

ENVIRONMENTAL EDUCATION

# RESEARCH BULLETIN

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## ABOUT THE RESEARCH BULLETIN

The *Environmental Education Research Bulletin* is a project of ChangeScale and the North American Association for Environmental Education (NAAEE), in partnership with Dr. Nicole Ardoin at Stanford University. The bulletin is designed to inform environmental and sustainability educators about recent relevant research, with a primary emphasis on informal, field, and residential settings, as well as stewardship behavior, conservation, and related topics. Although other environmental educators and those in related fields might also find this bulletin useful, it does not—nor is it intended to—cover all aspects of environmental education. This Research Bulletin, as well as past issues, is available online through the ChangeScale website: [www.changescale.org](http://www.changescale.org), as well as on the NAAEE website at <https://naaee.org/eepro/research/environmental-education-research>. Please send questions and feedback to [eereseearchbulletins@changescale.org](mailto:eereseearchbulletins@changescale.org).

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# INTRODUCTION

Dear Colleagues,

ChangeScale and the North American Association for Environmental Education (NAAEE) have partnered with researchers at Stanford University to create this ninth volume of the *Environmental Education Research Bulletin*. Talented environmental educators everywhere are conducting fantastic programs that build on effective practice, from collaborating with communities to using hands-on strategies to make critical links between enhancing environmental awareness, building skills, and supporting informed action. Yet, many of these committed professionals don't have time to keep up on the latest research studies, which may provide insight into how to improve the effectiveness of their work. We hope these Research Bulletins can help bridge the research-and-practice gap by summarizing recently reported research and help practitioners use the results to enhance their programs.

This issue includes synopses of peer-reviewed journal articles that are particularly relevant for frontline environmental education practitioners. We reviewed issues (published between January and June 2015) of a number of environmental education-related journals, including: *Journal of Environmental Education*, *Environmental Education Research*, *Applied Environmental Education and Communication*, *Australian Journal of Environmental Education*, *International Journal of Science Education*, *Science Education*, *Visitor Studies*, and *Journal of Environmental Psychology*.

We want these bulletins to be as useful to you as possible, so please send us any ideas or feedback that you have, as well as additional topics you'd like us to cover or journals you'd like us to monitor. We would also like to know if there is an alternative format that may be helpful. You can send suggestions to: [eerresearchbulletins@changescale.org](mailto:eerresearchbulletins@changescale.org).

We also encourage you to check out the research blog on eePRO, NAAEE's professional development community. The community has a section devoted to research and evaluation; you can join here: <https://naaee.org/eePRO/groups/research-and-evaluation>. You may also be interested in the NSF-funded Relating Research to Practice effort of CILS and the Exploratorium, available here: <http://relatingresearchtopractice.org>.

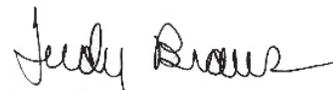
Thanks for all you do, and we look forward to hearing from you!



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# BEHAVIOR

## FACTORS INFLUENCING PRO-ENVIRONMENTAL BEHAVIOR OF HIGH-SCHOOL STUDENTS

We cannot change past human actions that have been harmful to the environment, but we may yet be able to influence choices made by rising generations. The question is, how? According to the theory of planned behavior, what we believe determines how we act, by way of our perceptions and intentions. The authors tested this theory on a group of teenagers in Luxembourg by looking specifically at the relationship between beliefs and pro-environmental behavior (PEB), such as recycling, saving water, and reducing waste. The results could inform interventions aimed at promoting PEB among youth.

The authors tested three hypotheses: that beliefs could predict PEB among high-school students; that those beliefs would be interrelated; and that a student's sex (male or female) and degree of empathy would correlate with his or her PEB. The participants were 602 students (292 female) 12–16 years old from nine Luxembourg high schools. The authors used a pilot study to identify the PEBs and vocabulary relevant to the demographics of the study population. Although 713 students were eligible for the main study, only 602 supplied enough data to analyze.

The authors gave participants two questionnaires, one at the beginning of a trimester and one at the end. Using a scale of 1 to 6, the first questionnaire focused on students' beliefs about, perceptions of, and intentions to perform various PEBs. Questions asked, for example, whether students believed it was important to recycle; there was social pressure to recycle; their role models recycled; and they intended to recycle that trimester. The questionnaire also asked students to rate their level of empathic concern as either high or low. The second questionnaire asked the students to self-report on the PEBs that they had actually performed. The data were then categorized and analyzed numerically to show statistically significant relationships between variables.

Using the theory of planned behavior and the students' answers in the first questionnaire, the authors were able to predict 30% of what students reported in the second questionnaire. In other words, 30% of the reported PEBs at the end of the trimester could be predicted



by the answers to the questionnaire administered at the beginning of the trimester. Yet, many students did not act on their intentions to perform PEBs. This could have been for a variety of reasons. One reason may be that the authors did not include enough variety of PEBs in the survey and, as such, students may have performed behaviors not included on the list; it may also have been because students encountered unanticipated obstacles to PEBs. By contrast, the authors suggest that students may have over-reported performance of their actual PEBs.

The significant predictors of PEBs were students' overall attitudes toward PEB (positive or negative); what they witnessed their role models doing; and how much control over being able to perform a PEB they perceived themselves as having. In addition to describing those categories more generally, the authors reported on the strongest factors in each of the three categories: The beliefs that a PEB would "save energy," "keep the planet clean," and "protect the natural environment" had significant effects on a student's attitude. The role models who had a significant effect on students' perceptions were their mothers (highest), family in general, fathers, and, lastly, environmental celebrities.

The significant factors in a student's perception of control were: the availability of double-sided printing; recycling bins at home; affordability of eco-friendly products; movies, documentaries, and articles about the environment that are interesting and suitable for their age; and the presence of stickers, boards, and voice guides that specified which behaviors to perform and how. Although students emphasized the importance of such tools in facilitating their PEB, the authors caution that, at this age, students might not be aware of their ability to self-regulate.

While the researchers found that gender had no effect on PEB, they found empathy to be significantly related to what students believed. Students with higher empathic concern generally had more positive attitudes and beliefs about PEB. The researchers suggest that, because those students already have generally positive attitudes, it may be more effective to focus interventions on students with low empathic concern.

The authors suggest that, if the theory of planned behavior is to be used effectively in such a study, then the beliefs about which students and other participants are asked must closely match the actual context. Specifically, students must have the skills and means to perform PEBs without barriers or unanticipated events that change either their ability or intention to perform a PEB. The authors conclude by suggesting that the key beliefs identified in their study may help guide future educational interventions that aim to foster PEB. This study's authors were working with a regionally small demographic within Luxembourg, however, and beliefs among diverse youth across different geographies and demographics may vary.

### THE BOTTOM LINE:

In encouraging pro-environmental behaviors (PEBs), it is important to consider existing attitudes toward each PEB and discover the specific barriers to implementing it so that those barriers can be addressed. In some cases, this means providing the necessary tools, such as convenient recycling bins. Students are also highly influenced by role models; finding ways to provide positive, pro-environmental role models could be a more effective way to promote new PEBs.

de Leeuw, A., Valois, P., Ajzen, I., & Schmidt, P. (2015). Using the theory of planned behavior to identify key beliefs underlying pro-environmental behavior in high-school students: Implications for educational interventions. *Journal of Environmental Psychology*, 42, 128–138.

## STUDENTS' WILLINGNESS TO MITIGATE GLOBAL WARMING

Global climate change is one of the most problematic issues facing the world today. Successfully responding to climate change will require citizens who can reason through complex issues involving scientific information. To do this effectively, citizens need to understand how scientific knowledge comes to be established through experiment and observation. Lacking this understanding, decision making may often be influenced more by personal and sociocultural factors rather than by scientific reasoning and understanding. With

these issues in mind, this study sought to clarify the factors that influence high-school students' willingness to mitigate global warming. In particular, the author posed two research questions: (1) How are students' beliefs about the validity and nature of global warming science related to willingness to mitigate global warming? (2) How are sociocultural indicators, such as socioeconomic status, gender, and ethnicity, related to willingness to mitigate global warming?

This study was conducted in a large, diverse school district located on the west coast of Florida. The author administered surveys to 595 students from several high schools across the district. Approximately 20% of the participants attended Title 1 schools, which have high populations of economically disadvantaged students. All students were enrolled in a marine science course, and 90% were juniors or seniors who had taken at least three science courses previously. The researcher chose the marine science students because the class focused explicitly on global warming, climate change, and the nature of science (NOS).

Of the 595 surveys distributed, 490 were returned. Incomplete surveys were discarded, as were surveys that "straight-lined," or answered all questions with the same answer choice. In the end, 324 surveys were retained for analysis. The survey—the Global Warming Science Attitudes and Actions Survey—included several sections. Those sections addressed the validity of scientists' global warming claims, the nature of global warming science methods, actions students would be willing to take to mitigate global warming, and the participants' demographics. These sections are described in detail below. Several statistical measures were used to successfully confirm the validity and reliability of the survey.

The first section of the survey presented claims from scientists that describe global warming and its impacts. Students were asked to rate the validity of each statement on a 5-point scale, ranging from "Not Valid" to "Very Valid." The second section contained statements intended to clarify students' perceptions about the methods used by scientists to understand global warming. For example, one statement

read, "If scientists cannot conduct controlled experiments in nature, they stand little chance of understanding if and how global warming is occurring." Again, students were asked to decide the extent to which they agreed with the statement on a 5-point scale, ranging from "Strongly Disagree" to "Strongly Agree." The third section asked students to indicate the extent to which they would commit to various actions in attempts to mitigate global warming, such as recycling, taking public transportation, and reducing meat consumption. Again, a 5-point scale was used. The fourth section collected demographic data, including gender, grade, and ethnicity. Once the data were collected, the author performed a specialized multiple regression on the data that could account for the categorical variables.

Survey results demonstrated the complexity of the factors that influence socioscientific decision making about global warming. The author identified three major findings from the data. First, he identified a complex relationship between self-interest and willingness to mitigate global warming. Generally, participants were less compelled to engage in mitigating actions that were financially, temporally, and personally costly. Approximately 26% of the variation in willingness to partake in relatively low-cost actions—such as recycling or supporting global warming education—was accounted for by students' views about global warming science and sociocultural factors. Essentially, students who agreed with the validity of scientific claims about global warming tended to show willingness to engage in low-cost activities to mitigate global warming. However, this association decreased with choices that were perceived as requiring more personal or financial sacrifice (e.g., those related to meat consumption or the number of children to have). Only 9% of the variation in willingness to partake in higher-impact actions (e.g., higher meat consumption, having more children) could be explained by a belief in the scientific basis of global warming.

The second major finding of this study was that the most important predictor of commitment to taking action was the extent to which participants perceived the validity of scientists' claims on global warming. The more students agreed with the validity of the claims, the more likely they were to commit to taking action. The third major finding of this study involved

sociocultural factors and the willingness to mitigate global warming. In this study, gender did not appear to influence the willingness to take mitigating actions. However, ethnicity did appear to have a relationship with students' willingness to take actions that involved energy conservation and major lifestyle choices (such as reduced meat consumption).

This study holds several implications for teaching. Students do not make decisions about their behaviors based solely on their perception of scientific claims. Rather, they consider personal, social, and cultural needs as they navigate these complex problems. In response to these findings, the author suggests two considerations while teaching. First, he suggests that teachers promote an understanding of NOS, which allows students to be flexible as they encounter complex socioscientific issues such as climate change. In particular, he emphasizes an approach that encourages reflection and questioning about the validity of different scientific claims.

Second, he also recommends that students consider how their unique sociocultural experiences influence their decision making about environmental actions. How does their cultural experience, for example, influence their decisions about eating meat or how many children to have? Once students identify and consider their own experience in relation to climate change and similar issues, teachers can then help them use multiple perspectives to go beyond their own experiences. In addition, teachers can help students weigh the implications of their choices and actions while also considering how NOS could contribute to decision making.

### **THE BOTTOM LINE:**

Students' understanding of the nature of science can influence their willingness to commit to taking action to mitigate global warming. Students who agree with the validity of scientific claims about global warming tend to be more willing to commit to specific actions. However, this willingness to act tends to decrease with more actions that are perceived as requiring more personal and financial sacrifice. Sociocultural factors can also influence willingness to take action. Thus, teachers should encourage students to reflectively consider the nature of scientific knowledge, as well as their own sociocultural experiences, when encountering complex socioscientific issues.

Herman, B. C. (2015). The influence of global warming science views and sociocultural factors on willingness to mitigate global warming. *Science Education*, 99(1), 1–38.

## **COMPARING VALUES TOWARD NATURE ACROSS CULTURES**

Values are the beliefs and goals that serve as guiding principles in our lives; they often influence our worldview and, therefore, the actions we take. The relationship between values, beliefs, and actions can be viewed as a pyramid: our values, basic beliefs, and value orientations form the base of who we are, and those translate into our attitudes toward the world around us. Eventually, those attitudes manifest in the behaviors we enact and the actions we take.

If environmental educators wish to help students engage in sustainable actions, it is important for them to understand students' values about the environment. This study set out to explore the different types of values that students hold related to nature and the environment by examining students from different cultures. In particular, the researchers were interested in the range of value orientations that students may hold toward nature, and also how those value orientations may differ among cultures.

The study focused on 12- and 13-year-old students living in urban environments in Guangzhou, China, and Minneapolis, Minnesota. The researchers matched students on certain variables, including socioeconomic status, geographic landscape type, population density of residential area, and access to natural spaces. Of the study participants, 51 were from Guangzhou and 59 were from Minneapolis. The researchers asked the students to complete three activities: (1) draw a picture representing what they thought the relationship between human and nature should be; (2) verbally explain their drawing; and (3) complete a short questionnaire describing what the human relationship to nature should be using four simple relational terms: subordinate, in harmony, dominant, or other.

The students' regular classroom teachers administered the activities during normal classroom instruction time, and the activities were not accompanied by any additional lessons or interventions. Each task was administered in the students' native language, and all responses were later translated into English for analysis. The researchers initially reviewed all responses to gain a general sense of the data; they then converted each of the drawings into a researcher-constructed written description. A different group of researchers then coded these written responses; the responses were segmented into phrases based on emergent categories and themes. Finally, the researchers counted the frequency of the themes.

The five themes of students' orientation to nature that emerged based on the drawings were: humanistic ("we should love nature deeply"); interdependence ("we rely on nature and nature relies on us"); stewardship ("it is our responsibility to take care of nature"); use ("nature is useful to us"); and dominion ("we should conquer nature"). The most frequently occurring theme was humanistic (6.7% in Minneapolis and 4.4% in Guangzhou). Guangzhou students were much more interdependence-oriented than the Minneapolis students (40%, as opposed to 10.2% in Minneapolis). By contrast, the Minneapolis students felt more strongly about stewardship than the Guangzhou students did (71.2%, compared to 37.8% in Guangzhou). Both use (8.5% in Minneapolis and 15.6% in Guangzhou) and dominion (3.4% in Minneapolis and 2.2% in Guangzhou) were comparatively lower.

To ensure validity of these results, researchers compared the drawing results to those of the four-response questionnaire. The researchers found that almost identical themes emerged from the questionnaire responses as had emerged from the drawings; the division among the five themes was similar to the division in themes in the drawings as well as their corresponding explanations. These findings suggest that students have specific value orientations toward nature, the value orientations are often diverse, and the orientations are different and distinct from one another. The value orientations also differ across cultures.

### THE BOTTOM LINE:

If environmental educators wish to inspire their students to undertake sustainable environmentally related behaviors, it is important to understand underlying value orientations that may influence people's views of nature and the environment. Asking a student about his or her value orientations toward nature may help develop and tailor educational experiences that align with the orientations that are most important and constructive to the student. This alignment can also create a space in which educators can discuss these value orientations. Educators can help students understand the environmental consequences of their value positions and help them articulate the consequences of related decisions.

Li, J., & Ernst, J. (2015). Exploring value orientations toward the human–nature relationship: A comparison of urban youth in Minnesota, USA and Guangdong, China. *Environmental Education Research*, 21(4), 556–585.

## HOW CHILDREN IMBUE RECYCLING SYMBOLS WITH MEANING

Despite research that shows students need multiple ways of interacting to learn, visual language is often treated as though it is the most effective form of teaching communication. Yet, scholars argue, visual information is always coded and interpreted in relation to particular cultures and contexts. To better understand interpretation of information within these cultural and contextual frames, this paper's authors observed video footage of four- to five-year-old children in several Swedish preschools sorting refuse into designated bins. They did so to address three research questions: (1) How are explanatory illustrations being used in natural science studies and mathematics education? (2) How do students make sense of such visual information, particularly in relation to environmental education and refuse recycling? (3) What problems and difficulties do these young students encounter when interpreting illustrations?

The authors conducted the study in two parts. In the first part, they conducted a survey to take an inventory of science software used in 10 preschools in Sweden. Through this survey, the authors identified an education entertainment program called *Ants in the Pants* that was used in 7 of the 10 preschools. This software involves an animated world within a forest where players follow a pathway and encounter games, activities, and environmental information along the way.

To begin, the authors had four pairs of preschool children play with the game in whatever way they liked. Next, the authors asked the children to play a specific activity within the game, called “Sort the Refuse,” in which players click on pieces of trash, both organic and non-organic, and attempt to drag the pieces of trash to the correct bin. They can choose one bin from among five: glass, metal, plastic, paper, and batteries. These bins are marked with symbols meant to illustrate each of these material types. Because the children playing are able to drag only the proper type of refuse onto the proper bin, the authors observed that the players used a trial-and-error strategy.

To understand how children would respond in a more open-ended scenario, the authors followed these observations with a refuse-sorting task of their own creation. The authors sampled a total of 30 children (19 girls, 11 boys) from three public preschools. All children were fluent in Swedish (for their age), although two were not native Swedish speakers. Researchers divided the children into groups of two or three for a total of 13 groups; the investigation was conducted one group at a time in a nearby room familiar to the children. The session leader then asked the children to sort the refuse items and, later, to explain why they had placed the items on each respective receptacle. This helped the researchers understand the children’s sorting strategies in relation to what the symbols represented to them. The bins used in the study employed the same symbols as those used in the *Ants in the Pants* “Sort the Refuse” game. The session leader introduced the task and gave instructions; each 15-minute session was recorded using two video

cameras, one placed close to the activity and the other placed further away. The researchers collected, in total, 210 minutes of video documentation, transcribed the videos verbatim, and coded the video data based on the way the children attempted to make sense of the recycling symbols.

From these analyses, the authors constructed four categories of sense-making strategies: (1) the material of which each item was composed (glass, plastic, or metal); (2) the type of each object (bottle, sheet, or can); (3) the appearance of each item (shape and color); and (4) the function each item served (container or wrapper). The children would often use these sense-making strategies in parallel; for example, for one item, they would sort based on the material while, for another, they would sort based on its appearance.

The authors share specific dialogue from the video transcripts to support these findings, emphasizing four other important findings from the study. First, only 5 out of the total 30 children interpreted the iconic symbols as representing material, and even those who did still put items into the wrong bins due to confusion about the composition of the items. Second, these five children were the only ones consistent in selection and bin placement. Third, the children most often correctly sorted glass and paper. Last, some children expressed the desire for more bin options; this usually occurred when the children made sense of the symbols as being in accordance with one of the four categories of sense-making strategies (material, kind of object, appearance, or function), but still could not identify a suitable bin for the item.

The study illustrates that sorting refuse is not innate but, rather, a cultural and social activity built upon social agreements. The authors identified that the children mastered two established functions of language and signs: the ideation function and the interpersonal function. However, the authors found that the third function of signs, known as the textual function, produced three potential stumbling blocks for children that included the

following challenges: (1) assigning the intended meaning to the symbol; (2) recognizing and communicating the composition; and (3) remaining with one way of interpreting each symbol and communicating why it was chosen. The authors conclude by discussing implications for teaching, including the authors' central point that educators should not assume an inherent connection between any sign and what it represents. They also emphasize that visual games can be useful learning tools when given appropriate context.

### THE BOTTOM LINE:

Using visual language—such as symbols—in a multimodal education program can be helpful for teaching environmental behaviors, such as refuse sorting. The connection between the symbols and the meaning of those symbols, however, is not inherent. Based on findings from a study with four- and five-year-old Swedish children, this paper recommends that children must be taught to associate refuse-sorting symbols with their appropriate referent behaviors; this teaching must happen not only with educators, but also with peers.

Ljung-Djårf, A., Åberg-Bengtsson, L., Ottosson, T., & Beach, D. (2015). Making sense of iconic symbols: A study of preschool children conducting a refuse-sorting task. *Environmental Education Research*, 21(2), 256–274.

## ENVIRONMENTAL CONCERN AS A FRAME OF COMMUNICATION IN ZOOS

Communicating complex environmental issues to the public requires careful consideration of not only the facts, but also of the framing of the message. How a message is framed can influence the attitudes and behaviors of those receiving the message. Environmental concern (EC)—a powerful construct related to pro-environmental behavior—might offer insight into how one might frame environmental messages in ways that are motivating and relevant. In a previous study, Schultz (2001) identified three types of EC: egoistic (concern for

self), social-altruistic (concern for other humans), and biospheric (concern for all living beings). Previous work suggests that Americans generally prefer egoistically framed messages. This study examines the use of EC as a frame for communicating environmental issues in an attempt to deepen our understanding of the connections between EC, messaging, and environmentally responsible behavior. The researchers studied zoo visitors to address the question, “What preferences do individuals have for messages framed by environmental concern?”

The study took place with visitors at two city zoos in Ohio. Data collection occurred at Zoo One over the course of a weekend in August 2009. Throughout the day, researchers positioned themselves in multiple locations throughout the zoo and asked visitors whether they would be willing to complete a questionnaire regarding their concern for the environment. The questionnaire included Schultz's (2001) EC scale, designed to help clarify which of the three EC types was most important to the participant. The questionnaire also included a brief description of the yellow sandshell, a locally endangered species native to Ohio waterways, and then asked participants to select the EC-framed statement with which they most agreed. The researchers pilot-tested the framing statements prior to the study to ensure consistency. They used six versions of the EC scale to address potential order bias. At Zoo One, the researchers asked 372 visitors to participate in the study; of those, 311 (84%) agreed, with 298 returning usable questionnaires.

At Zoo Two, the researchers collected data in a similar manner over the course of several weekdays in November 2009. Here, however, they gave participants a questionnaire that contained the EC scale along with three general statements on environmental issues, rather than the information and statements specific to the yellow sandshell. The EC-framed statements were similar to those provided at Zoo One, but were not focused on a specific species. At Zoo Two, the researchers asked 480 visitors to participate; of those, 415 (86.5%) agreed and 400 returned usable questionnaires.

All of the participants were over the age of 18. At Zoo One, 47.7% were male and 52.3% were female. Over 70% of these visitors were visiting in intergenerational groups. The researchers collected different demographic data from Zoo Two, where 40% of respondents were zoo members, 29% were visiting a zoo for the first time in the past year, 42% were visiting a zoo for the second or third time in the past year, and 29% had visited a zoo three or more times in the past year.

A majority (70.8%) of the sample from Zoo One preferred the biospheric-framed statement and 23.2% chose the social-altruistic-framed statement, while only 3.7% chose the egoistic-framed statement as their preference. Similarly, in the sample from Zoo Two, the majority (64%) preferred the biospheric-framed statement, while 24.8% chose the social-altruistic-framed statement and 11.3% preferred the egoistic-framed statement. Taken together, these findings suggest that zoo visitors have a stronger preference for statements framed by biospheric concerns. This finding differs from previous work that suggested Americans generally prefer statements framed with an egoistic orientation.

In analyzing the EC data, the researchers also noted that, as an individual's level of one type of concern increased, so did his or her levels of other types of concerns. So, as an individual's level of biospheric concern rose, so did his or her level of social-altruistic concern. Additionally, in the sample from Zoo Two, respondents showed significantly higher averages of biospheric-framed EC than nonmembers. Likewise, participants who had visited a zoo four or more times in the past year showed significantly higher means for the biospheric-framed statements than those who had visited fewer than four times. Thus, according to this study, people who engage in conservation-related behaviors—such as joining a zoo or frequently visiting a zoo—are likely to hold higher levels of biospheric EC.

In this study, the majority of participants preferred statements framed by biospheric concern, or concern for all living things. The authors suggest that visiting

a zoo might prime biospheric attitudes, making it a more common preference for the zoo visitors. Thus, biospherically framed messages may be most effective in motivating EC and pro-environmental behavior at zoos.

### **THE BOTTOM LINE:**

How environmental messages are framed is important as it influences individuals' attitudes and behaviors. Using an environmental concern frame might be particularly effective for engaging the public in caring about the environment and, by extension, becoming interested in developing conservation-related knowledge, skills, and perhaps even actions. In a study that sampled several hundred visitors at two zoos, the majority of participants preferred statements that were framed by concern for all living things rather than focused more specifically on social interactions or humans in particular. Therefore, for zoos, messages framed by concern for all living things—biospheric messages—may be effective in promoting environmentally responsible behavior among visitors.

Yocco, V. S., Bruskotter, J., Wilson, R., & Heimlich, J. E. (2015). Why should I care? Exploring the use of environmental concern as a frame of communication in zoos. *Journal of Environmental Education*, 46(1), 56–71.

## **EFFECT OF FREQUENCY AND MODE OF CONTACT WITH NATURE ON CHILDREN'S SELF-REPORTED ECOLOGICAL BEHAVIORS**

Often, one of the main elements of environmental education programs is spending time in nature. This derives from the belief of both practitioners and researchers that a relationship exists between time spent in nature and a person's environmental views, behaviors, and overall health. Better understanding the mechanisms behind this relationship could help inform environmental education practice. In this study, the authors considered frequency of children's contact with nature, attitudes toward the environment, and choices of environmentally related behaviors.

Although past research has demonstrated that a child's experience in nature can have a lasting impact, the relationship between how children feel about the environment and their related behavioral choices is not always strong and direct. This suggests that other factors are at play in this complex relationship. In this paper, the researchers found two such complicating factors: a child's frequency of interaction with the natural environment and the type of interaction experienced.

The research was conducted in Spain, where the authors surveyed a total of 832 children between the ages of 6 and 12. The average age of participants was 10; 49% of the research participants were male and 51% were female. The researchers separated children into three groups based on where they lived: the first group of children lived in urban environments, where they had access to more manicured nature settings; the second lived in a rural mountainous region, where they had access to "wild" nature settings; and the third lived in a region dominated by agriculture. The first two groups (urban and rural mountains) primarily had recreational interactions with nature; the third group (agricultural) had work-related interactions.

First, to establish the children's frequency of contact with nature, the overall sample of 832 children were asked to respond to the following two questions: "How frequently have you spent time in natural places such as the countryside, the beach, the mountains, etc.?" and "How frequently have you visited places such as zoos or aquariums?" The children rated their frequency of interaction in the last year from 0 (never) to 5 (more than 10 times). They were asked two more questions about their daily interactions with nature: "Do you play in natural places after school time?" and "Do you play in natural places during the weekends?" Responses to these were given on a scale from 0 (never) to 5 (always).

To measure attitudes toward the environment, the researchers then asked the 832 children whether they agreed or disagreed with a series of 16 statements about the environment. These statement included phrases such

as: "It makes me sad to see homes built where plants and animals used to live" and "Plants and animals are important to people."

Last, to measure the participants' environmental behaviors, the researchers asked the children how often they participated in five specific behaviors. The children reported their behaviors using the same scale of 0 (never) to 5 (always). The five behaviors were: (1) "I carry out activities to protect the environment;" (2) "To save water, I use less water when I have a shower or a bath;" (3) "In school, I talk to my teachers and peers about the importance of doing things to protect the environment (e.g., recycling);" (4) "At home, I help to separate items and to recycle;" and (5) "To save energy, I switch off the electrical appliances when I'm not using them." Furthermore, for each group, the researchers randomly chose 60 children to ask an open-ended question about their interactions with the environment. The question was, "What do you do when you are in natural areas near your house?" The children answered the question on a blank paper.

The results helped inform the relationship between participants' interactions in nature, attitudes toward the environment, and environmentally related behaviors. The children in the rural agricultural group, for example, wrote about work-related activities and mentioned places related to agricultural landscapes, such as fields and farms, when asked, "What do you do when you are in natural areas near your house?" The children from rural mountainous and urban areas both wrote about recreational activities in nature; their responses differed in that the rural children described wild places while the urban children primarily described manicured city parks. Overall, the children living in both rural and agricultural environments had higher frequency of interactions with nature.

For children living in urban environments, the researchers found that higher frequency of nature interactions positively influenced both environmental attitudes

and, to a lesser extent, pro-environmental behaviors. Environmental attitudes, in addition, had the largest effect (positive) on environmental behaviors. For rural children in mountainous areas, the researchers found no direct effect of nature contact on environmental behaviors. They did, however, find a positive effect on environmental attitudes. Results for children in the mountainous group were similar to those for the urban group; for the mountainous group, though, the positive effect of environmental attitudes on environmental behaviors was the largest. The authors hypothesized that there may be a “ceiling effect” where, after a certain point, interactions with nature may not have as much of an impact on the children’s environmental behaviors.

The researchers found that for children living in rural agricultural locations, the direct effect of contact with nature on environmental behaviors was negative, while the effect on environmental attitudes was positive. Because the effect of environmental attitudes on environmental behavior was positive, the researchers did note a positive effect of frequency of contact with nature on environmental behaviors mediated through environmental attitudes for the children in rural agricultural areas.

This study’s findings shed light on the complex factors that can impact a student’s tendencies to undertake pro-environmental behaviors and environmental attitudes. Specifically, the authors explored time spent interacting with nature as well as its effect on attitudes toward the environment and environmental behaviors. Similar to previous studies, this study found that time spent interacting with nature in activities that the authors term “unsatisfactory,” such as work, may have a negative effect on environmental behavior. In all cases, however, the authors found that contact with nature positively influenced environmental attitudes, which in turn positively influenced environmental behavior.

Although the results align with previous studies on these topics, the authors acknowledge limitations in their

study: because their study is cross-sectional, the authors cannot claim a causal relationship in their findings. They emphasize, furthermore, the importance of considering that their study was conducted in Spain with specific groups of children in particular locations. The authors suggest that what affected this group of participants may or may not affect a different group of students in the same way. Lastly, the authors recommend further studies to better understand why children who undertake work-related activities in natural settings seem to experience a negative influence on their environmental behaviors.

### **THE BOTTOM LINE:**

When considering nature interactions as a pathway toward promoting environmentally related behaviors with children, it is important to consider children’s previous interactions with and types of daily experiences with nature. For urban children, daily contact with nature appears to be an effective means toward encouraging pro-environmental attitudes and, similarly, pro-environmental behaviors. For children who already have daily exposure to natural areas—such as those who live in rural or mountainous areas—or for children who associate nature with work rather than leisure, alternative strategies to encouraging pro-environmental attitudes and behaviors might be more effective. Overall, although designing environmentally related programs that focus on spending time in nature seems to be an appropriate path toward encouraging pro-environmental attitudes and behaviors for certain groups of children, more research is needed to understand how to mitigate the negative effects of those who associate nature with work or other compulsory activities. These results suggest that practitioners might benefit from considering children’s existing daily relationships with nature when designing effective programming.

Collado, S., Corraliza, J. A., Staats, H., & Ruiz, M. (2015). Effect of frequency and mode of contact with nature on children’s self-reported ecological behaviors. *Journal of Environmental Psychology*, 41, 65–73.

## CONSERVATION ACTIVITIES DURING PROGRAMS INFLUENCE BEHAVIOR AT HOME

Often, one of the main goals of environmental education is to encourage students to become active and environmentally aware individuals. In particular, environmental educators want participants in their programs to practice conservation and environmental activities once they return home. In this study, researchers found that, when students participated in a conservation activity during environmental education programs, they were more likely to continue to engage in environmental behavior after the program had ended. This result suggests that, if environmental educators can incorporate conservation activities into the program, participants will be more likely to continue environmental behaviors when they return home.

For this study, the researchers chose waste separation as the target conservation behavior. The participants were students between the ages of 10 and 12 who attended three secondary schools in neighboring towns in Germany. The towns had similar socioeconomic and political landscapes. One school was assigned to be the control group; the other two schools received different test treatments.

The control group received no instruction and did not participate in a conservation activity. The first test group received instruction around several key themes: (1) “What happens to waste?” (2) “What is the significance of the green spot (the recycling symbol)?” (3) “How to sort waste correctly.” (4) “Why recycle?” Based on these themes, the students designed and implemented an advertising campaign about waste separation. The second control group received the same instruction around those four themes; however, they did not design and implement an advertising campaign.

To examine the impacts related to the elements of the program (instruction; design and implementation of the advertising campaign), the researchers administered a questionnaire as well as a field experiment before, immediately after, and eight weeks following the intervention. The questionnaire was adapted from Bogner and Weiseman’s (1999, 2002) environmental perception questionnaire and designed to measure self-reported behavior and waste-separation knowledge. In the field experiment, students were given a piece of candy for completing the questionnaire; then they were dismissed back to class. The candy wrappers were labeled with a UV marker. After the questionnaire session was complete, the researchers sorted through the school’s disposal systems to see whether students participating in the study had correctly sorted their candy wrappers.

Results from the field experiment with the candy wrappers showed a significant improvement of waste-separation behavior after the treatment in both of the control groups. The questionnaire results, however, revealed that the behavior was bounded by the theme of the teaching intervention (waste separation). In other words, the conservation behavior did not extend to other types of conservation behaviors but, rather, was specific to waste-separation activities.

With regard to the eight-week follow-up questionnaire, researchers found that both test groups had significantly higher self-reported waste-separation behaviors than the control group. In particular, the test groups showed a significant improvement between pre- and posttest scores related to the subject of “Talking to others about waste separation.”

The results from this study suggest that an intervention, such as the one in this study, which encourages participants to share what they have learned with others in a creative manner, may be useful in influencing

students' conservation activities after completion of an environmental education program. Choosing a particular type of conservation activity and asking students to construct a campaign around that activity could help encourage conservation and environmental behavior post-program.

### **THE BOTTOM LINE:**

Encouraging students to continue conservation behaviors once they have returned home after an environmental education program can be a daunting task. Educators are often left wondering whether—and in what ways—the environmental education experience influenced students' behaviors. This experiment demonstrated that, if the students participate in a conservation activity during programming, they are more likely to continue that conservation activity after the program. However, findings also suggest that the follow-up behavior remains specific to the activity in which the students participated during the program. Therefore, this research supports the idea that, if educators teach conservation activities during an environmental education program, the students will be more likely to continue that specific conservation behavior after the program is completed.

Baur, A., & Haase, H.-M. (2015). The influence of active participation and organisation in environmental protection activities on the environmental behaviour of pupils: Study of a teaching technique. *Environmental Education Research*, 21(1), 92–105.

# EVALUATION

## MEASURING PROGRAM SUCCESS IN THE FIELD

One of the biggest hopes for participants in environmental education (EE) programs is that, afterward, they undertake actions that are aligned with sustainability goals, in both the short and long term. Yet, it can be difficult to measure the long-term impact of environmental programs on environmentally related attitudes, identity, and, especially, behavior. Because of this, scholars have identified indicators, or intermediary outcomes, that have been correlated with longer term outcomes, such as environmental behavior change. Those measures include environmental awareness, attitudes toward nature, critical thinking skills, feelings of connection to nature, and environmental knowledge, among others.

How are intermediary outcomes being measured in the field, and what are challenges to evaluating programs that may be interested in measuring these kinds of variables? Researchers investigated this question by examining a range of EE programs and their evaluations, with a focus on residential programs. Using Internet searches, the researchers looked for information on EE programs with: functioning websites; descriptions of the EE provider's mission statement and specific program goals; at least one overnight "on site"; and intermediary outcomes such as knowledge, attitudes, and skills. Based on those criteria, the researchers identified 206 programs; of these, 37 had previously conducted evaluations.

The most commonly reported types of evaluation instruments used by the organizations in this sample were surveys, interviews, and participant observation forms. Researchers found that, in general, the programs' stated goals, mission statements, and philosophies matched the outcomes described in the evaluations. In other words, the programs appeared to be accomplishing the goals they set out to achieve. The objectives that the programs described commonly measuring were environmental awareness, attitudes, behaviors, skills, citizen participation, personal development, social skills, and community development.

As a follow-up to the finding that a small number of programs actually measure their outcomes, researchers interviewed 12 environmental educators working in a residential field science-based program to



identify some of the challenges to conducting evaluation in the field. The main barrier that the educators described was the time required for evaluation; their perception was that evaluations detract time from regular programming.

Educators did suggest several ways that evaluation might be more fully integrated into programming. Educators, in particular, identified student-generated material (such as journal entries), easy-to-use observation protocols, mapping exercises that demonstrate student knowledge connections, and student art projects (such as photographs) as potentially useful evaluation tools. An educator might teach an activity on snow pack levels and the importance of conserving water, for example, and, as an evaluation of its effectiveness, she might ask students to journal about their impact on the water cycle, how they could conserve water, and why that would be important. Another example of evaluation shared by the authors relates to a lesson on tide pool ecosystems: before and after the lesson, educators might ask students to draw a group map of a tide pool. The drawing could be evaluated using a rubric to examine for complexity and completeness of the ecological interactions depicted. An educator might also ask students to take photographs during the course of an environmental education program and use those to facilitate a discussion about what they learned throughout the week.

### **THE BOTTOM LINE:**

Intermediary outcomes—such as environmental awareness, attitudes toward nature, critical thinking skills, feelings of connection to nature, and environmental knowledge—can potentially be used as proxies for measuring ultimate desired outcomes, such as pro-environmental behaviors. To measure those intermediary outcomes, evaluations may be most effective if they are fully integrated into the program and when they do not disrupt regular educational programming. Evaluations that focus on student-generated material, such as journals, easy-to-use observation protocols, mapping exercises where students demonstrate knowledge connections, and student art projects, can be used as both evaluation measures and as part of regular programming.

Ardoin, N. M., Biedenweg, K., & O'Connor, K. (2015). Evaluation in residential environmental education: An applied literature review of intermediary outcomes. *Applied Environmental Education & Communication*, 14(1), 43–56.

## **INTERDISCIPLINARY PROJECTS AID INTEGRATION OF SUSTAINABILITY EDUCATION**

Sustainability education is solutions-oriented learning that parallels a larger movement of teaching complex problem-solving in K–12 education. Some researchers and practitioners suggest that sustainability education differs from more traditional environmental education in that it includes more of an emphasis on ethics and social factors in problem-solving and focuses on generating use-inspired knowledge and solutions. Sustainability education is often thought of as one solution for creating a more sustainable and environmentally friendly society, but measuring its ability to reach these goals can be challenging.

In this study, the researchers called attention to the ambiguity and lack of standards surrounding sustainability education. More metrics are needed to measure the efficacy of sustainability education. The authors created and tested a metric for measuring the concept of interconnectedness within schools that emphasize sustainability. The authors define interconnectedness as “the facilitation of the interactions, collaborations, and integrations between diverse and relevant disciplines, ideas, and educational stakeholders in order to teach students that our actions may, and often do, result in unintended consequences.” They then developed items aligned with this definition that would assess each of these elements.

The study investigated 289 sustainability projects within 59 U.S. Department of Education Green Ribbon Schools (ED-GRS). The study included schools that ranged in size and were in various locations across the United States. The participating schools included 26 elementary schools (grades K–6), nine middle schools (grades 6–8), 21 high

schools (grades 9–12), and three K–12 schools. Each study school submitted an application to be considered for ED-GRS status; the authors used those initial applications as data sources. The authors also obtained data through teacher interviews, as well as environmental education and sustainability reports.

The authors then placed the data within an “educational scale,” which included recording data related to curriculum, campus, and community. They coded the data using a sustainability lens, which included aspects such as a healthy environment, population wellness, and economic efficiency. The authors measured the construct of interconnectedness by considering how one project linked to more than one scale or focal category. Overall, the authors calculated each school’s level of interconnectedness by considering the number of connections divided by the number of projects.

The researchers then used the results to compile recommendations that were based on successful projects and strategies. These recommendations addressed three main questions: (1) What types of Green Ribbon School projects are prone to interconnection across different types of school programs, and why? (2) What types of Green Ribbon Schools achieve high levels of project interconnectedness, what types of schools do not, and why? (3) What common factors are shown to increase the interconnectedness of schools’ Green Ribbon programs?

In this sample, the Green Ribbon Schools that appeared to achieve higher levels of project interconnectedness were those that integrated sustainability across all curricula; typically, those schools had good organizational culture in addition to strong goals and norms. They also tended to be private or charter schools and, as such, had greater flexibility in their curriculum. The authors found that campuses that focused on student health and wellness were more likely to have higher levels of project interconnectedness. Other common factors shown to increase the interconnectedness of schools’ Green Ribbon programs included considering sustainability in schoolwide decisions, undertaking fewer

projects overall, forming strong community partnerships, receiving investment from administrators and other key stakeholders, providing professional development for teachers, emphasizing problem-solving in curriculum, and encouraging interdisciplinary curriculum development.

The schools with lower levels of interconnectedness typically had less time or flexibility within the curriculum. They were also often inner-city public schools with a large student body. Schools with lower levels of interconnectedness tended to have rigorous projects, but failed to adequately educate students and community members about the projects’ impacts. Moreover, the findings suggested that lower levels of interconnectedness existed among schools with projects billed as green, such as those with renewable energy systems, green roofs, onsite wastewater treatment systems, and National Wildlife Federation-certified schoolyard habitats. The authors speculate that the lower level of success of these projects, in terms of interconnectedness, may be due to the projects’ high visibility and the fact that the projects may feel somewhat disconnected from, and, therefore, less integrated with, the rest of the school. The authors suggest that those projects might help improve sustainability and interconnectedness if the successful projects, or elements of them, are integrated into other classes.

The authors suggest some steps for improving the interconnectedness of programs in sustainable schools, such as incorporating sustainability across the curriculum by emphasizing problem-solving and interdisciplinary learning. If sustainability is related to the community and campus—rather than relegated to the classroom setting—it is more effective. Educators and administrators can use the assessment metrics employed in this study to evaluate the efficacy of sustainability education.

### **THE BOTTOM LINE:**

In an increasingly complex world, it is crucial for students to learn to solve complex problems and be able to incorporate many ways of thinking and learning into decision making. Schools that connect curriculum, campus, and

community to address problems and provide real-world solutions offer a model for helping students develop those skills. Environmental educators can help students become engaged with complex problems by implementing a strong culture of goals and norms, emphasizing student health and wellness as part of the focus on global issues of sustainability, forming partnerships across communities, and emphasizing problem-solving skills. Doing so enhances relevance, improves understanding of environmentally related connections, and empowers students to become engaged with critical and complex issues.

Warner, B. P., & Elser, M. (2015). How do sustainable schools integrate sustainability education? An assessment of certified sustainable K–12 schools in the United States. *Journal of Environmental Education*, 46(1), 1–22.

## BEST PRACTICES USING MYSTERY SHOPPING METHODS

Environmental educators often have a clear idea of what best teaching practices are, yet it is difficult to critically evaluate one's own practice while also teaching. External evaluators, such as supervisors, can help, but the process of conducting evaluations often disrupts and changes the teaching day. This makes the evaluation results less helpful for improving practice. In this study, the researchers implemented an evaluation method traditionally used in retail service industries to evaluate the teaching practices of scientists at a science festival expo, a conference gathering that includes a large exposition hall with booths where scientists can highlight their research and interact with other researchers and conference participants. The researchers found that the method was informative, more accurate than other methods, and minimally disruptive.

The evaluation method, called the mystery shopper protocol, was developed in the 1940s as a way of evaluating customer service. In this protocol, a trained shopper completes a transaction as a typical customer while paying attention to predetermined areas of focus, such as setting, products, and employees. After the interaction,

the trained shopper immediately evaluates his or her experience against the predetermined protocol. Although the employee often knows that he or she is going to be evaluated, he or she doesn't know how or exactly when the evaluation will happen. This mystery element ensures a more genuine interaction and evaluation.

Although the protocol was originally used for investigating the transaction quality between a customer and a service provider, the researchers adapted it to assess educational aspects of interactions between scientists and their audiences. To do this, the researchers used a research-based approach to best science teaching practices developed by researchers Davies (2008) and Nisbet and Scheufele (2009) as their evaluation protocol. The protocol included 22 items divided into three sections; the items focused on describing the scientist's booth, the interaction of the scientist and the public, and an overall summary of the experience. The trained mystery shoppers participated in extensive training regarding how to use the protocol and conduct a mystery shopping experience. Overall, the mystery shoppers observed 192 booths.

To compare the effectiveness of the mystery shopper evaluation method, the trained researchers also conducted a 14-item evaluation survey with conference attendees. The protocol was similar to that used by the mystery shopper; the researchers collected data from 186 attendees.

To analyze the results, the researchers coded best practices as either occurring (a score of 1) or not occurring (a score of 0). Those results were compared to the overall booth rating, the time spent at the booth, and whether the message of the booth was clear. In comparing the two methods of evaluation (mystery shopper with surveys), the mystery shopper protocol was more in-depth: 93% of mystery shoppers provided rationale for their ratings, while only 54% of survey participants did so. Also, mystery shoppers were more critical in their evaluations, giving an average overall score of 3.11 (as opposed to 4.44 by the survey participants). The researchers concluded that these results indicated that the mystery shopping method

was not only an effective way to observe scientists' best teaching practices, but the mystery shopper protocol also offered a more in-depth and honest evaluation.

The results of implementing this evaluation method suggest that it could offer a more informative, and possibly accurate, way of evaluating teaching practices. Similarly, environmental educators might consider using a mystery shopping evaluation method to help critically examine and improve their teaching practices.

### **THE BOTTOM LINE:**

Evaluating and reflecting on one's own teaching practice is challenging, because it is difficult to become grounded in an unbiased, outside perspective. Evaluations conducted by outside observers are also often difficult, because they can disrupt the teaching day and are sometimes conducted by people unfamiliar with the program, topic, or setting. The mystery shopping method of evaluation, in which a highly trained mystery participant, or "shopper," observes and evaluates based on effective teaching practices, provides an alternative evaluation option. In comparison to survey methods, the method may provide more in-depth, honest, and less-biased feedback. Using this method may help educators reflect on and improve their teaching practices.

Peterman, K., & Young, D. (2015). Mystery shopping: An innovative method for observing interactions with scientists during public science events. *Visitor Studies*, 18(1), 83–102.

# TEACHING METHODS

## USING AUGMENTED REALITY TECHNOLOGY TO ENHANCE MARINE EDUCATION FOR CHILDREN

Education about riparian and ocean ecosystems is important for developing a broader understanding of life on earth. Game play and experiential approaches in outdoor marine ecosystems have been shown to improve the learning experience of young children. By providing interactive and immersive experiences, children's positive feelings increase in relation to their environmental awareness and knowledge. Incorporating marine learning into the classroom, however, can sometimes be more challenging. Many primary schools don't have access to marine environments, and therefore they need to develop teaching methods that would be as effective and fun in the classroom.

In this study, researchers have tested the use of an innovative learning mode that integrates augmented reality (AR) technology with storytelling and game-based tests to educate lower-grade primary school children about riparian and ocean ecosystems of Taiwan. As defined by the authors, "AR applications provide virtual objects and backgrounds, which are simultaneously projected on the real world, to create the sensation of immersion." The study's main objective was to test this learning mode's effectiveness on the learners' level of engagement, motivation, and knowledge acquisition. In addition, the study aimed to look at potential differences in its effectiveness of the intervention on low versus high academic achievers. The overall aim was to explore new possibilities for experiential learning in the classroom using the capabilities of AR technology.

Designed as an experiment, the research was conducted in 2010 in two elementary schools in Taipei. The participants included 51 male and female students, ages 7 and 8. The four-stage process is explained in detail below.

Stage 1, which occurred over 10 minutes, consisted of an activity that required students to complete a pencil-and-paper questionnaire. The questionnaire included 11 items divided into two challenges: Challenge 1 tested the capacity to match fish with their names and characteristics; Challenge 2 assessed students' understanding of fish habitats and species.



Stages 2 and 3, which lasted a total of 3 hours, consisted of implementing the educational activity, the AR teaching intervention, and the game-based assessment of knowledge acquisition. The activities were led by three teaching assistants (TAs) who provided the students with multimedia devices with preloaded hardware, a conventional digital projector, and a large screen.

The AR teaching intervention was designed in two parts: the first consisted of an interactive storytelling instructional activity and an interactive game-based test. In the first part, the teacher played the role of a storyteller who guided students through the adventure of a virtual water drop that traveled through the freshwater areas and coastal areas, and into the ocean of Taiwan. Simultaneously, the TAs—who wore special AR vests—took parts in role-playing 13 different species of fish encountered in each marine ecosystem traveled by the water drop. The AR vests included digital markers with codes for different fish species (which are considered “learning objects”). When each AR marker was scanned during the role-playing activity, a 3D virtual model of the particular fish species represented by the TA was displayed onto a screen. The students could then interact with the 3D model and closely observe the fish characteristics.

The learning content (i.e., water cycle, habitats, and characteristics of each species) was thus delivered using an engaging approach that combined storytelling and role-play with the AR technology.

The second part included two game-based tests designed to assess knowledge acquisition. Game 1, called “Fish Home,” measured knowledge regarding the ecological distribution of fish. Game 2, called “Save the Fish,” measured knowledge regarding fish characteristics and habits through small-group competition. The children played one game at a time, engaging with the AR display system through somatosensory interaction with the virtual platform. Some children used specific gestures to indicate correct/incorrect answers on the screen, while others participated in the game by giving advice or

encouragements. The interactive platform gave feedback on incorrect answers to reinforce learning messages.

Finally, Stage 4, which occurred over 30 minutes, used two questionnaires to measure learning achievements and learning motivation. The posttest learning questionnaire was a replica of the pretest but used a different order for the 11 questions; the motivation questionnaire consisted of 14 questions measuring confidence and satisfaction based on a 4-point Likert-type scale (1 = highly disagree, 4 = highly agree) adapted for this age group.

The survey findings suggested that the innovative instruction mode was matched with high confidence levels (3.59/4) of students and was received with high levels of satisfaction (3.62/4). Together, those two dimensions indicated that the AR marine learning activity increased the motivation of the elementary school children toward natural science learning. Moreover, posttest scores (9.80/11) were significantly higher than pretest results (5.23/11), revealing a significant improvement in knowledge and understanding of fish species and habitats. This outcome reflects the potential of the new instruction mode to enhance learning outcomes related to marine education.

Finally, the research examined for differences in the activity’s effectiveness with students who were considered to be low achievers in comparison with those who were considered to be high achievers, categorized based on pretest results. Findings showed the AR marine learning mode created equally positive learning motivation for both groups, but that the activity was more effective for improving the learning performance of students who were initially in the low-achievement group; thus, this activity allowed them to reach the level of those who were initially in the high achiever group.

#### **THE BOTTOM LINE:**

Augmented reality (AR) technology may provide a promising opportunity to teach elementary-aged children about marine environments in the absence of experiential

learning. By creating a visual layer of information, this technology can complement educational games and storytelling to provide a more complete immersive experience. Tested in two schools of Taipei, the approach enhanced students' memory skills and learners' motivation; it was also particularly helpful to those students who were initially classified as low academic achievers. Still relatively in its infancy, the use of AR technology to enhance classroom learning holds a potential worth exploring in different settings and with various environmental disciplines.

Lu, S.-J., & Liu, Y.-C. (2015). Integrating augmented reality technology to enhance children's learning in marine education. *Environmental Education Research*, 21(4), 525–541.

## PEDAGOGY IS A CRITICAL ASPECT OF FIELD TRIPS TO NATURAL ENVIRONMENTS

Field trips are enriching experiences for students. In addition to presenting new knowledge or clarifying concepts learned in the classroom, field trips provide opportunities for social and personal growth, and they can foster interest and motivation to learn. Field trips to natural places have particular potential for encouraging environmentally friendly actions. In sum, participation in field trips can lead to a wide range of positive learning outcomes. There is limited understanding, though, of what it is about field trips that leads to these results.

With this study, the authors attempted to explain how different aspects of field trips to natural environments relate to student outcomes. Specifically, they examined how preparation for the field trip, connections to school curriculum, and pedagogy related to students' knowledge acquisition, environmental attitudes, and commitment to environmental behavior. In other words, the researchers examined cognitive, affective, and behavioral outcomes. These field trip characteristics and student outcomes were based on work the authors had

done previously, in which they developed a framework for designing and assessing field trips, called the Field Trips in Natural Environments (FiNE) framework. The authors also considered students' socioeconomic status (SES) and whether the field trip was led by a classroom teacher or someone affiliated with an environmental organization as potentially meaningful factors.

To examine the relationship between field trip characteristics and outcomes, the researchers followed 26 groups of fourth through ninth graders in Israel, for a total of 566 students. These students participated in field trips to nature parks and nature reserves in central and northern Israel. The schools were selected to represent a range of SES groups and were sorted into four categories: suburban, which represented affluence; urban, which represented middle class; developing towns, which represented greater ethnic diversity and lower SES; and countryside schools, which are smaller and provide more outdoor education. Most field trips in Israel are led by professional guides, rather than by classroom teachers. This is particularly true at the elementary-school level (grades 1–6); junior high schools and high schools have teachers dedicated to outdoor education. To examine whether there were differences in *who* led field trips, the authors included 17 groups led by an environmental organization professional and nine groups led by teachers. All of the professional guides were affiliated with one of two major Israeli environmental organizations.

All of the study participants completed a questionnaire after their field trip, which was adapted from the Science Outdoor Learning Environment Inventory (SOLEI) and informed by the FiNE framework. The authors' final survey included 34 items that fell into three main categories: (1) planning—preparation in school, communication, and collaboration between the guide and schoolteacher, and connection to the school curriculum; (2) pedagogy—the guide's explanation and stories, and the guide's use of the environment, demonstrations, active learning, physical activity, and connecting to everyday life; and (3) outcomes—learning new things or enhanced learning, enjoyment of the outdoor experience, developing positive

attitudes toward the environment, and environmental action following the trip. The authors also observed the field trips and interviewed a subset of teachers, guides, and students about their field trip a few days after it occurred. The authors performed statistical analyses on the survey data, and they used the interview data to illustrate survey results.

Based on their analysis of survey data, the authors found that field trip characteristics related to pedagogy were the most impactful for students. The most powerful aspect was the guide's storytelling. When the guide told interesting stories, students reported positive results in all three domains—cognitive, affective, and behavioral. In addition to storytelling, students reported greater knowledge acquisition when the guide gave examples from everyday life and explained things that both the guide and the students discovered during the trip. Students who were given exploration tasks during the field trip and who were helped in making connections to concepts learned in school also showed greater cognitive learning outcomes. In the affective domain, when students engaged in physical activities and challenges, they reported more enjoyment and overcoming difficulties. Finally, in the behavioral domain, when students felt that concepts they learned in school were clarified during the field trip, they reported changes in their thinking about the environment and their intention to change their environmental behavior.

Although the authors anticipated that factors related to trip planning would be important, they found only one significant nonpedagogical factor: preparation for the trip in class was associated with cognitive learning. Despite their assertion that student SES (based on the school location) and the affiliation of the field trip guide might make a difference, the authors found no differences in outcomes based on these factors.

The authors acknowledge their finding that pedagogy, particularly the guide's storytelling, is the most critical element of these field trips differs from other researchers' conclusions that experience-based learning is superior to teacher-directed learning in natural environments.

However, they explain that the field trips in this study featured more guide-directed than student-led activities. In this context, the authors argue, storytelling is particularly powerful.

### **THE BOTTOM LINE:**

Field trips to natural environments provide opportunities for students to learn, develop new interests, and improve environmental attitudes and behaviors. This study points to the importance of strong pedagogy in these learning environments, particularly when the guide is instrumental in shaping the field trip activities. On a guide-directed field trip, when the guide tells interesting stories, offers opportunity for exploration, explains discoveries, relates experiences to everyday life, and clarifies concepts learned in school, students' experiences can be enhanced, with greater learning, attitudes, and changes in environmental behavior.

Alon, N. L., & Tal, T. (2015) Student self-reported learning outcomes of field trips: The pedagogical impact. *International Journal of Science Education*, 37(8), 1279–1298.

## **TEACHING MITIGATION AND ADAPTATION STRATEGIES FOR CLIMATE CHANGE**

The International Panel on Climate Change (IPCC) reports that mitigation strategies alone do not suffice to respond to potential negative impacts of global climate change (GCC), and adaptation strategies are equally important. Mitigation strategies are efforts to reduce greenhouse gases (GHG), and thus the severity of future GCC. In contrast, adaptation strategies are ways to help humans and other species adapt to the present and future changes related to GCC, such as drought, changes in ecosystems, and sea level rise. Education research on GCC has been largely focused on individuals' understanding of mitigation while overlooking the essential construct of adaptation, as well as the ability of individuals to differentiate between the two constructs.

In the perspective of addressing these research gaps, this study used a pretest, instruction unit, posttest format to identify aspects of middle school and high-school students' knowledge of mitigation and adaptation strategies related to GCC. It specifically looked at: (1) adolescents' conceptualizations of, and justification for, climate change mitigation and adaptation strategies in their communities; (2) the impact of GCC instructional intervention on students' understandings and beliefs; and (3) differences or similarities in conceptualization of the two constructs (adaptation and mitigation) at different developmental levels of middle and high school.

Student data were collected from 18 teachers in the California Bay Area who volunteered to implement the proposed GCC curriculum as a mandatory unit in their science classes. The study, however, focused on student data from only six teachers (three middle-school and three high-school teachers) selected based on two main criteria: (1) their classrooms included a representative sample of ethnic and racial diversity of students; and (2) they had implemented the GCC unit according to the instructions and had complete data sets at the time of analysis. The resulting sample included 387 students, of which 162 were middle-school students (age 11–14) and 225 were high-school students (age 14–18). The curriculum covered topics related to climate science, energy budget, and mitigation and adaptation and was tailored to the geographical characteristics of the California Bay Area. The researchers first designed the curriculum for high-school students and then modified it to the development level of middle-school students.

The instructional intervention was divided into several units and implemented mainly through group activities and experiments. First, students were exposed to the concept of GHG and its impact, along with four mitigation strategies: fuel efficiency, transportation conservation, building efficiency, and efficient electricity production. The next units focused on the impacts of climate change—such as sea-level rise and drought—and ways to both mitigate and adapt to it. While learning about adaptation

strategies, students were encouraged to imagine short-term and long-term solutions. While exploring the impact of GCC on water shortages and agriculture in California, for example, students discussed short-term adaptations for water shortage, such as increasing water use efficiency for irrigation, and long-term adaptations, such as developing drought-resistant crops. Lesson plans and related resources are available online at <https://pangea.stanford.edu/programs/outreach/climatechange/curriculum>.

The results showed the instruction was effective at improving students' knowledge of GCC mitigation and its causes. Specifically, when asked to suggest an approach for reducing the impact of temperature rise, the number of students who responded “no response” decreased from 13% at the pretest to 1% on the posttest. In addition, students' ability to justify why their chosen behavior reduces GHG emissions significantly improved from 55% to 85% after the educational unit. Although middle-school students were more confident in providing responses after the instruction unit, high-school students were more likely to provide correct responses and provided valid justifications more frequently.

On the other hand, conceptualizations of, and justification for, adaptation strategies were far less understood compared with mitigation strategies. In the pretest, over 36% of students chose “no response” when asked to suggest adaptation strategies, compared to 13% for mitigation. In addition, 24% of students conflated mitigation and adaptation by providing responses that only reduce GHG emissions and do not help humans or other species adapt to GCC. One common conflated response, for example, was: “use less energy.” Although using less energy is indeed important for *mitigating* GCC, this response shows the student did not recognize that using less energy won't help them and other species *adapt* to GCC. In other words, reducing energy use does not improve resilience to the impacts of GCC, such as more frequent storms, heat waves, droughts, and so on. Moreover, middle-school students were more prone to confusion than the older students, with more than half of the group providing no adaptation strategies

and 18% providing answers that conflate mitigation with adaptation. Posttest survey results showed an increase in the students' response rate on adaptation questions, which reflects improved confidence. However, the frequency of conflation of adaptation and mitigation did not decrease after the instructional unit.

Finally, in the pretest, the students had much more difficulty justifying their adaptation responses (70% had no or invalid justifications) than justifying mitigation responses. The instructional unit improved the capacity of students to provide correct adaptation responses, as well as valid justifications (60% of students). However, 30% of students still provided invalid responses due to sustained conflation of the two constructs.

### THE BOTTOM LINE:

In teaching about global climate change (GCC), it is essential to address both mitigation (reducing greenhouse gas emissions) and adaptation (e.g., improving efficiency of water usage in agriculture) strategies. Special attention needs to be paid to teaching about adaptation, in particular, as it is often overlooked, as evidenced by this study's findings that it is not as well understood as mitigation. Focusing on adaptation can be achieved by increasing the number, sophistication, and engagement level of activities that address adaptation as well as providing students with explicit instructions on how they might consider addressing adaptation; these activities must also make clear conceptual connections between adaptation strategies and the influence of those strategies on greenhouse gas emission levels. Moreover, future instructional units should focus more on improving students' abilities to differentiate and contrast between mitigation and adaptation to GCC. Finally, this study's findings—and those from other related studies—suggest that climate curricula are more compelling when tailored to the students' geographical area.

Bofferding, L., & Kloser, M. (2015). Middle and high-school students' conceptions of climate change mitigation and adaptation strategies. *Environmental Education Research*, 21(2), 275–294.

## USING CONSTRUCTIVE CONFLICT TO CORRECT CLIMATE CHANGE MISCONCEPTIONS

As students acquire new knowledge, they make sense of it by incorporating it into their existing frameworks of knowledge. Yet, if that information is incorrect and the students do not know that the information is incorrect, they will incorporate it into their existing knowledge frameworks unknowingly. Once embedded within an existing knowledge framework, it is often very difficult to correct those misconceptions.

In this study, researchers tested a potentially effective way to correct misconceptions about four concepts: global warming, the greenhouse effect, acid rain, and ozone layer depletion. The research team focused on these scientific concepts because prior research has suggested that students often have misconceptions about them, and those misconceptions might lead the students to make environmental decisions based on faulty knowledge.

The researchers set up a study in four Malaysian classrooms with 16- and 17-year-old students. The classes were in similarly sized schools, the students were from similar socioeconomic backgrounds, and the educators had similar teaching qualifications. All 73 students participating in the research study completed a pre- and posttest that included 13 three-part questions that asked the students to provide: (1) a response to a factual question based on each of the four concepts; (2) an explanation of their answer; and (3) an estimation of their level of confidence in their answer. After the posttest, researchers randomly selected 10 students to participate in interviews.

In between the pre- and posttest, the educators provided five weeks of instruction. In two of the classes (38 students in total), the educators taught the standard biology course using the regular science curriculum. These two classrooms acted as the control group, and the educators taught lessons on the four subjects using a teacher-centered lecture followed by small group discussions.

The experimental condition consisted of two classes, totaling 35 students. After presenting the information in a traditional format, the educators used hands-on activities that pertained to real-world issues and focused on the concepts of global warming, acid rain, ozone layer depletion, and the greenhouse effect. The students were split into small groups where they participated in discussions that were meant to surface their misconceptions and incite cognitive conflict. By creating a learning environment in which students were forced to examine conflicting information, they had to reconstruct, interpret, and modify their existing knowledge bases.

The results showed the students in the experimental group exhibited better understanding of all four subjects than their control-group counterparts. Specifically, although both groups showed gains in knowledge from pre- to posttest, only the experimental group showed gains that were statistically significant. These results were supported by the post interviews with students. While the control group still tended to exhibit misconceptions after the five weeks, the experimental group developed better understanding of the four subjects.

### THE BOTTOM LINE:

A lot of scientific misinformation exists, particularly related to controversial topics such as climate change, acid rain, greenhouse gases, and ozone layer depletion. Correcting misconceptions related to such topics may be challenging and cannot be done through simply sharing the correct information; rather, students must be able to examine their own knowledge alongside the correct knowledge, realize that there is a conflict between the two ways of conceptualizing the issue, and participate in an active process of incorporating that new information into their knowledge frameworks. Educators can help students do this by organizing activities that encourage students to engage in deeper dialogue, grapple with complex real-world situations, and discuss the information themselves.

Karpudewan, M., Roth, W.-M., & Chandrakesan, K. (2015). Remediating misconception on climate change among secondary school students in Malaysia. *Environmental Education Research*, 21(4), 631–648.

## BUILDING CITIZENSHIP SKILLS: DEVELOPING LOCALLY RELEVANT SUSTAINABILITY EDUCATION CURRICULA

Sustainability issues, such as energy sourcing and consumption, are complex and can be controversial to address as they are influenced by peoples' opinions, values, beliefs, and attitudes. Yet, the structure of education for sustainable development (ESD) can help to accommodate these controversies; it can help students develop the knowledge and skills for making robust, thoughtful, and community-oriented decisions. Additionally, ESD can strengthen students' critical thinking and deliberative skills. Because of this, education for sustainable development may require extra time, focus, and resources from teachers.

In this study, researchers examined an instructional unit, designed by the University of Florida's School of Forest Resources and Conservation, called *Should We Use Wood for Energy? A High School Education Program*. The study focused on the program's pilot test results and, based on those findings, gives suggestions for addressing barriers to ESD while offering suggestions for creating future ESD curricula.

The authors developed the instructional unit in response to local teachers' interest in educational materials about woody biomass. This interest was sparked because of a proposed biofuels facility in Florida. The curriculum, which is designed for grades 10 through 12, corresponds to state standards and includes four sections with 18 activities. The units incorporate a range of subjects, including environmental science, biology, economics, government, and language arts. The activities emphasize collaborating with peers to generate and address research questions, collect data, conduct experiments, discuss ethics, and explore issues from a range of perspectives.

The study's authors found that—through focused activities, guided reflection, and discussion questions—the curriculum directly and indirectly incorporates three

important components of sustainability: environment, economy, and society. The curriculum unit, which includes teacher-guided discussions and student worksheets, also promotes critical thinking about real-world issues. Many of the activities encourage students to consider multiple perspectives, identify biases, role-play, engage in community issues, and work toward solutions. The unit also facilitates students' understanding the interconnectivity of sustainability issues and promotes discussion about consequences of actions. This process, known as systems thinking, helps students envision how different parts of a system are related and how relationships within systems may change over time.

The authors used pre- and posttests to evaluate the curriculum with three teachers and 152 students in grades 11 and 12. They used a survey and essays to examine changes in students' knowledge of woody biomass, as well as community considerations of using wood for energy. The authors asked teachers to reflect on the curriculum's usability and applicability. The authors found that, overall, the students enjoyed many of the activities, and the curriculum succeeded in increasing students' knowledge of woody biomass. However, the authors also found that students had difficulty defining sustainability and relating it to the issue of using wood for energy. The authors found that teaching the material required a significant time commitment by the teachers.

Based on results from the pilot study, the authors revised the curriculum. They shortened some of the activities, provided more background information, added teacher keys, and included sustainability-related ideas in more of the activities. Since 2010, the instructional unit has been accessed widely; it can be found at <http://sfrc.ufl.edu/extension/ee/woodenergy/index.html>.

The study's authors make two sets of recommendations derived from the pilot process and findings. The first relates to overcoming barriers to education for sustainable development in the classroom and the second relates to practitioners who are interested in developing education for sustainable development curricula. To address barriers

in classroom-related settings, the authors recommend providing teacher workshops to help with program implementation. They also suggest including an outline and timeline for each activity to encourage teachers to actually use the activities. Finally, the authors suggest that teachers may wish to use the curriculum as a unit or implement it in teams to leverage expertise in science and social studies. For developing other curricula related to sustainability, the authors recommend focusing on locally relevant topics, including subject-specific activities that incorporate multiple components of sustainability, and infusing sustainability related themes into as many activities as possible.

### **THE BOTTOM LINE:**

Sustainability education curricula are successful when they include activities that are locally relevant, build on subject-specific activities that incorporate multiple elements of sustainability, and involve sustainability themes throughout the curriculum. To support the curriculum, it is important to provide teachers with professional development, and it may be helpful to encourage them to work in teams to leverage their subject-matter expertise. When education for sustainable development is successfully implemented, students may benefit by understanding complex sustainability related topics, developing systems-thinking skills, and feeling empowered to address issues in their community. In this way, they can become active citizens in addressing locally relevant environmental challenges.

Ireland, J. J. T., & Monroe, M. C. (2015). Should we use wood for energy? An education for sustainable development case study. *Applied Environmental Education & Communication*, 14(2), 82–89.

## APPLYING A PERMACULTURE DESIGN FRAMEWORK TO ENVIRONMENTAL EDUCATION TO CULTIVATE ENGAGED SCIENCE LEARNING

Permaculture and environmental education both originated in the 1970s and, although they have grown along different paths, they continue to have parallel, complementary goals and philosophies. Permaculture is defined, generally, as a systems approach that looks at a subject or area and attempts to maximize beneficial relationships while minimizing harmful ones. Originally, permaculture applied specifically to food cultivation, but since its inception, the notion has informed designs for many other systems, such as those in finance, law, business, and education.

In general, permaculture takes a bottom-up approach, cultivating fertile grounds to support vigorous growth and biodiversity. This means identifying—and addressing—deficiencies in existing foundational systems. After addressing inadequacies in the “soil,” or the foundational elements of systems, a permaculture approach supports beneficial connections and positive feedback loops while providing gentle guidance and support for the growing system.

In this study, the authors used a permaculture approach to science education with a class of 18 secondary school students (all 14 years of age) in New Zealand. The students participated in a curriculum that included three units: Environmental Chemistry, Ecological Principles, and Plants as Food. The units moved from a big-picture focus to a local focus, with an overall goal of improving environmental literacy and understanding the role of food production systems. In the final unit, students took field trips to two local permaculture sites: a diversified orchard and an eco-accommodation that used permaculture practices to increase its sustainability.

The authors assessed the impact of this curriculum using a mixed-methods approach. They used formal and

informal interviews with the teachers; for students, the authors used questionnaires before the curriculum was implemented, as well as focus groups after the curriculum had been implemented to gather a range of qualitative and quantitative data. Additionally, one of the authors worked closely with the class throughout the curriculum as a “participant observer.” This allowed for a long-term, more holistic view of the curriculum’s impacts on the students.

Although quantitative data for this study were not statistically significant because of the small sample size, the data did suggest some overall trends. The authors found that the focus on food provided students with a sense of relevance, which in turn related to higher levels of engagement and interest. All students reported enjoying the experiential aspect of the field trips. Themes of enjoyment and the ability to participate in real, applied activities were prevalent in student responses. The enjoyment of these activities, however, did not necessarily translate to increased interest in science and science learning. In particular, students who expressed disinterest in science in the pre-implementation questionnaires did not show increased interest after the curriculum had been implemented, even if they enjoyed the experiential learning. Also, the ability to link key words to make sustainability statements increased only for some students. After completing their participation in the curricular unit, many students felt more positivity toward science and science education, yet few demonstrated increased pro-environmental attitudes.

The authors emphasized the importance of the curriculum’s ability to engage students, even briefly, in science and sustainability topics by providing experiential learning opportunities using a permaculture approach. They note that the more locally and personally relevant the context is, the more nourishing the program will be for students. The authors also offer trellising as an alternative to the familiar concept of scaffolding; they draw a contrast between the imagery evoked by each term. The authors propose that scaffolding suggests knowledge that is built by outside forces that construct understanding within rigid constraints and according to a precise plan. By

contrast, trellising indicates knowledge that grows more organically, driven primarily by the learner with gentle guidance and support from others. Trellised learners, therefore, have the freedom to explore their own interests, make broader connections, and grow at their own pace.

### **THE BOTTOM LINE:**

A permaculture approach to education can cultivate healthy attitudes toward learning, which, in turn, promote growth. A permaculture approach identifies and amends deficiencies and enhances existing positive relationships and feedback loops (such as the feedback loop between relevance and engagement). This approach also gives students freedom to explore their own interests, grow knowledge organically, and find intrinsic motivations within a soft supporting framework, or trellis, rather than a rigid scaffold that may lead to more limited and less self-motivated learning. Environmental educators can use this approach to increase relevance and interest among students.

Lebo, N. & Eames, C. (2015). Cultivating attitudes and trellising learning: A permaculture approach to science and sustainability education. *Australian Journal of Environmental Education*, 31(1), 46–59.

# SENSE OF PLACE AND NATURE CONNECTION

## CONNECTING WITH NATURE TO INSPIRE COOPERATION

Virtually all environmental educators believe that connecting with nature can inspire better environmental citizens, but how does that process of influence work?

As the authors of this study point out, until recently, the bulk of prior studies that connected exposure to nature with environmental behavior used self-reports and questionnaires from participants. Those methods help build the case for the value of connection to nature, yet they give less insight into what the connection actually looks like. More recently, researchers have sought to tease out the causal links in this relationship through specific experiments.

The authors hypothesize that exposure to nature promotes cooperation and, through this mechanism, results in more environmentally friendly behavior. Environmental problems, they argue, are largely issues of collective action: as each person makes a self-motivated decision that uses resources, this collectively results in a “tragedy of the commons” where no one has access to the resource. Increasing cooperation, therefore, could decrease people behaving out of self-interest and instead encourage behavior in a way that promotes community interest. The scholars theorize that promoting cooperative (as opposed to self-interested) behavior is crucial to addressing sustainability issues.

To test this hypothesis, the authors conducted three laboratory-based experiments that manipulated participants’ exposure to nature. The authors then asked the participants to play a game that simulated the tragedy of the commons dilemma. The researchers hypothesized that participants who had been exposed to videos of nature-related content would exhibit higher levels of cooperation.

In the first study, 111 participants (all undergraduate university students) watched a 12-minute narrated educational video with content that related either to (a) the natural world or (b) the built environment. The natural environment content was an excerpt from the BBC miniseries *Planet Earth*, which highlights awe-



inspiring natural scenery from around the world; the built environment content was an excerpt from the film *Walks with an Architect*, which provides a tour of landmark New York City buildings.

The participants then played a computer “fishing game” with three co-players. (The co-players were, in fact, simulated by the program, rather than actual people.) Over the course of numerous fishing seasons, the participants were asked to decide how many fish to extract from the fishery. They were allowed to decide whether to extract fish at, above, or below the ecosystem’s replacement rate. Short-term selfish behavior by each player led to depletion of the fishery and diminished returns for all players. By contrast, cooperative, restrained behavior led to steady returns.

The authors conducted a second study with 121 undergraduate participants. In this study, the authors replicated the first study, but they added a control condition for the video component where participants did not watch a natural or built environment video. Both studies found a significant positive correlation between watching the nature video and more cooperative behavior in the fishing game. This correlation did not exist when participants watched the built environment video or the control video.

To test their findings, the authors took their investigation a step further. Other studies have found that exposure to nature improves mood, making subjects feel happier and more relaxed. Although seeing mood changes may be a possible effect of connecting to nature, the authors hypothesized that this effect was less lasting and substantial than the increase in cooperation. To make sure that cooperation—rather than mood change—was at the root of the environmentally friendly behavior, the authors modified their approach for the third study. They had participants watch the three videos and then tested for cooperation using a game that did not have a natural resource as the main component. Through studying 250 participants, they found that those with a developed sense of connection to nature were still more likely to behave cooperatively than the other two groups.

### THE BOTTOM LINE:

Through laboratory-based experiments, the authors demonstrated that connection with nature promotes more cooperative behavior. This finding suggests that nature might play an important role in solving not just environmental problems, but other thorny social issues as well. Environmental educators can facilitate this process by supporting a sense of connection with nature among their students. Additionally, educators can use cooperative learning games and activities to help students practice and develop a potentially increased sense of cooperation.

Zelenski, J. M., Dopko, R. L., & Capaldi, C. A. (2015). Cooperation is in our nature: Nature exposure may promote cooperative and environmentally sustainable behavior. *Journal of Environmental Psychology*, 42, 24–31.

# PROFESSIONAL DEVELOPMENT

## TEACHING COMPLEXITY IN EDUCATION FOR SUSTAINABLE DEVELOPMENT

The process of sustainable development is a complex one involving many science concepts and interconnections between the natural world and humans. Because of this, it is often difficult to describe these notions using simple language. In education for sustainable development (ESD), this presents an obstacle: How do educators teach about complex subjects without oversimplifying, while also helping students develop the critical thinking skills to be productive contributors to the sustainable development movement?

To address this dilemma, the author interviewed experienced ESD teachers. Specifically, the author sought to understand how these experienced educators approached complex sustainability issues, the techniques they found to be successful, and what they cared about most in their teaching. The teachers taught at Swedish schools known as hubs for ESD. Sweden has been known as an early adopter of ESD methods, and the schools where the participants taught specifically seek to embrace the complexity of sustainability issues as a teaching theme.

To select the interviewees, the author initially contacted 179 teachers working at three schools. Based on years of teaching experience, the authors selected seven teachers to interview. The interviews focused on the educators' goals in teaching about sustainability, as well as their attitudes toward their own teaching practices. The author coded the first round of interview data using a process specifically focused on the degree to which the teacher incorporated ESD concepts into their teaching. After the initial coding process, the author conducted further interviews with five of the seven teachers. During those second-round interviews, the author used an open-ended analytic process to explore in more depth the teachers' purposes for teaching about sustainability related issues.

One main theme emerged from the interviews: Overall, the teachers frequently mentioned the importance of the word, concept, or approach of complexity as a starting point for teaching ESD. The author found five categories of answers that related to complexity: humility, awareness, personal connection, developing skills, and



negotiable truth. First, with regard to *humility*, the teachers spoke of cultivating students' humility in various ways and keeping an open mind when approaching sustainability issues. Second, related to *awareness*, the teachers approached teaching ESD with a general form of awareness rather than a specific environmental awareness. Third, they discussed *personal connection*, both in the sense of their own connection to sustainability-related issues, as well as in helping their students feel more connected to complex issues in different contexts. Fourth, the teachers described helping students *develop skills*, such as analyzing, organizing, categorizing, thinking critically, and reasoning. All of the teachers mentioned that complexity is an integral part of today's world and that students need to be prepared to respond appropriately to it. The fifth, and final, category related to the idea of *negotiable truth*: although the teachers did not explicitly mention this term, because of the complexity of sustainability issues, teachers approached the idea of truth as negotiable, diverse, and without a single, final answer.

These five themes suggest that teaching complex scientific subjects requires careful thought and deliberate teaching practice. By teaching students how to recognize, examine, critique, and question the complexity in the world at large, the educators move away from a sole focus on students' environmental awareness. As such, the educators are able to help prepare the students to be productive, active participants in sustainable development.

### **THE BOTTOM LINE:**

Because complex issues and connections are at the heart of education for sustainable development (ESD), veteran teachers who use complexity as the starting point for their long-term teaching goals may be able to more effectively approach teaching about such challenging subjects. In this way, the experience of veteran teachers may be able to help inform environmental education practice more broadly. By focusing on cultivating humility, developing an awareness of complexity in scientific issues, creating a sense of personal connection to the issues, developing critical thinking skills, and emphasizing truth as a negotiable concept, educators

can help their students better understand and evaluate complex environmental issues. The effectiveness of this approach can not only help students understand issues more fully, but can also equip them to become informed, active participants in addressing environmental issues.

Sund, P. (2015). Experienced ESD-schoolteachers' teaching—An issue of complexity. *Environmental Education Research*, 21(1), 24–44.

# OTHER RESEARCH

## SUSTAINABILITY IN THE NEXT GENERATION SCIENCE STANDARDS

The recently released Next Generation Science Standards (NGSS), which provide recommendations for K–12 science education in the United States, include the subcategory topic of human sustainability. This subcategory represents one of five earth and space science topics that the NGSS recommend for high-school science education. Because modern conceptualizations of the terms *sustainability* and *sustainability education* are often complex and variable, the authors of this paper sought to identify the version of sustainability that the NGSS articulate. Additionally, they aimed to understand how such a definition of sustainability might influence students' understanding of the relationship between nature and society.

To decipher how the standards articulate sustainability, the authors scrutinized the entire set of documents that comprise the NGSS. Beginning their analysis with the human sustainability topic, the authors traced the disciplinary core ideas found under human sustainability to other topics with identical core ideas. The authors also examined the storylines provided by the NGSS, which demonstrate how disparate ideas are linked in a coherent picture. Additionally, the authors tracked the use of words associated with sustainability, such as *social* and *economic*, throughout the NGSS. Furthermore, the authors turned to scientific position papers about sustainability, as well as social scientific research on the meanings of sustainability. From this iterative process, three major themes regarding how sustainability is portrayed in the NGSS emerged: universalism, scientism, and technocentrism.

The authors define the first theme, universalism, as an emphasis on a global system where humanity is rendered as a single variable. With no focus on any specific places, the NGSS seem to prioritize teaching a global system, rather than teaching about global process through local examples. Because of this aggregation of all human activity, there is no accounting for the effect of one group of humans on other groups of humans. According to the authors' analysis, the NGSS portrays all humans as equally contributing to—or suffering from—sustainability challenges. The authors find this universal perspective “troubling, because it obscures the fact



that sustainability-related problems afflict some humans more than others and that human actions, embodied in contemporary policies and social institutions, contribute to poverty, hunger, and environmental vulnerability.” Essentially, humans do contribute to sustainability issues in unequal ways; not understanding this notion translates to a misunderstanding of certain issues.

The second theme, scientism, regards how the NGSS promote a specific epistemological stance, and what types of knowledge are relevant to sustainability issues. Through subtle means, the NGSS express an argument that natural sciences and quantitative methods are the best ways to understand sustainability challenges. In prioritizing science, the standards portray the social dimensions of sustainability as secondary, or less important. According to the NGSS, students are expected to understand sustainability through quantitative calculations and computer simulations. The authors claim that by not depicting sustainability as a complex problem requiring many different types of knowledge, the NGSS imply that sustainability is largely a scientific problem requiring scientific solutions.

Related to this, the authors also note a theme of technocentrism. The embrace of engineering and technology by NGSS makes engineering appear as a central factor in dealing with sustainability issues. Again, the authors argue, such a focus on technology oversimplifies sustainability.

As a result of their analysis, the authors claim that the vision of sustainability evident in the NGSS matches current trends in natural sciences. They argue that this vision resembles ecological modernization, a technology-centered, managerial perspective on sustainability. Such a vision, they argue, is troublesome for K–12 education, as it lacks a strong ethical component and awareness of social complexity. Students who learn about sustainability through such a vision could misunderstand how social and political structures contribute to sustainability challenges; they might be unprepared for a pluralist society that must

balance multiple needs and consider multiple sources of information to solve problems.

To counter these issues, the authors recommend systematic collaboration between science educators and social studies educators. Suggesting that science education should approach sustainability through collaboration with other disciplines, they emphasize the importance of recognizing that sustainability cuts across many fields. The authors also caution, however, against simply addressing sustainability both separately and in parallel through curriculum alignment. Such a separation could lead students to think there are two distinct categories of challenges. Rather, teachers should collaborate on planning, design, and implementation of sustainability-focused lessons. Ultimately, learning about sustainability should be more interdisciplinary.

#### **THE BOTTOM LINE:**

Although the Next Generation Science Standards (NGSS) represent a step in the right direction for sustainability education, there are issues in how the concept of sustainability is articulated in these standards. The authors noted three themes present in the NGSS: universalism, scientism, and technocentrism. The presence of these themes suggests that students learning about sustainability through NGSS could take away an oversimplified understanding of sustainability challenges that lacks complex ethical and social dimensions. Systematic collaboration between science educators and social studies educators could help to portray sustainability issues as the highly complex socio-scientific challenges that they truly are.

Feinstein, N. W., & Kirchgasler, K. L. (2015). Sustainability in science education? How the Next Generation Science Standards approach sustainability, and why it matters. *Science Education*, 99(1), 121–144.

## APPLYING THE CONCEPT OF SOCIAL CAPITAL TO ENVIRONMENTAL EDUCATION

The concept of social capital has garnered increasing attention from scholars over the past few decades because of its relevance to understanding and addressing societal issues. Little scholarship, however, has explored the relevance of social capital to environmental education (EE). The authors of this paper argue that two areas of social capital research are of particular relevance to EE. First, a number of studies have linked social capital to positive youth development and well-being. Second, research has shown that social capital fosters collective action, including community-based management of natural resources.

In this paper, the authors first present an in-depth literature review of social capital, focusing on its relevance to environmental education. Second, the authors propose a measure for social capital among youth that could be used in EE. They developed and tested this measure for reliability, and they present results from a preliminary study to demonstrate how the measure can be applied in EE research.

Much of the literature defines social capital as the goodwill and relationships that exist within a community. Individuals within communities develop (and use) social capital through community events and other relationship-building activities. This social capital can then, in turn, be enacted to bring about change. One of the critical debates in social capital literature is a “chicken-and-egg” problem. Specifically, researchers ask, is social capital the cause of collective actions, or does social capital result from collective actions? This paper’s authors propose that one way to address the issue is to accept that social capital makes collective actions possible and, in turn, such collective actions foster additional social capital. In other words, social capital may both be a contributor to and an outcome of collective action. The authors argue that this solution is consistent with non-linear or systems ways of thinking, which is considered an important element of EE.

The authors make three arguments for the need to link social capital and EE research and practice. First, they argue that EE programs need to adapt to address youth development and related outcomes of interest, especially in low-income, urban, and other stressed communities. Second, incorporating social capital into EE programs could expand existing work in civic participation. Specifically, social capital could provide new conceptual and analytic frameworks to expand scholarship in intergenerational learning, place-based learning, school-community partnerships for sustainability, and other forms of EE geared toward addressing social concerns. Third, social capital could be a valuable tool in EE for fostering collaborative natural resource management in communities. A key concept of this work is that resilient social systems and resilient ecological systems are interdependent. In particular, social capital offers a framework that shifts the focus from changing individual behaviors to creating the conditions that enable a community to take action to safeguard its natural resources.

Next, the authors turn their attention toward the challenges of measuring social capital. One of these challenges is being clear about the construct of social capital: Is it a static asset similar to financial capital, or is it dynamic and ever-changing? Various instruments and constructs have been designed to measure social capital in these different ways; each has advantages and disadvantages.

The authors report on their version of measuring social capital among youth; they note that this conceptualization may be particularly appropriate for EE. They developed and tested the measure for reliability. The authors drew constructs and scales from the National Social Capital Benchmark Survey, which has been used to measure social capital among adults. They adapted the questions to be suitable for use among youth between the ages of 10 and 14. The survey included five constructs: social trust; informal socializing; diversity of friendships; associational involvement; and civic leadership. The questions used 5-point, Likert scale-type items as well as dichotomous (yes/no) items.

The authors pilot tested the survey with nine teenagers (between the ages of 14 and 18) who were summer apprentices in a New York garden program. The youth provided feedback that informed minor revisions of the instrument to enhance comprehension. They conducted a second pilot test online with a random sample of 210 children between the ages of 10 and 14 (of the sample, 52% were male). The social capital questions were administered as part of a larger survey related to youth place meanings and attachment. Once again, the researchers revised the survey slightly related to pilot-test findings and feedback.

As a pilot test, the authors used the revised survey to evaluate the impact of summer EE programs on social capital among youth in the Bronx, New York. The authors administered pre- and post-program surveys to youth between the ages of 14 and 18. All of the youth were participants in urban EE programs (intervention,  $n = 63$ ) and in urban non-environmental youth employment programs (non-EE intervention,  $n = 24$ ). These programs were of the same length over the summer of 2010.

The results of this pilot test suggested that participating in EE programs was associated with statistically significant increases in some measures of social capital, including students' informal socializing and students' diversity of friendship. By contrast, there were not significant changes in any of these constructs in the non-EE intervention. In terms of reliability of the scales, the constructs for social trust and informal socializing and diversity of friendship were found to be statistically reliable, while the measure for social trust was usable, but on the low side in terms of being considered statistically reliable. The authors were not able to determine the reliability of the measures for associational involvement and civic leadership because the dichotomous scales in these questions meant they lacked appropriate statistics to measure reliability.

Overall, this pilot test provided an example of how social capital could be included in program evaluation, and suggested that certain EE programs are already addressing factors that increase social capital. The authors suggest

that further exploration is warranted for expanding the understanding of the relationship between social capital and EE.

### **THE BOTTOM LINE:**

The concept of social capital—which is fostered through collective activities that build social trust, networks, and connections between individuals, families, and community members—may be a valuable tool for developing and evaluating the impact of environmental education (EE) programs. Building social capital in communities can make community members more likely and able to take collective action to address environmental problems. Developing measures that appropriately and reliably assess different aspects of social capital, particularly within an EE context, is critical to better understanding what is occurring within an EE program to enhance social capital. In turn, those measures also help examine how social capital can contribute to various outcomes of interest, both environmentally related and otherwise.

Krasny, M. E., Kalbacker, L., Stedman, R. C., & Russ, A. (2015). Measuring social capital among youth: Applications in environmental education. *Environmental Education Research*, 21(1), 1–23.

## **SOCIAL INTERACTIONS AND RECOGNITION ENCOURAGE ENVIRONMENTAL IDENTITY DEVELOPMENT**

Although environmental education researchers have long considered how environmental attitudes may relate to environmental behavior, the connection remains unclear, primarily because there are so many pathways and intersecting relationships between the two constructs. Some have suggested, however, that environmental identity may provide another lens through which to consider environmental behavior. In this line of reasoning, people tend to act in ways that are consistent with how they see themselves as well as how they wish to be seen by

others. A number of different approaches have been taken to explore the topic of environmental identity in relation to the natural world.

Drawing on a theoretical frame of identity research from science education, the author considers the importance of social interactions in arguing that identity development is connected to practice, action, and recognition. In other words, one becomes a particular type of person through practice, expresses him or herself as a particular type of person in relation to others through action, and is recognized by others as a particular type of person.

The author applies this framework to a study examining environmental identity development among U.S. youth who are participating in a program focusing on climate change impacts in a South Asian nation. Program participants spent four weeks in South Asia: two weeks in the capital area; one week on a boat, learning about climate change impacts on a large mangrove forest; and one week in rural villages participating in service-learning projects. While in the country, participants lived with host families and each participant was paired with a host-country partner student. In addition to the time abroad, the program included a pre-trip orientation, a reunion three months post-trip, and participant-designed social action projects that were implemented in the participants' schools and home communities post-trip. In sum, 30 high-school students participated in the program; the students hailed from diverse socioeconomic and ethnic backgrounds and initially reported having varying interest in, and concern about, environmental issues.

The article focuses on data from post-trip interviews. The author interviewed 13 program participants three to six months after the trip. Similar to the overall pool of program participants, the interviewees were from diverse racial/ethnic backgrounds and initially reported having differing pre-trip levels of environmental awareness and concern. The author's interview approach was narrative, based on the initial prompt, "Tell me about the trip," followed by questions related to the participants' social action projects.

The author's analysis focuses on the interview data related to social interactions, paying particular attention to the impacts of interactions with different types of people (such as the host country residents, U.S. peers on the trip, and friends back home). The author uses Kempton and Holland's (2003) environmental identity development framework to analyze the data, identifying evidence of salience, or increased awareness of environmental issues; identification, or seeing oneself as an environmental actor; and practical knowledge, or knowledge about how to engage in environmental practice, which develops through action.

The author found that social interactions, both during the trip and after, were important for participants' environmental identity formation. Different types of social interactions were meaningful in reaching different stages in Kempton and Holland's model. Being recognized by others as environmental actors also enhanced environmental identity development.

One type of interaction—interaction with host-country residents—was particularly critical for moving participants toward the salience stage of identity development, while another type—interaction with co-participants—was more influential in moving participants toward the identification stage, or what the author terms the "environmental action" stage. When participants interacted with people in the host country who had been directly affected by climate change, the participants became more aware of climate change and its impacts, as well as of their own contributions to the climate-change problem. This heightened awareness also occurred for participants who began the program with little knowledge of, or concern about, the issue, as well as for those who were already concerned about climate change initially. The author suggests that those in the latter category moved deeper into salience, based on these interactions, indicating that there may be different degrees of salience.

Although interactions with people impacted by climate change were important for moving participants toward salience, interactions with co-participants were more

effective for moving participants toward environmental action. Many participants reported that they had adopted new environmentally friendly behaviors after the trip. They attributed some of these behavior changes to conversations with peers during the trip. Some described being inspired to act by peers whom they perceived as more knowledgeable and active in addressing climate change than themselves; by contrast, those who were already concerned about climate change found further motivation to act by realizing that there were others who shared their interests and concerns. This carried over after the trip, as some participants continued to share ideas and information that facilitated environmental action once home.

Another factor that the author found to be important in participants' environmental identity formation was being recognized by others as environmental actors. This happened in two ways. First, as part of the program, participants developed social action projects after returning from the trip. These projects took a variety of forms, but all were related to an environmental issue and were implemented in their school or community. In addition to providing an opportunity for participants to continue engaging in environmental action, the projects also allowed participants to be recognized and positioned by others in their schools and communities as environmental actors. Second, after returning from the trip, many participants reported teaching others in their communities about climate change, which led to others recognizing and positioning them as experts. This recognition, through the social action projects and their post-trip conversations, furthered and enhanced participants' environmental identities.

### **THE BOTTOM LINE:**

Environmental identity is a useful lens for examining people's movement toward environmental action and behavior. People act in ways that are congruent with not only how they see themselves, but also how they wish to be seen by others. Environmental identity develops over time, and different factors can influence this development. This study demonstrates the importance of social interactions

for developing an environmental identity. Moreover, different types of social interactions influence identity development in different ways: interacting with people who have been impacted by climate change can lead to awareness of environmental issues; interacting with peers, creating both inspiration and knowledge networks, can encourage environmental action. Additionally, being recognized by others as an environmental actor can further and enhance one's environmental identity.

Stapleton, S. R. (2015). Environmental identity development through social interactions, action, and recognition. *Journal of Environmental Education*, 46(2), 94–113.

## **ECOLOGICAL TALK AMONG FAMILIES AT TOUCH TANKS**

Touch tanks, which allow visitors to interact with marine organisms in a special enclosure, are popular exhibits at aquariums, zoos, and some science museums. The hands-on, up-close-and-personal features of touch tanks might be especially useful for helping visitors enhance their understanding of ecological science—or the study of relationships among organisms and their environment. Little research has been done, however, on how and what people learn when visiting touch tanks. In this paper, the researchers used observational methods to investigate what kinds of ecological content families discuss at touch tank exhibits and whether particular exhibit features influence the extent and type of ecological talk in which families engage.

Researchers frequently use conversations in informal learning settings to better understand what background knowledge families bring to the setting and what they might be learning when they engage in those settings. In this case, the researchers observed family conversations at four aquariums in Oregon and California. Two of the aquariums had touch tanks that the researchers classified as naturalistic, meaning the tanks were designed to look like natural tide pools, including details such as artificial rock walls and sandy floors. The other two aquariums had

touch tanks that were classified as utilitarian, meaning that the tanks were not designed to look like naturally occurring pools but, rather, had plain sides and floors, filled with clear water.

The researchers recruited families, inviting them to participate in the study as they approached the touch tank exhibit. Once the families agreed to participate, they were outfitted with small, wireless microphones and an additional digital audio recorder. The wireless microphones fed into a handheld video camera held by a researcher. The participants included 41 English-speaking families that were comprised of at least one parent and one child per family; the families' racial/ethnic backgrounds were reflective of the overall visitor populations of the aquariums in the study.

The researchers transcribed and analyzed the audio and video recordings, honing in on sections of the recordings when families engaged in instances of ecological talk. Within larger conversations centered on ecology, the researchers identified smaller "segments of ecological talk" (SET) and categorized those instances along two dimensions: (1) whether the segment related to organism-to-organism interactions (for example, an organism eating another organism) or organism-to-environment interactions (for example, an organism that lives in the wave zone interacting with the tides), and (2) whether the segment involved only family members or both family members and aquarium staff.

Overall, families spent about 15 minutes engaging with the touch tanks; of that, about 9% of the overall time was what the researchers coded as SET. Those segments were often brief, with nearly 80% of SET lasting only 30 seconds or less. In terms of the types of interactions families discussed during their ecological talk, a minority (17%) were organism-environment interactions. The majority (83%) were organism-organism interactions; of those, 40% referred to interactions between nonhumans and humans (typically, the humans were the people at the touch tank). One mother exclaimed, while interacting with a nonhuman organism, "Let's see if I can reach it.

Wow, look at it curl up." Although the prevalence of discussion about human-nonhuman interactions is not surprising, given the nature of the exhibits, the authors see it as a positive finding in terms of developing ecological awareness.

Median SET was greater for participant-staff interactions (26 seconds) than for participant-only interactions (12 seconds), suggesting that staff play an important role in supporting families' learning about ecological topics. However, although it might seem reasonable that naturalistic environments would spur families to engage in more ecological talk, especially about organism-environment interactions, this study did not support that assumption. Comparing ecological talk at naturalistic touch tanks to utilitarian touch tanks, the researchers found no significant difference in median SET time (17 seconds at naturalistic tanks and 16 seconds at utilitarian tanks). Time engaged in SET is used as a proxy for quality of ecological talk, as longer talk time may likely be related to deeper engagement. The researchers, thus, conclude that there is no evidence that naturalistic tanks support more or better-quality ecological talk among families.

### **THE BOTTOM LINE:**

Families visiting touch tanks at aquariums engage in ecological talk, although it accounts for only a small proportion of their overall engagement. This study provides evidence that staff interactions with visitors make a difference in terms of time spent engaging in ecological talk; therefore, institutions with touch tanks may consider investing in training staff members explicitly to support ecological explorations. This study does not provide evidence, however, that naturalistic touch tanks, which may be more expensive to build than more utilitarian ones, are more effective for supporting ecological talk.

Kopczak, C., Kisiel, J. F., & Rowe, S. (2015). Families talking about ecology at touch tanks. *Environmental Education Research*, 21(1), 129–144.

## CHILDREN'S EPISTEMIC KNOWLEDGE STRUCTURES: USING POLLUTION AS A FOCAL ISSUE

Environmental problems are often interdisciplinary and broad in scope. This presents a challenge in designing effective, compelling environmental education curricula, because cognitive abilities appropriate for understanding complex and multifaceted issues develop gradually. This paper's authors conducted semistructured interviews focused on pollution with school children between the ages of 9 and 16. They used these interviews to construct and understand the children's belief structures, which the authors defined as "not only the information the children possess, but also how the different concepts used by them are related." This concept provides one way of understanding how children may incorporate hidden elements and ideas into their concepts about the environment and how it functions.

One way of illustrating children's cognitive development is through the idea of mental models. Being able to consider multiple mental models enhances one's ability to understand a system. The paper's authors cite several studies that demonstrate the development of mental models through, for example, conditional statements, such as, "If [a] then [b]." The most rudimentary understanding occurs in the form of a conjunction: "Both [a] and [b]." The most sophisticated understanding comes later; it requires the ability to understand many different scenarios and may look something like this: "Both [a] and [b], neither [a] nor [b], [b] and not [a], but no [a] without [b]."

Previous research has demonstrated that, early in life, belief structures are largely based off of the senses and the present moment. Later, the ability to think in terms of invisible things (like microbes) and further into the past or future develops. The authors focused their research on three higher-level cognitive abilities: recognizing hidden dimensions of systems, making generalizations, and thinking temporally.

The researchers identified seven categories into which the children's responses to the pollution-focused questions fell. From combinations of those categories, the researchers assembled epistemic structures by considering how the pollution-related categories were clustered around different ages. The authors describe how the epistemic structures differ in how the antecedent (the pollutant) is connected to its impacts (consequences). As the children age and mature—and as their conceptions become more sophisticated—they begin to create more complex structures, or mental models.

For the first epistemic structure, corresponding with the youngest students, the authors did not separate the pollutant from its impacts either by time or distance. For the second epistemic structure, corresponding with the middle-age group, the students described the pollutant as separate from its impact but without a sophisticated understanding of the processes. For the oldest age group, with the third epistemic structure, the students separated the pollutant from its impacts in both space and time; rather than supposing a hidden agent for the impact, the students suggested a "disequilibrium in the amount of substances in the environment."

The research results challenge previous theories by offering insight into the cognitive abilities of children at different developmental levels. Although not easily suggesting a pathway to immediate implementation, the findings do suggest that leveraging this knowledge for curriculum design and future research will be helpful.

### THE BOTTOM LINE:

Tailoring curriculum to an age group's cognitive ability may be an important step in bridging the gap between knowledge and action in environmental education. Younger students' perceptions of environmental problems tend to be linked to the "here and now," whereas older students may be able to make more advanced abstractions, especially about the causes and effects of environmental phenomena, as well as hidden elements in causal structures. The sequence of such developments, however, is still somewhat unclear.

Rodriguez, M., Kohen, R., & Delval, J. (2015). Children's and adolescents' thoughts on pollution: Cognitive abilities required to understand environmental systems. *Environmental Education Research*, 21(1), 76–91.