in the classroom or less of a rapport with that particular group of students. For NGOs engaged in climate change education, this study suggests that providing learning materials and professional development opportunities for teachers may be a more effective use of funds compared with supporting outside presenters.

One limitation of this study was the extremely limited number of presenters and teachers involved (only one of each). Although the paper's authors argue that this one teacher and one presenter are representative of all classroom teachers and outside presenters, this may or may not be the case and, therefore, a follow-up study involving more teachers and outside presenters would improve the robustness of this finding.

THE BOTTOM LINE: Given the same time, content, and pedagogical strategies for teaching a unit on climate change, this study indicated that a classroom teacher is more effective than an outside presenter. Student knowledge of the subject increased significantly following the intervention taught by the regular science teacher, whereas students had no significant gains when participating in the same unit taught by an educator working for an NGO. This study suggests that climate change education may be more effective when taught by classroom teachers who are provided with learning resource materials and professional development, rather than supporting specialized outside presenters to go into classrooms to teach the same material.

Porter, D., Weaver, A. J., & Raptis, H. (2012). Assessing students' learning about fundamental concepts of climate change under two different conditions. *Environmental Education Research*, *18*(5), 665-686.

AUDIO TOURS PROVE MORE MENTALLY DEMANDING THAN GUIDED TOURS

Museums and other sites of informal learning that once relied exclusively on guided tours have increasingly developed digital media (e.g., audio tours) to make interpretive experiences accessible to more visitors. Previous research suggests that media-based tour platforms may split the user's attention, however, because the user must attend to both the content of the tour and the manipulation of the tour device. The author of this study sought to measure whether the type of tour a visitor took affected either the perceived difficulty of the learning experience or the participant's ability to transfer their learning after the tour.

The research was conducted at the Winnipeg Exchange District, a Canadian historical site "celebrating the manufacturing and trade history of the Canadian prairies." Since summer 2008, the nonprofit group that offers guided tours of the Exchange has added "MP3 self-guided pre-recorded audio tours using iPod Touch devices" as an alternative interpretive option. Because the content in both guided and audio tours is the same, "this tour program presented a unique opportunity to compare guided and audio tour participants' experiences."

Between July and September of 2008, 151 individuals agreed to participate in the study (95 taking the guided tour, 56 taking an audio tour). After the tour, participants completed a self-administered questionnaire, asking about

demographic information, personal characteristics, tour experience, and cognitive load (measured by asking how difficult the learning experience was and how much effort participants expended to understand tour materials).

The author found that "audio tour participants perceived greater cognitive load than guided tour participants"—that is, participants who used the iPod Touch devices for their tours reported putting in more mental effort and experiencing greater mental difficulty than did those participants who took a guided tour. "This was expected considering the attention needed to operate the mobile device, which guided tour participants do not have to attend to." However, tour type (audio versus guided) had no impact on learning transfer, and learning transfer was not affected by cognitive load.

The author calls for further research to "expand on this work by (1) examining factors mediating the relation between cognitive load and learning, (2) employing a mix of measures for the independent and dependent variables, and (3) examining a range of free-choice learning environments."

THE BOTTOM LINE: According to this paper's author, "This study represents the first published work to measure cognitive load in an interpretation setting to better understand how interpretation tools impact learning." The research revealed that self-guided audio tours do not affect learning transfer, but they do require greater cognitive effort than do traditional guided tours. The author urges those designing interpretive tools to consider "the overall visitor experience and satisfaction with that experience."

Van Winkle, C. M. (2012). The effect of tour type on visitors' perceived cognitive load and learning. *Journal of Interpretation Research*, *17*(1), 45-57.

ROLE PLAY IMPROVES UNDERSTANDING OF THE NATURE OF SCIENCE

The nature of science (NOS) generally refers to the understanding of how scientific knowledge is developed and the values and beliefs associated with this process. The NOS has received attention from educators and researchers alike, as evidenced by the growing body of research around the topic and increased emphasis on the NOS in science education reform. The authors of this paper note a lack of research exploring both the views of the NOS of elementary school children and the use of role-play activities in science education. To help address this research gap, the authors conducted role-play activities with young children and investigated the effects on participants' views of the NOS.

In reviewing the few studies that examine role playing and science education, the authors found that role play did have a positive effect on science learning. By its very nature, role play is play, and children have an innate desire to play that can lead to increased learning. In role play, students construct their own meaning and employ skills and behaviors from multiple domains (cognitive, affective, and psychomotor), all of which are involved in science learning. Dramatic activities also are more interactive and less authoritarian than traditional science education methods, which involve memorizing facts and participating in structured lab exercises. As the authors also note, successful role-play activities are not free-form activities, but rather they incorporate explicit, scaffolded, teacher-led reflection and discussion.

To test their theory that role play would enhance elementary students' views of the NOS, the authors implemented role-play activities with a group of 18 children, ages 10-11, at a university in Turkey. The authors designed a 10-day program consisting of a three-hour session of role-play activities each day. The participants acted out a variety of scenes from important times in the lives of two scientists, Isaac Newton and Marie Curie. Throughout all 10 sessions, the researchers (who served as the instructors)

asked explicit questions to encourage critical thinking about targeted aspects of the NOS.

To assess potential changes in the participants' views of the NOS, the authors administered a questionnaire both before and after the role-play program. The researchers selected seven aspects of the NOS to target: tentative, empirical, multiple methods of investigation, subjective-theory laden, sociocultural-embeddedness, creative-imaginative, and image of a scientist. Each question focused on one aspect of the NOS. The researchers categorized the children's responses to each question as either "naïve" or "informed" and computed percentages of correct responses for each aspect of the NOS.
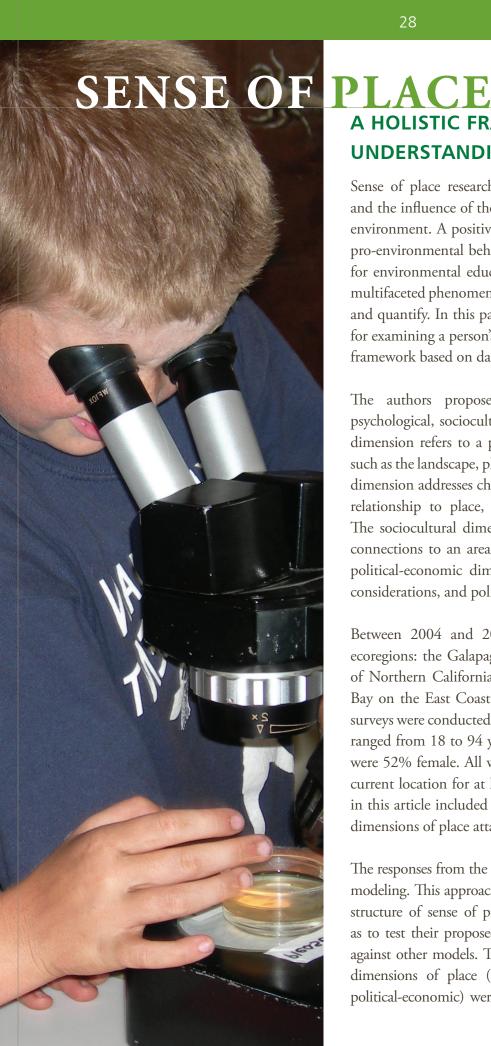
Pre- and post-assessment results showed that participants developed more informed understanding of all seven aspects of the NOS targeted in this study. The characteristic of the NOS that saw the biggest move of participants from naïve to informed views was the idea that science does not have to follow one set scientific method, but can result from multiple methods of investigation. Some of the most interesting results related to questions about the children's images of scientists. In terms of gender of scientists, the authors found that the children, even after the role play, "had a strong occupational male bias for engaging [in] science even though they mention gender is not an obstacle for doing science." Another question asked about the place where scientists study. In the pre-test, the majority of the children said scientists work in a lab, but after the role play, a significant percentage of the children described scientists as working in a variety of settings.

The authors concluded that role play positively influences elementary students' views of the NOS. The authors point out that the discussions with children after role playing are key to the strategy's success and suggest that "teachers in the class should pay particular attention to a whole class discussion in a well-organized manner through the explicit prompts." The teachers should "allow children to express their understanding in a collaborative fashion." The authors suggest future studies to explore the replicability of their results with other groups of children and explore which variables of the role-play program contribute most to the change in views.

THE BOTTOM LINE: Teaching about the NOS requires different strategies than those often found in traditional science education. This study found that role plays can help lead students from naïve to more informed views of the NOS. The interactive nature of role playing can capture students' interest and provide an engaging way to explore new viewpoints and information. Concurrent and follow-up discussion, as well as instructor-led reflection with explicit questions to help expand critical thought, are essential to effective role play.

Cakici, Y., & Bayir, E. (2012). Developing children's views of the nature of science through role play. *International Journal of Science Education*, *34*(7), 1075-1091.

SENSE OF PLACE

A HOLISTIC FRAMEWORK FOR UNDERSTANDING SENSE OF PLACE

Sense of place research considers how people connect with places and the influence of those connections on their engagement with the environment. A positive sense of place has been shown to encourage pro-environmental behavior, and as such has important implications for environmental education. However, sense of place is a complex, multifaceted phenomenon, which has made it difficult to define, study, and quantify. In this paper, the authors propose a holistic framework for examining a person's sense of place, and evaluate the merits of this framework based on data collected from three distinct ecoregions.

The authors propose four dimensions of place: biophysical, psychological, sociocultural, and political-economic. The biophysical dimension refers to a person's interest and appreciation of elements such as the landscape, plants, and animals of an area. The psychological dimension addresses characteristics internal to a person and a person's relationship to place, such as a feeling of belonging somewhere. The sociocultural dimension refers to a person's social and cultural connections to an area, such as a local circle of friends. Finally, the political-economic dimension refers to job opportunities, financial considerations, and political boundaries of an area.

Between 2004 and 2006, data were collected in three different ecoregions: the Galapagos Islands of Ecuador, the Klamath-Siskiyou of Northern California and southern Oregon, and the Chesapeake Bay on the East Coast of the United States. Overall, 712 interview surveys were conducted, in both Spanish and English. The participants ranged from 18 to 94 years old, with an average age of 41 years, and were 52% female. All were full-time residents who had lived in their current location for at least three months. The survey items analyzed in this article included 23 questions designed to measure the various dimensions of place attachment.

The responses from the surveys were analyzed using structural equation modeling. This approach allowed the authors to examine the common structure of sense of place across these three distinct places, as well as to test their proposed four-dimensional structure of sense of place against other models. The results of the analysis showed that the four dimensions of place (biophysical, psychological, sociocultural, and political-economic) were distinct, but correlated, factors of a person's

sense of place. Compared with other frameworks, they also found that this four-factor model was the best fit for the data.

The authors point out a number of limitations and suggestions for future research. One limitation was that the collected responses were skewed towards affirmative, and had relatively little variability. This might be addressed in future research by expanding the answer options from a 5-point to a 7- or 10- point scale, and also conducting the research in locations that aren't iconic sites and vacation destinations. Future research could also be conducted to examine how each of these dimensions of place relates to the others, whether these dimensions differ by locations or circumstances (for example, rural versus urban contexts). Future research is also needed to validate a scale based on these theoretical underpinnings for measuring sense of place.

THE BOTTOM LINE: The proposed framework of four dimensions of place—biophysical, psychological, sociocultural, and political-economic—could be a useful tool for those developing place-based education initiatives. Specifically addressing each of these four factors could more holistically address the various ways that people connect with the places where they live. The authors point out that in the United States especially, the dominant focus has been on the biophysical dimension of place, perhaps because of philosophical grounding in wilderness education. Focusing on the biophysical over the other dimensions of place might limit the effectiveness of place-based education, particularly as our society becomes increasingly urbanized and as we learn more about the sociocultural nature of learning and environmental behavior.

Ardoin, N. M., Schuh, J. S., & Gould, R. K. (2012). Exploring the dimensions of place: A confirmatory factor analysis of data from three ecoregional sites. *Environmental Education Research, 18*(5), 583-607.

PLACE MEANINGS TIED TO PLACE ATTACHMENT

Recreational visitors represent an important stakeholder group to Australia's Great Barrier Reef Marine Park (GBRMP) in terms of their sheer magnitude and economic contribution. As such, their attitudes toward the natural environment offer potential insight into the meanings associated with place.

Two terms—place meaning and place attachment—are commonly used to understand how and why individuals value and feel connection with natural settings. Although many previous studies have treated these terms independently, this study examines the association between the two in an attempt to understand why resources are meaningful to visitors.

The study's authors first reviewed place-related literature. They define place meanings as the "affective, cognitive, and behavior aspects of the relationship between the individual and a setting." Place meanings qualitatively describe why people develop a bond with a setting. Place attachment, on the other hand, quantitatively captures the degree to which visitors identify with or value the natural resource; it is the "emotional intensity of the human-place bond." Both terms are social constructions that usually reflect the lived experiences and social interactions that occur in the setting.

The authors used a mixed-method design of interviews to measure place meaning (this occurred in Phase I) and questionnaires to measure place attachment (this occurred in Phase II). They used two sample groups, one consisting of 20 key informants who worked professionally with a group of tourist industry representatives and resource managers associated with the GBRMP and the other consisting of 727 respondents living adjacent to the GBRMP. Both groups were also recreational visitors.

In Phase I of the investigation, the 20 key informants were interviewed in a semi-structured format about their emotional attachment and personal connection to the GBRMP. Transcripts and field notes from these narratives were coded to reveal 34 unique ideas, which were then grouped into 10 broad themes about place meaning importance. The authors rated the themes on a 5-point scale, with 1 indicating only slight importance and 5 indicating extreme importance. The two themes rated with the greatest importance were "aesthetic beauty" and "unique natural resource," and the theme with the lowest rating was "connection to the natural world."
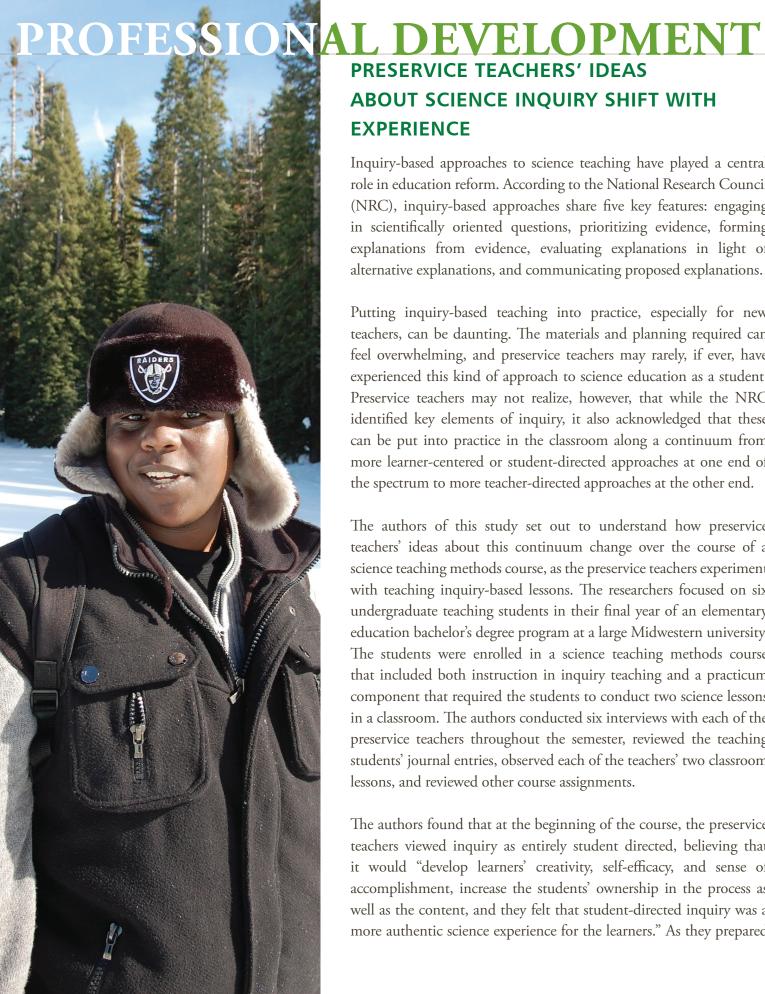
Based on the 34 unique ideas and 10 place meaning themes that emerged from Phase I, the authors designed a survey instrument for Phase II. They used two scales to establish a link between context (the place meaning scale) and intensity of attachment (the place attachment scale). The authors measured the association between place meaning and place attachment.

Their findings indicated that certain place meaning themes were correlated with the level of place attachment. Respondents in the "high attachment" category, for example, were more likely to indicate the place meaning theme "lack of built infrastructure/pristine environment" in their description of place. The authors also believe that the people who enjoy recreational activities that require wild settings such as those the GBRMP provides are more likely to recreate there. As a result of recreating there, those park users experience higher levels of attachment to the GBRMP.

THE BOTTOM LINE: This study helps shed light on why natural settings are meaningful to recreational visitors. The findings suggest that people can become more attached to a place when it's the setting for the outdoor activities they enjoy. Aesthetic beauty, on the other hand, is not as significant in developing place attachment, because even those who are not attached to a place can note its aesthetic beauty. These results seem to suggest that offering recreational opportunities in natural settings can help increase people's attachments to those settings.

But this strategy is only beneficial among people with an interest in outdoor recreation.

Wynveen, C. J., Kyle, G. T., & Sutton, S. G. (2012). Natural area visitors' place meaning and place attachment ascribed to a marine setting. *Journal of Environmental Psychology, 32*(4), 287-296.

PROFESSIONAL DEVELOPMENT

PRESERVICE TEACHERS' IDEAS ABOUT SCIENCE INQUIRY SHIFT WITH EXPERIENCE

Inquiry-based approaches to science teaching have played a central role in education reform. According to the National Research Council (NRC), inquiry-based approaches share five key features: engaging in scientifically oriented questions, prioritizing evidence, forming explanations from evidence, evaluating explanations in light of alternative explanations, and communicating proposed explanations.

Putting inquiry-based teaching into practice, especially for new teachers, can be daunting. The materials and planning required can feel overwhelming, and preservice teachers may rarely, if ever, have experienced this kind of approach to science education as a student. Preservice teachers may not realize, however, that while the NRC identified key elements of inquiry, it also acknowledged that these can be put into practice in the classroom along a continuum from more learner-centered or student-directed approaches at one end of the spectrum to more teacher-directed approaches at the other end.

The authors of this study set out to understand how preservice teachers' ideas about this continuum change over the course of a science teaching methods course, as the preservice teachers experiment with teaching inquiry-based lessons. The researchers focused on six undergraduate teaching students in their final year of an elementary education bachelor's degree program at a large Midwestern university. The students were enrolled in a science teaching methods course that included both instruction in inquiry teaching and a practicum component that required the students to conduct two science lessons in a classroom. The authors conducted six interviews with each of the preservice teachers throughout the semester, reviewed the teaching students' journal entries, observed each of the teachers' two classroom lessons, and reviewed other course assignments.

The authors found that at the beginning of the course, the preservice teachers viewed inquiry as entirely student directed, believing that it would "develop learners' creativity, self-efficacy, and sense of accomplishment, increase the students' ownership in the process as well as the content, and they felt that student-directed inquiry was a more authentic science experience for the learners." As they prepared

their first lessons, the preservice teachers included a variety of teaching methods that put students at the center of the experience, allowing them to develop their own questions, design their own experiments, record their own data, and generate their own conclusions.

In enacting their lessons, however, the student teachers encountered a variety of challenges that they hadn't anticipated. Students didn't always ask questions related to the specific concepts the student teachers were trying to teach, some were better at self-directed work than others, some students lacked experience in sharing and discussing explanations, and so on. In moving on to their second student teaching experience, the preservice teachers began to embrace more teacher-centered approaches. One preservice teacher explained, "I thought to have inquiry it had to be student led, but now I see that there are certain parts which might work better as teacher-directed." The teachers included more scaffolding to support students toward the learning goals, and felt relieved that their students could still be engaged in inquiry despite the teacher support.

The authors argue that while preservice teachers may hold initial ideas about the importance of student-led inquiry, it may prove too difficult for a novice teacher to operate at this end of the inquiry spectrum. Leaving open the option of using a more teacher-directed approach can help new teachers be more effective. The authors explain, "In short, to learn to productively engage students in science as inquiry, [preservice teachers] must first internalize the ultimate objective of engaging in inquiry—promoting student learning."

THE BOTTOM LINE: Although experienced teachers may be wary of student-led, inquiry-based approaches to science education, the preservice teachers in this study fell at the other end of the spectrum, believing that inquiry should be student-led to be most effective. When they put their beliefs into practice, though, the preservice teachers found that an entirely student-led approach can be very difficult to manage and did not always lead to the desired learning goals. This research serves as a reminder that there is not a one-size-fits-all approach to inquiry-based education,

and when it comes to teacher professional development, teachers can feel relieved to know that they can mix and match teacher- and student-led approaches to fit their experience, students, learning goals, and time frame.

Biggers, M., & Forbes, C. T. (2012). Balancing teacher and student roles in elementary classrooms: Preservice elementary teachers' learning about the inquiry continuum. *International Journal of Science Education*, *34*(14), 2205-2229.

PRESERVICE TEACHERS IDENTIFY OUTDOOR LEARNING'S BENEFITS AND BARRIERS

With mounting evidence that outdoor experiences are important for young learners, researchers are increasingly examining nature education in preschool. This study explored preservice preschool teachers' preferences for different natural landscapes, feelings of connection to nature (nature relatedness), and motivations and barriers to using natural settings for education.

The researchers worked with 110 students involved in a university's early childhood teaching licensure program. The teaching students were spread across the program's four years. The authors presented the preservice teachers with photographs depicting different local outdoor settings, including water, woods, an open grassy field, and a park. The photos were all taken during spring, did not include people, and depicted these different settings in both undeveloped and developed states. A questionnaire explored the preservice teachers' preferences for the different landscapes, which settings they thought were most conducive to education, and how likely they would be to use natural settings with their students. The questionnaire also included items to rate the preservice teachers' level of nature relatedness.

The preservice teachers identified a playground, pavilion in the woods, and shoreline of Lake Superior as the most conducive to education. They viewed an open forest with no path, open grassy field with no path, and

stream with narrow foot path as the least conducive to education. There was some overlap with the preservice teachers' personal preferences for the natural areas, with the shoreline of Lake Superior also among the most preferred landscapes, and the stream with the narrow footpath among the least preferred landscapes. There did not appear to be a connection between a preservice teacher's level of nature relatedness and his or her landscape preferences.

A site's ease of use with young children was most frequently given as a reason for a site's educational benefits, while safety hazards were most often named as making a site least conducive to education. As a result, teachers were most likely to point to maintained, and not undeveloped, sites as the most conducive to education. The preservice teachers' personal preferences, however, led them to select undeveloped sites as their favorite landscapes.

The preservice teachers believed that outdoor experiences would foster appreciation for the environment, and they generally agreed that these types of experiences would be beneficial for their students' development and health. The preservice teachers were most likely to name the need for transportation to natural areas as a barrier to using natural outdoor settings. Nevertheless, as a whole, the preservice teachers indicated they were likely to use natural outdoor settings to teach. The researchers found that a preservice teacher's perceptions of the difficulty of using outdoor settings, recognition of the importance of outdoor experiences on children's wellness, and his or her level of nature relatedness predicted an intention to use an outdoor setting for education.

In summary, it appears that preservice teachers are particularly concerned about safety hazards and the ease of use of outdoor natural areas. As a result, the preservice teachers preferred maintained natural areas for education. Working to change preservice teachers' beliefs about these potential barriers could help increase the use of natural areas for education. In addition, most of the teachers believed that outdoor settings were good places for learning about nature, not necessarily developing

other knowledge and skills while they were in nature. The authors conclude that "these results suggest there is an opportunity for environmental educators to better convey the importance of unstructured learning and nature exploration. . . ." They caution, however, that this research was conducted with just one group of preservice teachers, and more research with preservice teachers in other areas with different cultural backgrounds could help confirm the results.

THE BOTTOM LINE: Although some preservice preschool teachers may personally prefer undeveloped natural landscapes, when considering them as sites for teaching and learning, they tend to prefer more maintained outdoor areas as beneficial educational settings. The preservice teachers in this study named concerns about safety and ease of use among the reasons they might not use a natural area for teaching. In this study, a teacher's recognition of the importance of nature experience for children's health and wellness was the strongest predictor of his or her intention to use natural outdoor settings in his or her teaching. Professional development for early childhood educators that emphasized the developmental and educational benefits and opportunities provided by natural play areas and provided strategies for overcoming the challenges might increase the educators' comfort with these settings and, thus, enhance their use.

Ernst, J., & Tornabene, L. (2012). Preservice early childhood educators' perceptions of outdoor settings as learning environments. *Environmental Education Research, 18*(5), 643-664.

CLIMATE TRAINING BOOSTS TEACHER KNOWLEDGE OF CLIMATE CHANGE

Previous research has shown that K-12 students often hold misconceptions of key ideas in climate change, and many of these misconceptions remain even after the student has undergone instruction. Studies have also demonstrated that many elementary school teachers do not have a functional understanding of these complex

concepts, making it challenging, if not impossible, for them to deliver quality climate-change instruction to their students. This study sought to assess preservice and practicing teachers' knowledge about climate change. The participating teachers received an instructional intervention and were given pre- and post-tests about their understanding of climate change in four key areas.

In total, 149 current and aspiring teachers were included in the study. The teachers were a mix of undergraduate students in a preservice program and graduate students working toward a master's degree. All participants were enrolled in a methods course on teaching science. The tool used to assess the teachers' knowledge of these concepts was called the Knowledge of Global Climate Change (KGCC) instrument. This instrument was developed around four constructs: the greenhouse effect, the carbon cycle, causes of climate change, and consequences of climate change. Results from the pre- and post-tests were analyzed in each of these conceptual areas. Responses were scored according to a rubric designed for the instrument.

The study found that knowledge of climate change science increased among teachers after the intervention. Additionally, teachers "developed more interest and confidence in learning about climate change." Lastly, participants had more positive views about the nature of science and climate change after completing the course. The authors further specified the results by conceptual area. In terms of the greenhouse effect, most teachers were not able to accurately demonstrate understanding of this process before the intervention. After the intervention, some teachers expressed an increased understanding while many others still expressed misconceptions about greenhouse gases and the greenhouse effect. With the carbon cycle, teachers were generally unable to describe any part of the carbon cycle before the intervention. After the intervention, most of the teachers were able to express some understanding of these processes.

In analyzing responses to questions asking about the causes of climate change, the authors concluded that the teachers had difficulty expressing the differences between climate and weather, though there was improvement in this area after the intervention. Teachers were most successful in the last conceptual area, the consequences of climate change. Pre-test scores in this area were the highest, though the teachers demonstrated a lack of understanding about the relationship between climate change and oceans. The authors point out that although the knowledge gains from this intervention might not have been drastic, they were acceptable for a short-term intervention such as this one. Also, the teachers who participated in the intervention were "more interested and motivated to study the climate change issue in more depth" after the instructional unit.

THE BOTTOM LINE: There is a widespread lack of understanding of central scientific concepts in the area of climate change. Although more general public education is important and necessary, it is also essential that teachers have a correct conceptual understanding of climate change and develop confidence around teaching these concepts. Interventions such as the one described in this article—which provides science and climate change education for educators—can help build both conceptual understanding and teachers' confidence in and ability to teach about climate change with students.

Lambert, J. L., Lindgren, J., & Bleicher, R. (2012). Assessing elementary science methods students' understanding about global climate change. *International Journal of Science Education, 34*(8), 1167-1187.

PRESERVICE TEACHERS STRUGGLE TO DEFINE BASIC ECOLOGICAL CONCEPTS

In Ontario, Canada, education leaders have made a commitment to building ecological literacy, instructing all teachers to integrate ecological literacy across subject areas in grades K-12. The province does not, however, require teachers to receive any specific preservice instruction in ecology.

In a recent study, the authors of this paper found that preservice teachers in Ontario had a poor grasp of the meaning of most key ecological concepts. The authors described the ecological terms the teachers used as "opaque empty shells," with most teachers being able to use, but not accurately define, basic ecological concepts. The authors explain that "the teacher candidates used the words in articulate (university-level) speech, though," which made the teachers appear to understand the terms. Only the researchers' probing revealed that educators were expected to teach something about which they, in reality, knew very little.

In this study, the researchers focused on 25 preservice teachers enrolled in a Bachelor of Education program who were beginning a course that would qualify them to teach environmental science in middle and high school. Nearly three-quarters (73%) of the participants had undergraduate degrees in science, geography, or outdoor recreation. During the first week of classes, the researchers administered a concept analysis test asking the preservice teachers to define 10 ecological concepts that are part of the province's science guidelines (such as "greenhouse gas," "recycling," "clean energy," "biodegradable," and others). The authors explain that in this type of open response, "the learner must construct meaning in order to provide a definition rather than pick the 'right' meaning [in a multiple choice format] via some kind of mechanical analysis." In this way, the authors could gauge the teachers' level of understanding of the terms. In addition, the authors administered a short survey to the teachers.

As the authors found in their earlier research, the teachers had a poor grasp of the terms, despite many of the teachers' past training in fields related to ecology. Out of 250 total definitions provided in the study, three quarters were either undefined or scored at the lowest level, indicating a vague or incorrect definition. No definitions scored at the highest level, indicating a robust understanding. Interestingly, the survey results reveal that the preservice teachers received a moderate amount of experience with ecological concepts as undergraduates,

and were moderately confident about teaching ecological concepts. In the authors' view, in light of the preservice teachers' poor results in defining the concepts, "a moderate level of confidence is not merited."

The preservice teachers were most likely to agree that most of their university education had come from lectures and assigned readings. As a result, the authors question whether this type of instructional style has truly been effective. They point to previous research that has demonstrated that lecture-style educational approaches are largely ineffective at helping learners "make meaning and adapt understanding." As a result, the authors advocate new approaches to teacher professional development, so that teachers no longer "pass through" their training with their misconceptions "undetected." They explain, "The authors have little reason to believe the . . . trend will change for the foreseeable future with similar cohorts of teacher candidates year after year unless elementary and secondary schooling and higher learning are re-conceptualized significantly. . . ."

THE BOTTOM LINE: Sometimes you have to probe a little to find out just how deeply a student (including student teachers) understands a concept. This research suggests that while teachers may be able to use ecological terms correctly, they may not have a robust—or even passable—understanding of the terms' meaning. And that vague understanding is likely to make it difficult for teachers to effectively teach their students. Although this research focused only on a small group of Canadian preservice teachers, it serves as a reminder that teacher professional development should be based on the most current research about effective education, and that assessing teachers' knowledge should go beyond quick multiple-choice methods to probe conceptual knowledge more deeply.

Puk, T. G., & Stibbards, A. (2012). Systemic ecological illiteracy? Shedding light on meaning as an act of thought in higher learning. *Environmental Education Research, 18*(3), 353-373.

OTHER RESEARCH

HOPE IS IMPORTANT FOR ENGAGING YOUNG PEOPLE IN ENVIRONMENTAL ISSUES

Although many young people think that global climate change is a serious problem that needs to be addressed, studies have also found that feelings of hopelessness, pessimism, and helplessness are common. Few studies have explored how hope, or the lack thereof, relates to engagement concerning environmental problems. This article explores whether a sense of hope among young people is positively related to pro-environmental behaviors, or whether it is simply a sign of illusory optimism.

The author defined hope as a cognitive and emotional experience that occurs when a positive goal is felt as being within reach. Specifically, the study investigated three sources of "constructive" hope concerning the environment, as opposed to hope based on denial of the seriousness of climate change. The first is *positive re-appraisal,* where a person is able to describe their worries about environmental problems, and then think about them in a different, positive, way. An example of this would be pointing out that awareness of climate change has increased during recent years. The second source of hope arises from *trust in sources outside oneself,* specifically trust in technology and trust in environmental organizations. The third concerns *trust in one's own ability to influence environmental problems,* the belief that laypeople's actions can make a difference.

Two questionnaires were designed to explore whether an aggregate measure of constructive hope concerning climate change—based on positive re-appraisal, trust in sources outside oneself, and trust in one's own ability to influence environmental problems—has a significant relationship to pro-environmental behavior, specifically household energy conservation. The questionnaires aimed to control for hope based on denial, as well as for factors already known to influence pro-environmental behavior, including values, social influence, knowledge, and gender. One of the questionnaires was conducted with a group of Swedish teenagers still living with their parents (n = 723), and the other with a group of Swedish young adults who had moved from their childhood homes (n = 381).

The results showed that among both the teenagers and young adult samples, those who had a high degree of constructive hope were significantly more likely to also be engaged in household energy conservation behaviors. The results also revealed that hope based on denial of climate change had the opposite effect, indicating that it is critical to distinguish between constructive and denial-based hope.

One of the limitations of the study is that the design didn't allow for a directional, causal relationship to be drawn between hope and environmental behavior. It is possible that hope can cause pro-environmental behavior, and it is also possible that pro-environmental behavior can be a source of hope. An interesting and useful direction in future studies might be to explore the causal relationship. In addition, the author notes that future studies should include additional items for measuring facets of hope based on denial of the seriousness of climate change, as reasons for this viewpoint are complex and were not fully explored in this study. Finally, future studies could explore the relationship among hope and more collective and political forms of environmental engagement, compared with individual energy conservation behaviors.

THE BOTTOM LINE: Constructive hope about climate change arises when a person understands the seriousness of climate change and concurrently feels there are positive goals within reach for addressing the issue. Young people who have constructive hope about climate change are significantly more likely to engage in positive environmental behaviors, compared with young people who lack hope and those who have hope based on denial of climate change. For educators, three ways to encourage constructive hope are identified: The first is to co-create with students a story that focuses on positive aspects of the climate change situation. The second is to encourage trust in others, such as politicians, environmental groups, and technology—although not in an unrealistic way. The point here is to avoid extreme cynicism. The third is to promote students' trust in their ability to make a difference by highlighting the power of collective action and encouraging the development of students' capacity to take action.

Ojala, M. (2012). Hope and climate change: The importance of hope for environmental engagement among young people. *Environmental Education Research*, *18*(5), 625-642.

CHILDREN'S STRATEGIES FOR COPING WITH CLIMATE CHANGE AFFECTS ENGAGEMENT AND EMOTIONS

Research has shown that late childhood and early adolescence are critical periods for sparking an interest in global environmental issues. However, learning about global problems can also trigger feelings of anxiety, helplessness, and hopelessness. This may be especially true for children, who have fewer strategies for dealing with negative emotions than adults. The aim of this study was to investigate how 12-year-olds cope with climate change and to examine how different coping strategies relate to environmental engagement, emotional well-being, optimism concerning climate change, and a sense of purpose in life.

The author defined coping as a *conscious* effort that one makes to handle different kinds of psychological stress and threats, as opposed to automatic or unconscious behavior. Based on past research, three main coping strategies for dealing with environmental problems were examined: problem-focused coping, meaning-focused coping, and emotion-focused coping. In problem-focused coping, a person concentrates on ways to solve the problem, such as searching for information about what one can do. Meaning-focused coping requires one to evoke positive feelings that can work as a buffer from negative emotions. An example of meaning-focused coping is trusting in different societal actors—such as scientists, teachers, and politicians—to help solve environmental problems. Emotion-focused coping involves eliminating negative emotions through avoidance, distancing, and denial.

For this study, the author surveyed 12-year-old children in Sweden (n = 293, 48% female). The survey was designed

to measure: the child's sense of their environmental efficacy (exemplified in the statement "I can make a difference," for example); pro-environmental behavior in everyday life (for example, "helping one's parents to recycle"); life satisfaction; general negative affect (anxious and depressive feelings felt during the last week); optimism concerning climate change; sense of purpose in life; and worry about climate change.

Analysis of the results supported that using three different coping strategies (meaning-, problem-, and emotion-focused) was an effective way to describe and organize the data, accounting for more than 50% of the variance in the responses. Having established this, the author investigated how each of these coping strategies correlated with levels of environmental engagement, emotional well-being, optimism concerning climate change, and sense of purpose in life.

The results showed those who were engaged in problem-focused and/or meaning-focused coping were more likely to report high levels of environmental efficacy, pro-environmental behavior, optimism concerning climate change, and a sense of purpose. However, problem-focused coping was positively correlated with negative affect; in other words, the more a child was engaged in problem-focused coping the more they reported feelings of depression and anxiety. By contrast, children who tended to use a high degree of meaning-focused coping were less likely to experience negative affect and more likely to experience life satisfaction and general positive affect.

Children who used emotion-focused coping by deemphasizing or denying climate change were less likely to report a sense of environmental efficacy, and reported less pro-environmental behavior. However, these children also reported a low degree of depressive and anxious feelings, which indicates that this coping strategy may function as a way to regulate emotions.

Overall, the results point out the benefits of meaning-focused coping strategies for increasing environmental engagement without increasing feelings of anxiety and depression. One example of this strategy is positive reappraisal, where a person describes her or his worries about the environment and then is able to think about those worries in a different way so as to activate hope. One way to do this is to think about the problems in a historical context, noting that awareness of the problem has increased in recent years.

THE BOTTOM LINE: Learning about severe environmental problems such as climate change can be uncomfortable and fear inducing, and each person finds different ways to cope with this discomfort. These coping strategies can be understood with three categories: problem-focused strategies (for example, "How can I solve this problem?"); meaning-focused strategies ("I trust that we have the capacity to make a difference in solving this problem"); and emotion-focused strategies ("climate change is a lie"). In this study, the author examined coping strategies among 12-year-old Swedish children. She found that children who engage in problem-focused or meaning-focused strategies are more likely to be environmentally engaged, whereas those who used emotion-focused strategies, such as denial, were less likely to be engaged. However, children who were primarily problem-focused tended to have increased levels of anxiety and depression compared with children using other strategies. The study highlights the importance of focusing on meaning-focused strategies, such as generating feelings of hope and trust, so that we can make a difference in addressing the problem of climate change.

Ojala, M. (2012) How do children cope with global climate change? Coping strategies, engagement, and well-being. *Journal of Environmental Psychology*, *32*(3), 225-233.