

ENVIRONMENTAL EDUCATION

# RESEARCH BULLETIN

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## ABOUT THE RESEARCH BULLETIN

The *Environmental Education Research Bulletin* is a project of ChangeScale and ee360, a cooperative project of the U.S. EPA and the North American Association for Environmental Education (NAAEE), and 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/eepr/research/eeerb>. Please send questions and feedback to [eereseearchbulletins@changescale.org](mailto:eereseearchbulletins@changescale.org).

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# TABLE OF CONTENTS

## EQUITY, INCLUSION, AND CULTURAL RELEVANCE

Culturally Responsive Teaching for Science Education Page 5

## BEHAVIOR

Hope, Responsibility, and Action: How do young people view environmental issues? Page 7

Social Psychology's Influence on Environmental Concern and Behavior Page 8

Scientific Citizenship: Understanding student knowledge, motivations, and beliefs Page 10

## EVALUATION

Drawing-Based Evaluation of Ecosystem Knowledge Used as Alternative Assessment Page 12

Improved Conservation Knowledge after a Park Visit Page 13

## TEACHING METHODS

Enhancing Education for Sustainable Development during Adolescence Page 16

Using Portraiture in the Classroom to Stimulate Kinship with Animals Page 17

An Integrated Approach to Inquiry in the Science Classroom Page 19

Addressing the Nature of Science through Teaching about Climate Change Page 20

Using Music Videos to Teach Science Page 21

Mobile Devices for Improving Students' Understanding of Flowers Page 22

Teaching Climate Change Alongside the Carbon Cycle to Improve Learning Page 24

## SENSE OF PLACE AND NATURE CONNECTION

- Using Playscapes to Connect Young Children to Nature Page 26
- Self-Esteem and Connectedness to Nature on Youth Wilderness Expeditions Page 28
- Understanding the Role of Eco-Attractions in Fostering  
Human–Nature Connections Page 29

## PROFESSIONAL DEVELOPMENT

- Interactions and Outcomes in an Online Course for Environmental Educators Page 30
- A Framework for Guiding Primary School Students through Inquiry-Based Science Page 32

## OTHER RESEARCH

- The Emotional Impact of Zoo Animals Page 34
- Using Tablets to Increase Science Literacy among National Park Visitors Page 35



# INTRODUCTION

Dear Colleagues,

ChangeScale and the North American Association for Environmental Education (NAAEE) have collaborated with researchers at Stanford University to create this eleventh issue of the *Environmental Education Research Bulletin*. Talented environmental educators are conducting fantastic programs, collaborating with communities, using hands-on strategies, and making critical links that help enhance environmental awareness, build skills, and support informed action. Yet many of these committed professionals lack the time to keep up on the latest research, 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 2016) of a number of environmental education-related journals, including *Journal of Environmental Education*, *Environmental Education Research*, *Applied Environmental Education & Communication*, *Journal of Experiential Education*, *International Journal of Science Education*, *Journal of Interpretation Research*, and *Visitor Studies*.

We want these bulletins to be as useful as possible, so please send your feedback on additional topics or journals you would like us to cover as well as alternative formats that may be helpful. Send suggestions to: [eereseearchbulletins@changescale.org](mailto:eereseearchbulletins@changescale.org).

We also encourage you to check out and contribute to the research blog on eePRO, NAAEE's professional

development community. To join the eePRO community section devoted to research and evaluation, visit:

<https://naaee.org/eeepro/groups/research-and-evaluation>.

You may also be interested in the NSF-funded Relating Research to Practice resource, a joint effort of the Exploratorium, the University of Washington, King's College London, and the Afterschool Alliance. The website is available here:

<http://relatingresearchtopractice.org/>.

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



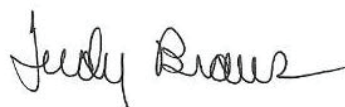
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# EQUITY, INCLUSION, AND CULTURAL RELEVANCE

## CULTURALLY RESPONSIVE TEACHING FOR SCIENCE EDUCATION

Science education standards in the United States have shifted to focus on practices and processes, as well as to include interdisciplinary and crosscutting topics, such as environmental science. With this shift, teachers are apt to include environmental education topics and programs as part of their curriculum, and more students with diverse backgrounds have the opportunity to participate in environmental education programs. Against this backdrop, it has become critically important to train environmental educators in culturally responsive teaching.

In this study, researchers identified key practices that support culturally responsive and rigorous science teaching. The researchers studied a professional development program: Science Teachers Are Responsive to Students (STARTS). The program's creators used research on curriculum design, professional development, and instructional practices to create the initiative, and they specifically sought resources that would support teachers' efforts in offering culturally competent and rigorous science instruction. The program took place over six months and consisted of both job-embedded activities and monthly Saturday sessions. The teachers constructed, analyzed, and revised lessons; participated in tasks that promoted reflective practice and incorporation of students' backgrounds into instruction; studied science curriculum topics; identified professional growth areas; and participated in face-to-face collaborative sessions as well as in teaching science units.

The researchers followed five life science teachers through the program, all of whom taught in a large, culturally diverse school district in the southeastern United States. The participating students reported having diverse racial and ethnic backgrounds, including Latino/a, Haitian, Black, White, Asian, and multi-racial. The teachers were female, of multiple ethnic backgrounds, and had between 2 and 24 years of teaching experience.



The researchers used a design-based approach and technique called “conjecture mapping.” Data sources included group interviews, video recordings, program artifacts, reflective writing prompts, feedback on program effectiveness, and teachers’ culturally responsive science units. Researchers analyzed the data to identify “mediating processes” the specific program experiences associated with desired teacher outcomes. In other words, they sought to identify the professional development experiences that helped participants become more culturally responsive teachers. Based on their previous work, the researchers grouped the desired teacher outcomes into six themes: community-building, conceptions of culturally responsive science education, views of students, instructional changes, repositioning, and using a toolbox.

The researchers reported on three critical processes. First, teachers simultaneously examined their classroom practices and learned about students’ experiences, both in and out of school. They could then identify strategies that were responsive to classroom needs and topics relevant to the students. Second, teachers evaluated exemplars of culturally responsive teaching while also thinking critically about their own classrooms; they could then envision instruction specific to their context and discipline. Finally, when teachers were involved in selecting and justifying instructional practices for their classrooms, they received support to connect their instruction with students’ experiences. The researchers argued that those processes deepened teachers’ understanding of the purpose and feasibility of culturally responsive science instruction, facilitating their acquisition and application of relevant teaching tools.

This study focused on a limited sample of teachers. The authors, therefore, indicate the need for additional studies across varied contexts, noting that such an expansion would help identify key elements and processes that contribute to developing culturally responsive science practices.

### **THE BOTTOM LINE:**

Meaningful professional development related to culturally responsive teaching requires more than simply providing information about those practices. Teachers also need support to reflect critically on their own practices and contexts. Teachers should be given simultaneous and continuous opportunities to learn about their students’ experiences and needs, examine their own teaching practices, link research-based practices to classroom needs, and create an overall vision that combines rigorous science instruction with community building.

Brown, J. C., & Crippen, K. J. (2016). Designing for culturally responsive science education through professional development. *International Journal of Science Education*, 38(3), 470–492.



# BEHAVIOR



## HOPE, RESPONSIBILITY, AND ACTION: HOW DO YOUNG PEOPLE VIEW ENVIRONMENTAL ISSUES?

Many young people struggle to link their personal actions with global problems. Despite concern about environmental issues, those uncertain connections can create confusion on how to take relevant environmentally related action. Furthermore, young people tend to think that government, rather than individuals, is primarily responsible for the environment. This can result in a discrepancy between understanding the source of environmental problems and how individual actions—such as voting, attending political rallies, or recycling—might create change. We may find ways to support young people in meaningfully linking these ideas by considering the factors that drive their concern for environmental issues and their understanding of effective environmental actions. Fostering a holistic approach to addressing multifaceted environmental problems may be especially important. This study's authors surveyed young people about their perceptions of environmental issues and actions.

Three-hundred-and-five high-school students (135 male and 170 female) between the ages of 12 and 18 answered, in class, a 9-item, survey about their attitudes and concerns regarding current environmental problems. The students attended one of five public high schools in Southeast Queensland, Australia. Researchers designed the three-section survey to measure: (1) attitudes about the environment and views of who is responsible for environmental problems, (2) the perceived relative importance of environmental threats, and (3) perceptions of the actions most critical in addressing environmentally related issues. Researchers designed the questions to understand students' general environmental concerns and whether a sense of hope and, relatedly, hopelessness, fueled their feelings. Using statistical analyses, and controlling for age and gender, the researchers looked for relationships across students' attitudes, views on responsibility for environmental problems, and perceived importance of environmental issues and actions.

The researchers found some “mismatched” environmental perceptions. As in previous studies, the researchers found that, overall, young people viewed environmental action as important, but the specific type of action that young people considered important was inconsistent with some of their other views. While students assigned a higher level of environmental responsibility to the government than to themselves, for example, they also ranked “writing to politicians” as the least important environmental action and “saving electricity” as the most important.

Respondents’ sense of hope or hopelessness was critical to how they perceived environmental threats. In turn, those perceptions related to how they thought about responsibility and action. If the student believed that an action was useful, for example, then they were more likely to feel empowered to take that action. Young people who perceived the government as responsible for protecting the environment were more likely to indicate that global warming was an important environmental issue. Meanwhile, respondents who took personal responsibility for the environment were more likely to view resource consumption as the most important environmental issue. Overall, students’ ideas about the environment were strongly influenced by their hope that people can work together to improve the environment.

The authors acknowledged the study’s limitations. This study did not control for social and political drivers, which are likely influencers of young people’s feelings of hope or hopelessness. Further, some of the questions were quite abstract in their structure and content. This abstractness may have limited respondents’ abilities to interpret and respond to ideas related to complex environmental issues (such as, for example, “resource consumption”). Additional studies could strive to elucidate some of those confounding factors.

### **THE BOTTOM LINE:**

This study identified disconnections between young people’s understanding of environmental issues and their perceptions of impactful environmental actions. Students’

feelings of hope or hopelessness relate to their ideas about the environment; in particular, a sense of hope may help young people understand the individual or collective actions they can take to address environmental threats. Environmental educators can help young people develop a sense of environmental connectedness, cultivate feelings of hope, and relate environmental issues that most concern them with specific, relevant, and impactful actions.

Wilks, L., & Harris, N. (2016). Examining the conflict and interconnectedness of young people’s ideas about environmental issues, responsibility and action. *Environmental Education Research*, 22(5), 683–696.

## **SOCIAL PSYCHOLOGY’S INFLUENCE ON ENVIRONMENTAL CONCERN AND BEHAVIOR**

Environmental educators are often concerned with providing opportunities and pathways that connect people with environmental action, yet understanding the disconnection between pro-environmental attitudes and environmentally related behaviors can be challenging in a field with a range of theoretical frameworks. In the quest to understand influences on environmental behavior, many behavioral science researchers disagree on whether it is more important to emphasize social demographic factors or social psychological factors. A 1998 study found that social psychological factors, such as thought patterns and biases, were particularly influential in how people felt about and acted toward the environment. Findings from that study suggested that social psychological variables were more influential on environmental behavior than social demographic factors, such as one’s background and socioeconomic situation.

Re-examining past research using new measures and current data can help test whether long-held ideas remain accurate, particularly in light of changing social and environmental conditions. For that reason, this study’s authors sought to replicate the earlier environmental-concern-and-behavior study, exploring whether social psychological variables or



demographics might better explain behavior. To that end, the researchers conducted a quantitative analysis of data from the 2010 U.S. General Social Survey (GSS), which included demographic and psychological measures not previously used. The GSS included interview data from 2,044 people about the following:

- *Behavioral indicators*, including consumer behavior, belonging to environmental groups, views on environmental spending, willingness to pay or sacrifice for the environment, signing petitions, and thinking the government should protect the environment.
- *Knowledge, attitudes, beliefs, and cognitions*, including Awareness of Consequences (AOC), knowledge of environmental causes, knowledge of environmental solutions, and internal or external locus of control (whether people feel their actions can make a difference).
- *General worldview and ideology about humanity and the environment*, including whether respondents think economic progress and human activity are environmentally harmful, and whether they consider themselves to be postmaterialist (defined as “a value orientation toward self-expression and quality of life over economic and physical security”).
- *Social demographic variables*, including gender, race, education, age, income, religion and spirituality, party identification (liberal, conservative, or independent), and political ideology (liberalism).

Researchers analyzed these data to examine how social demographic and social psychological factors related to environmental concern and behavior. Controlling for social demographics, social psychological factors explained a significant amount of the differences in environmental concern and behavior, with “Awareness of Consequences” showing the strongest relationship to environmental behavior. Although not all of the social psychological variables were significant, many of the variables linked with some aspects of environmental concern and behavior, but not with others.

Social demographic characteristics, together with the postmaterialism variable, explained between 8% and 19% of the variance in environmental attitudes, values, and beliefs. Researchers also found statistically significant relationships between some of these factors and measures of intention and behavior. In particular, they found the following to be important:

- *Age* related to consumer behavior. Individuals who were in the slightly younger age bracket (30- to 44-years-old) were significantly less likely than those in the middle-age category (45- to 65-years-old) to behave pro-environmentally. This finding is somewhat different from what past research has suggested; the authors postulated that other factors, such as economics, might explain this finding.
- *Education* was related to environmental attitudes, values, and beliefs, as well as behavior. In this case, the authors surmised that the “education” variable might serve as a proxy for environmentally related knowledge and skills. Interestingly, the authors found a slight negative relationship between education and “Awareness of Consequences,” such that respondents with a higher level of education were less likely to report being aware of consequences of various environmentally related issues.
- *Race*-related demographic variable(s) resulted in mixed findings. The authors found that race related to some social psychological factors surrounding environmental beliefs, but not others, leading them to suggest that future research should consider potential mediating factors, such as education, organizations, affiliations, and communication networks.
- *Political ideology* was associated with public behaviors related to environmental activism, but it was not associated with non-activist public behaviors, such as approval of regulations or public policies, or private behaviors, such as making environmentally friendly purchases.
- *Religion* was somewhat associated with behavior, with those indicating a Catholic religious orientation more likely than those indicating a Protestant orientation to engage in pro-environmental consumer behavior.



- *Postmaterialism*, or valuing quality of life over economic and physical security, was positively associated with environmental action and advocacy.

Overall, the findings from this study suggest that researchers cannot discount demographics entirely. The study identified several demographic factors that relate to pro-environmental attitudes, values, beliefs, intentions, and behaviors. The authors suggest, therefore, that researchers should further study these complex relationships to understand how the variables interact.

### THE BOTTOM LINE:

Given the many situational and psychological variables that affect how people learn, think, feel, and act, researchers and practitioners who are interested in motivating pro-environmental behaviors must consider complex relationships among attitudes, values, knowledge, and skills, as well as the context in which those variables interact. Consistent with prior research, this study indicates that, although social demographics cannot be discounted, social psychological variables are more likely to be significantly associated with multiple measures of environmental concern and behavior. In particular, environmental educators may wish to focus on developing “Awareness of Consequences” among participants, as this factor shows strong relationships with environmental intentions and behaviors.

Newman, T. P., & Fernandes, R. (2016). A re-assessment of factors associated with environmental concern and behavior using the 2010 General Social Survey. *Environmental Education Research*, 22(2), 153-175.

## SCIENTIFIC CITIZENSHIP: UNDERSTANDING STUDENT KNOWLEDGE, MOTIVATIONS, AND BELIEFS

Developing the knowledge, skills, and motivation to engage in appropriate pro-environmental action is a cornerstone of environmental education. Educators can support students in becoming scientifically minded citizens through focusing on activities that deepen environmentally related knowledge, attitudes, and skills. Research that examines how and why young people engage in scientific citizenship, and using those data to inform curriculum design, can encourage action on important socio-scientific issues in school settings and beyond.

This study’s authors argue that teaching scientific citizenship should not feel didactic but, rather, should work to translate scientific knowledge and beliefs into actions. Therefore, educators should be aware of what citizenship activities students are already participating in or what activities interest them. To that end, the study explored the interactions among students’ scientific knowledge, motivations, and beliefs, and the actions that they reported taking.

The authors focused on behaviors that students reported consciously taking to “make the world a better place,” such as riding bikes to school. The authors noted that people might act in the same way for different reasons: one student, for example, might ride a bike in order to reduce her overall carbon footprint, while another might do so because she does not have access to a car or have a driver’s license yet. Based on the reasoning and motivation, the behavior might (or might not) be considered purposefully pro-environmental, driven by scientific understanding, and intended to be a type of citizenship behavior. In this example, although the resulting environmental outcome may be the same, the reasoning in the latter description (not having access to a car or not having a license) would not count as a purposeful citizenship action.

To collect data for this study, the authors interviewed 35 upper-secondary international students who were all attending a Millennium Youth Camp focused on science and engineering. The researchers conducted semi-structured interviews around a number of key themes, with an emphasis on what students perceived to be the biggest problems facing humanity and what they had done personally to make the world a better place.

Based on initial analyses of the interview data, the researchers developed three categories of action that reflected students' citizenship and motivations: personally responsible action, participatory action, and preparation for the future.

*Personally responsible actions* described cases in which students reported an awareness of wanting to help the environment or other people through their individual actions, such as efforts to recycle and make ecologically friendly consumer choices. Students reported the lowest level of engagement with this category, with 20 out of 35 students reporting some form of personally responsible action. Students offered two main reasons for taking these kinds of actions: being motivated by their personal values, such as kindness and justice, and wanting to lead or inspire by example.

*Participatory actions* described those performed as part of a group, whether the student reported organizing or participating in the group. Out of 35 students, 21 reported taking some form of participatory action, explaining their motivations for doing so as a desire to advance their own or others' understanding of an issue or promote community awareness. Examples of these kinds of actions included participating directly in local projects, fundraising for charities outside their community, and conducting awareness-raising campaigns.

*Preparation for the future* described actions that students took to prepare for more complex or wide-reaching actions in the future. Examples included studying hard or learning new skills that would help with future career choices, such as becoming a scientist. This was the most common category in which students showed scientific citizenship, with 25 out of 35 students rationalizing their current activities as working toward future goals. Many hoped to contribute to future scientific or technological developments to make the world a better place.

### THE BOTTOM LINE:

Young people engage in activities that they see as “making the world a better place” in a variety of ways. Student-centered learning techniques that reflect the diversity of reasons for action can support and encourage those activities. Participating in scientific citizenship can help develop students' sense of *personal responsibility* and nurture their interest in scientific citizenship. Giving students opportunities to share their work with peers and the community can be a powerful *participatory* motivator for student actions, inspiring them to *prepare for future* actions by interacting with a range of professionals, including politicians and community leaders. Such interactions may help students visualize how to translate their interests into careers, as well as understand scientific issues within socioeconomic and political contexts. These and other student-centered techniques can support personal, societal, and vocational motivations for scientific citizenship.

Vesterinen, V. M., Tolppanen, S., & Aksela, M. (2016). Toward citizenship science education: What students do to make the world a better place? *International Journal of Science Education*, 38(1), 30-50.



# EVALUATION

## DRAWING-BASED EVALUATION OF ECOSYSTEM KNOWLEDGE USED AS ALTERNATIVE ASSESSMENT

Many informal environmental education programs lack protocols for assessing their participants' knowledge. When assessments do occur, educators typically assess students' knowledge with conventional multiple-choice, true-or-false, and short-answer questions. This study's researchers investigated an alternative, drawing-based method of assessing student understanding.

The study took place at an informal environmental education facility, The E.O. Wilson Biophilia Center at Nokuse Plantation ("The Center"), which focuses on re-establishing the longleaf pine ecosystem in the Florida Panhandle and educating visitors about biodiversity, balanced ecosystems, conservation, preservation, and restoration. The Center and the school districts whose students attend Center programs sought an alternative to conventional knowledge assessments.

The Center chose to use a drawing-based assessment because they perceived it to be minimally intrusive, easy to administer and score, and enjoyable for participants. Existing research on the efficacy of drawings as learning assessment tools is mixed, however. Some studies find a link between drawings and student understanding, while others find no link. Therefore, this study's researchers sought to understand whether drawings might be an effective way to measure changes in fourth-grade (9–10 years old) students' understanding of the local ecosystem after participating in programs at The Center. To do so, they also wished to develop a reliable rubric for scoring the drawing-based assessment.

Over two years, the researchers collected pre- and post-program drawings from fourth-grade students who attended multiple days of programming at The Center. Classroom teachers asked students to draw a picture of the longleaf pine forest prior to attending The Center's program and again after attending the program. In the first year, the researchers collected drawings from 205 students who attended the program for two days and from 201 students who attended for five days. In the second year, the researchers collected drawings from 293 students who attended the program for four





days. The assessment, called Draw a Longleaf Pine Forest Ecosystem (D-LLPFE), asked students to draw what they thought the longleaf pine forest ecosystem looked like in northern Florida. The researchers designed the assessment to measure understanding of the ecosystem's ecologically important aspects. During the first year, researchers did not provide a script explaining the activity; during the second year, they provided a script and drawing paper.

Based on pilot results and trends, the researchers created a scoring rubric based on the ecosystem's key ecological features that were the focus of The Center's program. The rubric included 20 items grouped under Fauna, Flora, Ecosystem Diversity, and Characteristics Specific to Longleaf Pine and Forest Processes. The highest possible score was 20 points. The researchers tested the rubric through several iterations with independent science educators and examined inter-rater reliability; they also collected evidence of the assessment's content validity.

From analyses of the first-year data, the researchers found improvement from pre-test to post-test in the students' portrayal of important aspects of the longleaf pine ecosystem for both the two-day and five-day groups. The researchers made changes to four items in the rubric for the second year, based on first-year results. Analyses of the second-year data also showed an increase from pre-test to post-test in the depiction of important ecosystem components. Specifically, comparing pre- and post-program drawings, researchers found a statistically significant increase in average scores of 11.7%. The researchers did not find any significant differences in scores based on students' gender or ethnicity.

The researchers pointed out several important limitations to the study: the restrictions on drawing size and amount of time given for the task, the way the teachers introduced the task to the students, and the students' desires and attempts to "make it look nice" may have influenced the exclusion of certain ecosystem components. In year two of the study, however, the researchers mitigated some of those limitations by providing a standard assessment prompt and an explanatory script. The researchers also

interviewed 41 students from the second year, asking clarifying questions about their drawings. Although the interviews provided some evidence of the assessment's validity, the students' responses also indicated concerns about some of the assessment's limitations, such as time restrictions and students' drawing abilities.

### **THE BOTTOM LINE:**

A drawing-based assessment, paired with a scoring rubric, may offer a reliable, valid, and useful alternative assessment option for particular purposes and contexts, such as the one in this study: assessing fourth-graders' learning about key ecological features of a specific ecosystem. Drawings may provide a useful alternative assessment for informal educational settings, as they are enjoyable, minimally intrusive, and the authors argue that they are easy to administer and score. In the case of this program, comparing student drawings from pre- and post-participation was useful in helping assess changes in ecological understanding. As much as possible, however, evidence for the reliability and validity of the assessment is important to consider, particularly if the data will be used for high-stakes or evaluative purposes.

Dentzau, M. W., & Gallard Martinez, A. J. (2016). The development and validation of an alternative assessment to measure changes in understanding of the longleaf pine ecosystem. *Environmental Education Research*, 22(1), 129–152.

## **IMPROVED CONSERVATION KNOWLEDGE AFTER A PARK VISIT**

Partners within the international protected areas network increasingly offer conservation education programs. However, few studies have evaluated the impact of those programs on participants' pro-environmental attitudes and behaviors, especially in the developing world. In this study, researchers evaluated the conservation education program offered at Serra Malagueta Natural Park (SMNP) in Cape Verde, a small developing-state island in Africa's Sahel

Region. The researchers studied the program's impact on student participants' environmental knowledge, opinions about the park and biodiversity conservation, and self-reported behaviors. They compared the results with those of a similar group of students who did not participate in a park visit.

The park-visit group included 392 students in grades 5 through 12 from 10 schools who visited SMNP between March and July 2011. Students in these groups completed a questionnaire in the park immediately before their visit and in their classrooms one week after the visit. Of those 392 students, 54 responded only to the pre-visit survey. Over the same time and using the same questionnaire, the researchers collected data from students in similar schools and grades who did not visit the park or participate in the conservation education program; this sample included 296 students from seven schools. Researchers also asked students in the non-park-visit comparison group to complete the questionnaire twice; however, 170 students in this group completed the questionnaire only once. Additionally, the researchers collected questionnaire data from 18 teachers, 12 of whom were with the park-visit group and six with the comparison group. The teacher questionnaire asked whether the teacher had previously visited the park with students and whether s/he had recently taught park-related material in the classroom. The questionnaire also asked teachers to indicate their gender and level of educational attainment.

Researchers designed the student questionnaire to account for recommendations that previous studies had made. The questionnaire included four sections, assessing: (1) socio-demographic background; (2) biodiversity conservation knowledge (multiple-choice and open-ended questions on plant and animal diversity); (3) opinions on parks and conservation (Likert scale-type questions); and (4) self-reported pro-environmental behaviors, focusing on actions mentioned by park educators (e.g., frequency of littering).

The researchers used a method called Differences-in-Differences (DID) to compare the pre-visit and post-visit responses of the park-visit group. They also compared the post-visit responses of the park-visit group with the no-visit comparison group. The researchers considered characteristics of the students such as gender, whether they were rural or urban residents, their grade level, and the type of school they attended (for example, public or private). They found that, on these characteristics, the two groups were similar in all aspects, except that the park-visit group included a higher percentage of rural residents.

Of the findings related to conservation knowledge and opinions, the primary finding related to biodiversity conservation knowledge: The park-visit group demonstrated a statistically significant increase of 9.5% in their biodiversity-conservation knowledge when comparing their pre-visit and post-visit scores. Students in higher grades showed greater knowledge gains than those in lower grades. The researchers posited that these increases might indicate that the SMNP program is more appropriate for older students, or that younger students in Cape Verde may have poorer test-taking skills. They argued that the latter explanation is more plausible, as Cape Verde students rarely encounter multiple-choice tests. The researchers found no differences in program impact based on student gender or type of school attended (public/private).

Biodiversity conservation knowledge (measured at post-visit) was also significantly higher in the park-visit group versus the comparison group. Park-visit students also demonstrated higher initial (pre-test) knowledge than the comparison group. The researchers mostly attributed this difference to preparatory learning about the park before their visit. Indeed, data from the teacher questionnaires revealed that nine of the 12 park-visit teachers reported teaching their students about the park before the visit, whereas only two of the six no-visit teachers had done so. Further, six of the park-visit teachers previously had taken their students to the park, compared with one teacher

in the comparison group. To account for the in-class preparatory activities, the authors recommend that future studies administer the pre-test survey before the teacher initiates field-trip discussions.

The study found no significant differences in students' opinions on parks and conservation, both when comparing the pre- and post-visit responses of the park-visit group and also when comparing the post-visit responses of the park-visit group with those of the no-visit group. One possible explanation is that pro-environmental opinions were initially high for both groups; therefore, there was little opportunity for improvement based on the park program. Finally, self-reported behavior did not change pre- or post-visit for the park-visit group, and it was not significantly different between the park-visit and comparison groups. This finding is consistent with the SMNP's educational goals, which purposefully focus on conveying knowledge about biodiversity and not on connecting that knowledge to personal behaviors.

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

Opportunities exist to increase young people's biodiversity and conservation knowledge through direct, place-based experiences and engaging, firsthand educational programs, such as those afforded through visits to nearby parks. Visiting a national park can positively influence students' local environmental knowledge, particularly when coupled with pre-visit preparation in the classroom. Male and female students, as well as students from public and private schools, can benefit equally from such experiences. However, after such a visit, the students may not engage in any more, or any different, environmentally related behaviors, particularly if the program does not specifically emphasize those types of behaviors. If educators desire for a program to influence environmental behavior-related outcomes, then they must specifically design the program to do so.

Burnett, E., Sills, E., Peterson, M. N., & De Perno, C. (2015). Impacts of the conservation education program in Serra Malagueta Natural Park, Cape Verde. *Environmental Education Research*, 22(4), 538–550.



# TEACHING METHODS

## ENHANCING EDUCATION FOR SUSTAINABLE DEVELOPMENT DURING ADOLESCENCE

Sustainable Development (SD) stands on three pillars: environmental, social, and economic. Studies suggest that people's interest and concern about environmental issues may wane during adolescence (ages 13–17), but researchers know less about whether this same trend occurs with interest in the other two pillars of SD: social and economic issues.

This study, therefore, set out to address this knowledge gap, examining changes in the broader concept of Sustainability Consciousness (SC). The authors define SC as “a composite of knowingsness, attitudes, and self-reported behavior” as those concepts relate to environmental, social, and economic dimensions of sustainable development.

The research took place in Sweden, which the researchers deemed an appropriate setting thanks to recent curricular revisions focusing on sustainability. Sweden introduced a certification system related to Education for Sustainable Development (ESD), providing ESD-related teacher professional development and ensuring that certified schools would use this approach to teaching.

The authors surveyed 2,413 students from Swedish schools, examining for age-related differences in SC. They did so by comparing the views of adolescents to those of younger and older groups. The focal study group was 15- and 16-year-old (grade 9) students (termed as “adolescents” in this study). The two comparative groups were 12- and 13-year-old (grade 6) students (“pre-adolescents”), and 18- and 19-year-old (grade 12) students (“young adults”). Researchers selected study participants at each grade level to represent ESD-certified and non-certified schools. The researchers developed a 50-item instrument to measure students' sustainability consciousness, carefully creating three age-adapted, but compatible, versions of the same questionnaire. Students submitted their responses online, which minimized missing responses and allowed direct transfer of data to the statistical software used by researchers.

The researchers found a dip in students' SC as they entered and went through adolescence, but that decline subsided when they transitioned into adulthood. Mean SC scores were statistically significantly lower in



all three SD dimensions for adolescent students compared to sixth and twelfth graders. Those results expand on prior studies that have documented a similar drop in environmental attitudes and concerns: in other words, these researchers found a similar adolescent-related pattern when also integrating SD's social and economic dimensions. This research contributes new knowledge by comparing youth at various age ranges, finding that the older group had significantly higher SC scores and mean values on all SD dimensions than the adolescent group.

The data demonstrated this adolescent decline regardless of whether the students attended an ESD-certified school. Further, the analyses suggested that the decline might be amplified for students attending schools with ESD certification. According to the authors, Kaplan and Kaplan's (2002) "Reasonable Person Model" (RPM) might offer one explanation. They describe this adolescent phenomenon as relating to interacting cultural and evolutionary factors. The RPM integrates three informational needs: (1) the need for building mental models (capacity to seek, understand, and use information); (2) the need for effectiveness (increased level of confidence and competence); and (3) the need for meaningful actions (opportunity to do what one believes matters). The informational needs increase during adolescence, while brain changes promote a shift toward autonomy. Consequently, adolescents pay less attention to others and are less concerned with environmental, social, and economic issues in their surroundings.

The *need for meaningful actions* is particularly relevant in light of the surprising finding that the ESD-schools were negatively associated with adolescents' SC. Kaplan and Kaplan highlighted that meaningful action has to include high levels of autonomy, social support, and respect for the youths' own thoughts on what constitutes meaningful action. This paper's authors posit that ESD-certified schools may reinforce a traditional, normative, fact-based teaching approach that does not consider the needs of different age groups, including adolescents' increased informational needs. The Swedish education system has modernized its curricula and certification program to promote the integration of a novel training-based approach to ESD. In light of the authors' findings, they highlight

potential challenges in implementing the ESD approach. The authors call for more research to better characterize the relationships between ESD methods and the SC adolescent dip; they also suggest the need to study other geographical contexts.

### THE BOTTOM LINE:

Sustainable Development (SD) relies on three pillars: environmental, social, and economic. Research shows that youth consciousness related to all three pillars of SD declines, particularly during adolescence. However, an Education for Sustainable Development (ESD) approach that fosters student empowerment, ownership of lessons learned, and opportunities to take autonomous and meaningful actions might counteract that downward trend.

Olsson, D., & Gericke, N. (2016). The adolescent dip in students' sustainability consciousness: Implications for education for sustainable development. *Journal of Environmental Education*, 47(1), 35–51.

## USING PORTRAITURE IN THE CLASSROOM TO STIMULATE KINSHIP WITH ANIMALS

Animal portraiture is an artistic form that some artists, educators, and researchers suggest has the potential to change human perceptions, attitudes, and emotions about animals. They envision this type of portraiture as being part of a holistic approach to environmental education because, rather than reinforcing utilitarian viewpoints, this type of artistic representation might encourage respectful perspectives on human/non-human relationships. Moreover, animal portraiture can suggest notions of kinship and individuality, encouraging the idea that non-human animals exhibit similarities to humans and focusing on their characteristics as individuals. Little research has occurred on the effects of animal portraiture on affective and cognitive outcomes, however, and most research has been conducted in free-choice settings (such as museums); little has been conducted in formal settings (such as classrooms).



The researchers conducted this study with pre-university students in Montreal, Canada, and focused on a slideshow designed to activate affective responses to animals. The study's participants enrolled in a literature-related course called, "Human versus Nature?" The study sample of 51 students included 22 males and 28 females; 1 student did not indicate their gender identity. The students, 47% of whom were Canadian, reported being from diverse racial/ethnic backgrounds. The majority (35) were 18–19 years old, with the range being between 18 and 39 years of age.

The researchers used Personal Meaning Maps (PMMs), which is a research method that explores how participants make meaning of an experience, concept, or idea. The researchers collected data over the course of two days before, during, and after the students watched the slideshow. Before the slideshow, researchers gave each participant a blank sheet of paper with the prompt "Animal" written in the middle. Then, the researchers asked the students to write all thoughts, images, sentences, or words that came to mind in relation to that word. They encouraged the students to elaborate on those words using examples and explanations. Next, the researchers asked students to watch a 6-minute slideshow, which included 31 photographs of animal portraits, mixed with 5 slides of nature poems, and a brief video interview with the animal-portrait artist explaining his artistic method. After the slideshow, the researchers asked the students to review their pre-slideshow PMMs, make amendments, if desired, and elaborate on new concepts or constructs. The researchers provided different colored pens at each step to track changes in comments and descriptors.

To analyze the data, the researchers first identified eight thematic categories emerging from the participants' words in pre- and post-slideshow PMMs: (1) Pets/Symbols, (2) Biological/Wild Nature, (3) Commodity/Resource, (4) Dangerous, (5) Kinship, (6) Sentience/Individuality, (7) Mistreated/Vulnerable, and (8) Free/Majestic. The researchers created two measures within each category. First, the researchers defined *breadth* as "the proportion of students whose meanings fell into the thematic category pre- and post-slideshow." Second, they calculated *intensity* as an aggregate of *depth* (complexity and detail of descriptors

of "Animal") and *emotion* (strength and magnitude of the descriptors' attributes); they scored each component (depth and emotion) with 1 to 3 points, leading to intensity scores ranging from 2 to 6 points.

The mapped meanings of "Animal" were different before and after the slideshow for 92% of the students. In terms of breadth, pre-slideshow student meanings mostly landed in the following categories (in order of frequency): Biological/Wild Nature (100% of students), Pets/Symbols (72.5%), Commodity/Resource (66.6%), Dangerous (58.8%), and Free/Majestic (58.8%). After the slideshow, maps showed statistically significant decreases in the previous top four themes, and significant increases in the mentions of Kinship (+21.6%) and Sentience/Individuality (+19.6%).

The measure of *intensity* extends these findings. The researchers noted a 202.9% increase in *intensity* of descriptors for Kinship in post-slideshow PMMs. Examples of participant comments with the highest score on *intensity* (six points) included: "Animals have families and are part of a bigger system like humans," and "I saw real human emotion in the eyes and faces of the animal portraits, remind[s] me of real people." By contrast, the lowest-scoring comments on *intensity* (two points) were very brief, such as "Similar to us." Researchers found the second-highest increase in *intensity* for the theme "Sentience/Individuality" (78.4%). Comments with the highest scores (six points) in this category included, "Felt like they all have their own personality, not just between species but between individuals," and "After the slideshow, they seemed a little deeper mentally..." There was a *decrease* in the intensity of descriptors for "Biological/Wild Nature," "Pets/Symbols," "Commodity/Resource," and "Dangerous." Finally, researchers noted no change in *breadth* or *intensity* for the "Free/Majestic" theme, and there was no evidence that exposure to poems impacted results.

The researchers concluded that the study provides evidence that animal portraiture in a classroom setting can play a role in increasing care for animals, extending prior studies conducted in free-choice or museum

environments. The authors call for re-examining the effectiveness of current animal narratives and visual representations. They highlight, for example, that the visual cultures of movements for animal rights and wildlife conservation tend to depict animals as “distant and separate from the human as either a victim or part of a romanticized nature,” and this might be counterproductive. By contrast, the researchers argue that bringing animals into a human frame and representing them as individuals may improve viewers’ capacity to relate and empathize with the animals, which could stimulate a desire for animal protection and conservation.

### THE BOTTOM LINE:

Placing non-human animals in a more human frame, through an artistic medium such as portraiture, can help people associate non-human animals with human-like qualities. This study demonstrates that students exposed to animal portraiture may have enhanced perceptions of animal kinship and individuality. Environmental education and conservation professionals who focus on animal protection may wish to consider using creative methods, such as animal portraits and portraiture, in teaching. Such methods might help build empathy toward non-human animals as well as broader ecosystems, and may augment understanding related to species individuality.

Kalof, L., Zammit-Lucia, J., Bell, J., & Granter, G. (2016). Fostering kinship with animals: Animal portraiture in humane education. *Environmental Education Research*, 22(2), 203–228.

## AN INTEGRATED APPROACH TO INQUIRY IN THE SCIENCE CLASSROOM

Science educators often uphold inquiry-based teaching as a key practice. The authors of this theoretical study argue, however, that inquiry models for teaching often fall short because they are too restrictive and do not account for the implementation difficulties that many teachers

experience. Existing practices try at times to oversimplify teaching-and-learning processes, resulting in a systematic cookbook-type approach that can reduce the potential for individual inquiry. The authors suggest that a more constructivist approach, in which students build on previous experiences, may be more effective. This kind of approach would mean student-led and student-centered inquiry, scaffolded by the teacher; as such, students would take more responsibility for their own learning.

The authors suggest a “3D model” that creates an intertwined, fluid learning process, building on the three dimensions of (1) scientific knowledge, (2) procedures and methodology, and (3) psychological energy. The learning process draws in each of these dimensions at different stages. The authors describe scientific knowledge as the body of knowledge for the student; procedures and methodology represent the mechanical skills important for scientists to know; and psychological energy is akin to intrinsic motivation, or the motivation to do investigative work. The authors argue that this kind of student-led approach allows students to feel a sense of autonomy, competence, and connectedness to others, which in turn fosters self-determination. They suggest that incorporating these dimensions in inquiry-based teaching should benefit students by encouraging a positive relationship with science and furthering students’ personal growth.

The authors admit that this scaffolded model will likely be more difficult to implement than previous models for inquiry-based science teaching. However, the researchers believe that this kind of approach will lead to less algorithmic and more active learning that more closely resembles “authentic science.” It encourages consideration of how to help students push themselves in areas of interest and allows the space to decide how best to explore those areas. The authors have yet to test a practical application of their model, yet they aim to test possible forms of their suggestions in a pilot study.

### THE BOTTOM LINE:

A three-pronged approach to inquiry, incorporating (1) scientific knowledge, (2) procedures and methodology

for generating and handling scientific evidence, and (3) psychological energy or intrinsic motivation, may be more motivating and engaging for young people. Integrating these three dimensions into inquiry-based science teaching may support the development of more competent and confident students who are motivated to have a positive and long-lasting relationship with science and science education.

Bevins, S., & Price, G. (2016). Reconceptualising inquiry in science education. *International Journal of Science Education*, 38(1), 17–29.

## ADDRESSING THE NATURE OF SCIENCE THROUGH TEACHING ABOUT CLIMATE CHANGE

Traditionally, secondary-school science education presents science as static, rather than dynamic; focused on inventions, rather than on building knowledge; and intended for a small, elite audience, rather than being inclusive. Those perspectives are important to unpack when considering students' attitudes toward science, especially when addressing topics such as climate change, which can be charged in social and political discourse.

To investigate the influence of such perspectives on secondary- or high-school-level students' attitudes toward and experiences with science, the authors developed and researched an eight-week science education program. The program, called *Climate Exchange for Language and Learning* (CELL), focused on nature of science (NOS) views and scientifically related decision-making, more broadly, as well as beliefs, attitudes, and behaviors related to climate change, specifically. The program used a literacy approach, including reading and discussions, to expose students to academic and scientific language, highlighting the ways in which science is a dynamic process. The CELL curriculum described science as theoretically based and building knowledge, emphasizing that, rather than being an elite subject, science is for everyone.

The researchers implemented CELL with students in four countries: the United States (141 students from northern California, and 54 students from elsewhere in the United States), southern China (30 students), New Zealand (25 students), and Norway (32 students). Students participated in weekly classroom discussions about scientific studies on climate change-related issues, followed by online discussions with their peers from other schools. Occasionally, seven scientists from various disciplines joined the online discussions to provide resources and prompt the students with questions related to the student-led commentary. The scientists, however, did not directly answer the students' questions.

To present climate science while incorporating NOS views, the authors adapted 12 research studies, changing the text length and readability, but preserving the original research questions, figures, and tables. The researchers provided each classroom with reading resources, discussion guides, and access to the online community. The studies focused on five topics: global temperature change, sea-level change, human-induced greenhouse effect, biodiversity, and forest cover. Discussion questions focused on aspects of scientific studies, such as methods, results, and conclusion. Students were encouraged to compare study findings with other resources from their peers and the scientists, along with their own sources, such as personal experiences, websites, and blogs.

The authors conducted pre- and post-programmatic interviews with 96 of the students. In the interviews, the researchers asked the students the following two open-ended questions: *What does climate-change science mean to you?* and *What do you think climate-change scientists do in their work?* At the outset of the pre- and post-programmatic interviews, the researchers provided each student with the interview questions on a piece of paper. Following the interview, the interviewer asked each student to, *"Please throw away the paper"* in front of him or her. The student could then choose to put the paper into an easily accessible waste bin or a more-difficult-to-access recycling bin. This activity served as a proxy for knowledge of climate change issues, as well as a direct measure of propensity to conserve.



Researchers analyzed the interview data, seeking evidence of students' NOS views and understanding, as well as use of academic and scientific words. They identified instances of NOS understanding, including: understanding the iterative process of science inquiry, understanding the principle of replicability, understanding knowledge of consensus-building, and understanding of evidence-based reasoning. While coding the data, researchers were unaware of the students' identities or whether the data were from pre- or post-programmatic interviews. Before and after engaging in the program, researchers found statistically significant changes in NOS views and use of academic and scientific language. In the pre-interviews, researchers identified 35 instances of NOS understanding (as dynamic, all-inclusive, and knowledge building), compared to 54 instances in the post-interviews. In the pre-interviews, researchers coded 85 out of 1,125 words as academic/scientific; in the post-interviews, they coded 117 out of 1,114 as academic/scientific. With the recycling activity, only 34.4% of students recycled the paper in the pre-interview, and 61.5% of students recycled the paper after the program.

Because of many intervening factors, as well as cross-cultural differences, the study's design cannot establish a causal link between the program and the changes in students' beliefs, attitudes, and behaviors during the time of the study. However, the findings do demonstrate that, on average, the students had an enhanced understanding of the NOS, climate change, climate science, and environmental conservation after participating in the educational program.

### THE BOTTOM LINE:

Secondary students can simultaneously learn about topics such as climate change while also developing a more progressive perspective on the nature of science. Many science teachers and environmental educators are interested in exposing students to scientific language and highlighting science as dynamic, inclusive, and aimed at building knowledge. Those educators may benefit from using programs and curricula that feature adapted scientific texts with authentic language and data, as well as discussions that are evidence-based, open-ended, and peer-led.

Arya, D., & Maul, A. (2016). The building of knowledge, language, and decision-making about climate change science: A cross-national program for secondary students. *International Journal of Science Education*, 38(6), 885–904.

## USING MUSIC VIDEOS TO TEACH SCIENCE

Given the critical role of science, technology, engineering, and mathematics (STEM) education in fostering a new generation of scientific thinkers and environmental leaders, educators continually seek engaging ways to teach STEM in formal and informal settings. One strategy that could appeal to a range of students is using music videos to convey scientific information. Because music is ingrained in youth culture, it is poised as an entry point and may provide personal connection for many students. This study examined music videos as a tool for engaging with and retaining scientific information.

The researchers conducted a three-part study with over 1,000 participants to examine the relationship between music videos and scientific learning. In Study A, the researchers chose 15 music videos that appeared to be appealing, were publicly accessible, and included scientific content. The study included 568 complete datasets (pre- and post-tests), representing 550 participants (some of whom watched more than one video), ranging from kindergarteners to adults. The researchers administered a multiple-choice test on scientific information before and after the video; they then asked study participants how much they enjoyed the video.

Study A was limited because it only compared participants' scientific knowledge before and after watching a music video; it did not isolate the role of music in participants' retention of scientific information or engagement with the video. Therefore, in Study B, the researchers asked 403 participants to watch various sequences of science-related music videos and non-music science-related videos and then take a test on scientific information. Study B targeted similar participants as Study A. Again, the researchers asked

participants how much they enjoyed the video; this time, they also asked participants whether they would watch similar videos to learn about other science topics.

Study C considered the longer-term impacts of information retention from watching the “Fossil Rock Anthem,” a music video parodying LMFAO’s “Party Rock Anthem.” In this study, participants from two schools in Dunedin, New Zealand, watched one of two videos: one school watched the “Fossil Rock Anthem,” while the other watched a non-music video. Both of the videos included the same scientific facts. Participants took the same test on scientific information covered in the videos at three different times: before, immediately after, and 28 days after watching their assigned video. Participants also answered questions about how much they enjoyed the video and whether they wanted to further interact with and share the video.

Results from the three studies suggest that music videos can help teach science concepts and increase student engagement. In Study A, participants had higher knowledge test scores after watching 13 out of the 15 music videos, indicating that students can retain scientific information (in the short term) from watching just one short video. In Study B, although test scores were similar after both the music and non-music videos, participants greatly preferred watching the music videos. The findings from both studies indicate that the music in videos seems not to detract from information retention in students but, rather, it can enhance viewers’ personal connection to and engagement with the subject matter.

In Study C, the knowledge test results from the immediate-post-viewing group were higher for the non-music video group than the music video group. However, long-term information retention was greater for those who watched the music video, while any gains made by the non-music video group were lost after 28 days. In addition, all participants reported enjoying the music videos more than learning from a textbook; also, when compared to participants who watched a non-music video, those who watched a music video were more likely to rate the video as “fun” and be willing to share and engage with the video in the future.

### THE BOTTOM LINE:

Music videos, which offer a creative and enjoyable way for students to connect with and learn science, can serve as an engaging alternative to textbooks, non-music videos, and other traditional teaching tools in environmental education. Although they might not necessarily be better than other methods for teaching and retaining scientific information in the short term, they may help with retention in the longer term, perhaps because of their engaging and affective/emotional nature.

Crowther, G. J., McFadden, T., Fleming, J. S., & Davis, K. (2016). Leveraging the power of music to improve science education. *International Journal of Science Education*, 38(1), 73–95.

## MOBILE DEVICES FOR IMPROVING STUDENTS’ UNDERSTANDING OF FLOWERS

The use of mobile devices in daily life is encouraging researchers to re-think learning in the digital age. There is growing interest in what is now called “mobile learning,” which recognizes that the unique characteristics of mobile devices, such as mobility, sensitivity to context, and immediacy, can contribute to and transform the learning environment. Yet, few researchers have studied pedagogical approaches that incorporate mobile devices, and more research is needed to identify how each feature of a mobile device might individually contribute to (or distract from) students’ learning.

To that end, this study focused on the data collection and recording capabilities of mobile devices. Researchers compared the learning that occurred among fourth-grade students who used mobile devices to learn about flower concepts with the learning that occurred among those who used sketching, a more traditional teaching method.

Because teachers often find it challenging to teach flower-related concepts to elementary-aged children, they used this as the central topic to study with 48 nine-year-old

students (23 girls and 25 boys) in two public-school classes in Cyprus. Researchers designated one class as the experimental group and had them use mobile devices. They designated the other class as the comparison group and had them use sketching in the flower lesson.

Both groups had the same teacher, same amount of experience using mobile devices in a school setting (more than one year), and exposure to the same curriculum and field trips. Students in both groups used a personal notebook and pen to take notes, as well as to collect and record data. Students in the experimental group also used a tablet or smart phone to record field observations, including pictures, videos, and sound recordings; the comparison group used magnifying glasses and colored pencils to sketch their observations.

Researchers conducted the study over six weeks and integrated it as part of the regular school routine and science-class schedule. During the first week, the teacher and researchers administered a pre-test to assess the students' baseline knowledge of flower concepts, namely: (1) flower parts and their functions, (2) pollinators, (3) pollination processes, and (4) relationships between plants and animals. In the second week, teachers briefed students about the activity structure and gave them instructions on note-taking, as well as either sketch-making or mobile-device use.

The inquiry-based activities took place from week two to week five and consisted of four sessions; each session included a field trip to the school garden followed by an indoor learning activity. Students worked in clusters of four and engaged in collaborative learning. Time in the garden was allocated for observation and data collection, while indoor work included studying curriculum materials and answering related test questions. At all times during the sessions, students were allowed to refer to their notes (both groups); sketches (comparison group); or digital photos, videos, and sound recordings (experimental group). After each session, the researchers collected students' science notebooks and analyzed the students' responses to science test questions.

Finally, researchers asked each student to create three artifacts: (1) a list of flower parts that the student can distinguish from his/her sketches (comparison group) or photos (experimental group); (2) a list of identified pollinators; and (3) a list of evidence that a flower had been pollinated. In the final week of the study, researchers administered the knowledge post-test (identical to the pre-test) and collected all student notebooks for analysis.

Both groups improved their conceptual understanding of flowers from pre-test to post-test. The mobile-device group showed larger gains in knowledge about plant concepts than the sketching group: students who used mobile devices scored significantly and consistently higher on all four components of the post-test. Further, comparisons of the three student artifacts (from the pre- and post-tests) "flower parts," "pollinators," and "pollinated flowers" found that the experimental group provided more detailed information about those parts. For "flower parts," for example, students using mobile devices had more precise answers on the numbers of certain flower parts, such as petals and sepals, and they were able to identify small parts, such as pollen, which are usually difficult to see. Experimental group students were able to "re-see" details with precision because of the "zoom" feature on digital pictures. Results for "pollinators" were almost the same between groups, except a higher number of students in the experimental group identified the wind as a pollinator. The researchers attributed this result mainly to students' ability to review video recordings in slow motion and see small things carried by the wind. Finally, compared to the students using traditional sketching methods, students using mobile devices were better at identifying "pollinated flowers" and providing supporting evidence.

The researchers also analyzed the students' science notebooks and looked for differences in the scientific accuracy of their responses to the in-session test questions, which were separate from the pre- and post-test. Students in the experimental group had significantly more detailed and scientifically accurate responses than those of the comparison group. Moreover, scientific accuracy in



notebook test responses was positively correlated with scores on the post-test. The researchers argued that the capacity of students in the experimental group to use more scientifically accurate information could be one of the reasons for their higher post-test results. Mobile devices supported authentic and accurate recordings of observations. Since researchers allowed all students to revisit their notes and records, the experimental group had continuous access to high-resolution digital pictures of flowers and processes, while the comparison group students relied on their memory and lower-resolution sketches.

### THE BOTTOM LINE:

Although mobile devices and sketching methods both allow students to revisit plants, animals and other parts of nature they have examined in the past, digital photos and videos typically provide more accuracy and high-resolution detail than students' sketches. While careful observation is helpful in retaining scientific facts no matter what the medium, mobile devices specifically can assist with paying attention to details. The photo and video applications on mobile devices may be particularly well-suited for teaching plant concepts and other science and environmental topics that require students to make detailed observations.

Zacharia, Z. C., Lazaridou, C., & Avraamidou, L. (2016). The use of mobile devices as means of data collection in supporting elementary school students' conceptual understanding about plants. *International Journal of Science Education*, 38(4), 596–620.

## TEACHING CLIMATE CHANGE ALONGSIDE THE CARBON CYCLE TO IMPROVE LEARNING

Climate change can be a confusing issue for much of the U.S. public. Similarly, and often as a result of its relation to the public discourse, teaching about climate change can at times be challenging for K–12 science teachers. This study proposes a potential way to address some of those challenges: teach climate change alongside the carbon

cycle rather than separately from the standard curriculum. The authors suggest that climate change-related content fits naturally within a carbon cycle unit. The researchers hypothesized that, if students are interested in learning about climate change, then this teaching technique might also improve students' understanding of the carbon cycle. In short, attitudes about climate might influence learning about the carbon cycle.

To test these ideas, the researchers assessed and interviewed two groups of ninth-grade students who had learned about the carbon cycle at a weeklong summer science program in Florida. The treatment group (23 students) learned about climate change at the same time as learning about the carbon cycle, while the comparison group (24 students) learned about the carbon cycle first and then separately learned about climate change. All of the students took short pre- and post-tests on carbon-cycle comprehension. The researchers also investigated the students' beliefs about climate change using focus-group interviews.

Findings indicated that integrating climate change-related content in lessons about the carbon cycle effectively enhanced learning comprehension, as well as subject-matter interest. By the end of the program, students who had learned about climate change embedded within the carbon-cycle lesson scored higher on the comprehension quiz than those in the comparison group. In the follow-up focus groups, most of the students said that they found learning about the carbon cycle to be more interesting when the educators included climate change-related information.

The researchers also analyzed data on the political views of the students' parents to see whether students whose parents held more conservative-leaning perspectives were less interested in learning about climate change. Comparing students who reported that their parents were Republicans with those who reported that their parents were Democrats, the researchers found no significant difference in students' interest in climate change (measured at post-test) or in knowledge gain from pre- to post-test.

Several key aspects of this study are important to note when considering the applicability of these findings to K–12 school settings. First, the researchers conducted the study with summer science-program participants; therefore, it is likely that the participants already had a relatively high level of interest in science. Second, the sample size was small (47 participants). Third, researchers collected the follow-up data through focus groups, in which context and dynamics may have influenced participants' responses.

### **THE BOTTOM LINE:**

Educators may find that developing activities and units that intertwine related topics, such as the carbon cycle and climate change, and showing how the topics are related may have benefits on several dimensions. In this study, students who learned about the carbon cycle in the context of climate change tested higher in their carbon-cycle comprehension. The students also found the carbon cycle more interesting when teachers included information about climate change at the same time. These enhanced outcomes may derive from the heightened relevance that occurs when demonstrating connections among various topics.

Monroe, M. C., Hall, S., & Jie Li, C. (2016). Can climate change enhance biology lessons? A quasi-experiment. *Applied Environmental Education & Communication*, 15(2), 125–137.

# SENSE OF PLACE AND NATURE CONNECTION

## USING PLAYSCAPES TO CONNECT YOUNG CHILDREN TO NATURE

With electronic devices more pervasive than ever in the world of children and adults alike, many parents, classroom educators, and environmental educators fear that children do not spend enough time away from screens and exploring natural spaces. This diminished connection with the natural world may cause cascading impacts on childhood development, impeding opportunities to connect with nature as a whole. Playscapes, or enclosed play spaces that incorporate natural elements, seek to fill this void, at least partially. Little is known, however, about whether and how playscapes might foster exploration of natural systems, support inquiry-based learning, and/or establish the foundations of environmentally responsible behavior. This study compares preschoolers' interactions with a playscape and their activities at a regular playground.

The researchers observed 64 preschoolers, aged three to five, who attended a laboratory preschool at a Midwestern university. Half of the preschoolers were allowed to play freely on their school playground, a small and familiar area adjacent to busy roads. The other half of the preschoolers were allowed to play freely at a large and complex playscape at the Cincinnati Nature Center. The playscape featured caves, paths, forests, streams, sand pits, and other natural elements. Researchers videotaped the children during three separate play sessions at each of the two locations.

The researchers collected 50 minutes of usable video footage from the Nature Center playscape and 25 minutes of usable footage from the school playground. The researchers then split the footage into short clips and coded each video clip according to: (1) the type of science inquiry observed, (2) the type of play observed, and (3) the specific location within the playscape or playground where the action happened. Following in the footsteps of past researchers, this study used four types of increasingly complex science inquiry: observation, exploration, representing and recording, and language. The researchers also coded for four types of play: functional play (using senses to learn about materials); constructive play (such as





building up or breaking down objects); dramatic play (through imaginative role-play); and games (involving set rules).

At the playscape, researchers saw children playing in the water and in the woods—environments not available at most regular playgrounds. Children at the playscape mostly engaged in *functional play*, such as splashing and running (62%). *Constructive play*, such as building forts (26%), and *dramatic play*, such as acting out “The Lion King” (12%), occurred less frequently. Comparatively, children at the playground showed mainly constructive play (55%) and functional play (42%), with only a few instances of dramatic play (2%). The researchers attributed the dominance of constructive play at the playground to a single teacher-led activity during one of the play sessions; omitting this activity, functional play was dominant in both the playscape and the playground, with the higher rate of dramatic play at the playscape being the only major difference between locations. Researchers did not observe *games* at either location.

In both playscape and playground interactions, children engaged in science inquiry mostly through *observations* (35% and 40%, respectively) and *exploration* (43% and 46%, respectively). *Representing and recording* occurred rarely (5% and 0%, respectively) and scientific *language*, such as naming species, happened on occasion (17% and 14%, respectively). Importantly, children on the playground only used science *language* while participating in a teacher-led activity, while children at the playscape used science *language* during independent play.

Although children at both the playscape and the playground engaged in the various types of play and science inquiry at similar rates overall, closer analyses of specific locations within each play area revealed differences. Within the playscape, there were four locations (water, woods, cave, and gravel pit) at which children engaged in all three observed types of play (*functional, constructive, and dramatic*); in contrast, the playground offered only one location that spurred the same variety of play. Researchers also observed at least three types of science inquiry taking place at

four locations within the playscape, while none of the playground locations saw more than two types of science inquiry. Altogether, these findings support playscapes as facilitating diverse play and inquiry experiences for young children.

The playscape also seemed to offer more opportunities for the children to build curiosity and respect toward nature. In several instances, preschoolers at the playscape interacted with slugs and insects. Video clips of these interactions showed children naming the creatures, observing their characteristics, exclaiming their cuteness, and attempting to protect them from harm. One preschooler expressed, “Don’t kill nature, guys.” The presence of these actions at the playscape, but not at the playground, may reflect the greater number of opportunities for nature engagement in the playscape.

As encouraging as these results are, this study has limitations. The researchers emphasize that the study was a preliminary look at the potential of playscapes, as it was observational rather than experimental in design. Further, the study did not control for differences in demographics between the two groups, which may have influenced how children interacted with their play areas. Results may also be confounded by the fact that one play area was entirely new to the children (the playscape), while the other was familiar (the playground). Finally, intentionally or unintentionally, the videographers may have biased the data through what they chose to capture on video.

### THE BOTTOM LINE:

Playscapes have the potential to connect children with nature in diverse, play-based, and science-rich ways. Because they are safe, enclosed spaces that also contain natural elements, they may offer a best-of-both-worlds scenario for educators who wish to facilitate science inquiry and nature connections, while effectively managing a large group of young students. Within a playscape, the rich variety of nature-based locations (such as water, woods, and caves) provides opportunities for children to play in multiple ways, engage in student-led exploration and observation, and use science language.

Those opportunities may foster lasting curiosity about and appreciation for the natural world.

Wight, R. A., Kloos, H., Maltbie, C. V., & Carr, V. W. (2016). Can playscapes promote early childhood inquiry towards environmentally responsible behaviors? An exploratory study. *Environmental Education Research*, 22(4), 518–537.

## SELF-ESTEEM AND CONNECTEDNESS TO NATURE ON YOUTH WILDERNESS EXPEDITIONS

Poor mental health and self-esteem often continue throughout a lifetime, and those with low self-esteem may be less able to cope with stress and more prone to depression and anxiety. While previous studies show a relationship between exposure to nature and improved well-being and overall health, most of those studies are qualitative or descriptive. This study provides quantitative evidence about the relationship between wilderness expeditions and self-esteem, as well as connectedness to nature among adolescents. The study also investigates differences that may relate to participants' gender, living environment, and the length and location of the expedition.

The study included 130 adolescents between the ages of 11 and 18, who participated in 16 wilderness expeditions organized by the Wilderness Foundation UK between 2006 and 2012. The participants included 57 males and 75 females; 36% of the participants lived in a city, 26% in a large town, 18% in a village, 11% in a small town, and 9% in a rural area. The wilderness expeditions took place in South Africa or Scotland, and they ranged in duration from 5 to 11 days. The purpose of the expeditions was to grow the connection between people and nature, as well as to improve leadership and life training skills in a challenging setting. The expedition settings were completely immersive: the settings had no electricity, and participants obtained water from nearby rivers or other natural sources.

At the beginning and end of each wilderness expedition, participants completed questionnaires on self-esteem and connectedness to nature. Researchers measured self-esteem using Rosenberg's Self-Esteem Scale, which asks respondents to rate their level of agreement with 10 statements about feelings of self-worth or self-acceptance using a 4-point Likert-type scale. They then aggregated responses into a single self-esteem score. Similarly, the researchers measured Connectedness to Nature using the State Connectedness to Nature Scale, in which they asked respondents to rate their level of agreement with 13 items using a 5-point Likert-type scale.

The results showed a statistically significant increase in participants' self-esteem scores from pre- to post-expedition. Boys reported significantly higher self-esteem scores than girls before the expeditions, but there was no difference in self-esteem between genders after the expeditions. These results suggest that it may be particularly beneficial for girls to spend time in nature and on these types of wilderness-expedition experiences, given that girls had significantly lower self-esteem than the boys did at the beginning of this study, but the gap closed by the end of the expedition. Although the study did not examine the reasons for this improvement in self-esteem, the authors suggested that the opportunity for girls to demonstrate perseverance, feel a sense of accomplishment, and challenge conventional views of what it means to be female may contribute to these shifts.

Participants' connectedness to nature scores also significantly increased from pre- to post-expedition. The study showed no significant differences between boys' and girls' connectedness to nature scores either before or after the expedition.

### THE BOTTOM LINE:

Immersive experiences in nature may help improve adolescents' mental well-being and health. Participation in wilderness expeditions may increase adolescent self-esteem, particularly in girls, and increase their sense of connectedness to nature. Incorporating such experiences into school curricula and other youth programs may be an effective way to influence positively adolescents' well-being.

Barton, J., Bragg, R., Pretty, J., Roberts, J., & Wood, C. (2016). The wilderness expedition: An effective life course intervention to improve young people's well-being and connectedness to nature. *Journal of Experiential Education*, 39(1), 59–72.

## UNDERSTANDING THE ROLE OF ECO-ATTRACTIONS IN FOSTERING HUMAN–NATURE CONNECTIONS

As many scholars and practitioners have recognized, much learning occurs outside of the classroom, whether in settings designed for informal learning or in the course of everyday life. Eco-attractions, such as botanical gardens and nature reserves—tourism sites that emphasize conservation outcomes—offer opportunities for experiential environmental education, while also capitalizing on the intrinsic motivation of visitors. Such sites can engage people with nature and increase their awareness of environmental issues through hands-on, immersive experiences.

This study investigated the value of eco-attractions for environmental education. The researcher interviewed students and teachers in educational programs at three eco-attraction sites in the United Kingdom: a botanical garden, a country estate with conservation areas, and a wetland reserve. Each site offered two-day programs, with the goal of promoting young people's connection to nature, and each used their unique setting and resources to encourage visitors to explore interactions between humans and the non-human world.

The researcher interviewed a total of 24 students and 4 teachers, and each participated in 1 of the 3 programs. The students were between 13 and 15 years old and selected from cohorts of 12 to 13 students at each site. The goal of the interviews was to understand the individual experiences of young people at each of the three eco-attractions. Researchers designed the interactive interviews to allow the interviewee to direct the discussion. The researcher recorded the interviews and analyzed the data for recurrent themes relating to

program impacts. The author also conducted observations at the three sites, including more than 430 students over the course of six months. Finally, the researcher analyzed the educational programs' course materials.

Based on analyses of these multiple data sources, the researcher identified three major themes. First, the programs fostered an appreciation for the role of plants in ecosystems and in sustaining human life. Second, the experiences may have encouraged students to reconsider human relationships to the environment and develop a desire to address ecological crises. Third, the programs emphasized nature-culture connections, highlighting connections between plants and everyday objects and experiences.

These findings suggest that eco-attractions can offer opportunities to address human relationships with the natural world. Although the programs did not prompt students to adopt specific pro-environmental behaviors, the results suggest that the programs may support students and teachers to reflect on their ecological knowledge, everyday decisions, and involvement with conservation efforts.

### THE BOTTOM LINE:

Even relatively short programs at eco-attractions, such as botanical gardens and wetland reserves, can foster ecological citizenship and complement the efforts of other environmental education initiatives. Educators at eco-attractions can foster connections between the natural world and young people's everyday lives by making human-nature connections visible. Specific strategies that help do this include emphasizing the role of plants in ecosystems and in sustaining human life, and helping students explore sustainability by highlighting connections to their daily social and cultural contexts.

Dunkley, R. A. (2016). Learning at eco-attractions: Exploring the bifurcation of nature and culture through experiential environmental education. *Journal of Environmental Education*, 47(3), 213–221.



# PROFESSIONAL DEVELOPMENT



## INTERACTIONS AND OUTCOMES IN AN ONLINE COURSE FOR ENVIRONMENTAL EDUCATORS

Online courses have become key tools in professional development for environmental educators. Course designers seek innovative approaches to expand course outcomes beyond content acquisition. One such approach uses the course web platform to stimulate interactions among participants, as well as between participants and instructors. However, scholars and educators know little about the interactive processes of environmental educators' online learning and how those processes influence learning outcomes. In this study, the researchers addressed this knowledge gap by analyzing three types of participant interactions and their relationships to learning outcomes in an online course on urban environmental education.

*Environmental Education in Urban Communities* is a 12-week professional development course offered online by Cornell University as part of EECapacity, a U.S. Environmental Protection Agency (EPA)-funded professional-development program for environmental educators in North America. The course's learning goals are to: (1) learn diverse methods and outcomes of environmental education in an urban context, (2) understand the ways environmental education research can enhance practice, (3) develop and exchange (among participants) research-based activity plans that can be used in practice with various audiences, (4) contribute to developing the (new) national *Guidelines for Excellence in Environmental Education* (North American Association for Environmental Education [NAAEE], 1994–2004), and (5) develop a peer network of urban environmental educators.

The researchers, two of whom were also course designers and instructors, selected 25 educators (5 males and 20 females) to participate in the course. Criteria for selection included geographic representation across the United States, interest and

expressed commitment, and potential to bring diverse perspectives to the discussion on urban environmental education. Participants represented a range of experience working in education: they had between 2 and 30 years of experience, with a mean of 12 years; and they represented a variety of institutions, including community organizations, nature centers, city park departments, K–12 schools, and colleges/universities. Overall, 24 participants completed the course.

The course required certain online interactions and encouraged other interactions as well, including discussing research findings among participants, commenting (by peers and instructors) on course assignments, drafting guidelines for environmental education in urban areas, and exchanging lesson plans drafted by participants. Participants completed all assignments individually, with the exception of one group exercise on guideline development, which they completed in a small group. Weekly assignments consisted of videos and readings about environmental education in cities, environmental justice, audience diversity, behavior change, and the *Guidelines for Excellence*. Every week, participants were required to post reflections on how course materials related to their own practice and leave at least two comments on their peers' posts. The instructors also commented on participants' posts.

Researchers collected participants' posts and comments throughout the course, and they conducted a content analysis of the data. They coded for three types of interactions: (1) participant–participant, (2) participant–content, and (3) participant–instructor. They also coded for four outcomes: (1) participant motivation to learn, (2) intent to adapt ideas and information in their own practice, (3) actual adaptation in their practice, and (4) professional network development. The researchers coded the data per participant and per week, and they used regression analysis to build models that established (non-causal) relationships between interactions and outcomes. The

models defined “interactions” as the independent variables and “outcomes” as the dependent variables. They also included other variables that might influence the results, such as frequency of receiving comments on posts from the previous week, number of years of experience in environmental education, and course progress (e.g., week two of the course), among others.

The results showed that participant–participant interaction was significantly and positively associated with “participant motivation to learn” and “professional network development.” The positive correlations are congruent with the literature that recognizes interactions among participants as conducive to enhanced content learning. However, participant–participant interaction was not associated with “intent to adapt ideas” or “actual adaptation of ideas.” This negative finding was surprising, as it is counter to the EECapacity program's foundational hypothesis that innovations in environmental education derive from educators networking and exchanging knowledge.

Researchers also found positive correlations between participant–content interaction and “motivation to learn,” “intent to adapt ideas in practice,” and “actual adaptation of ideas.” This finding highlighted the importance of attention to content, even in online courses that focus on interactive social learning.

Participant–instructor interaction was significantly positively associated with only one outcome, “professional network development,” which is consistent with previous studies of online courses that examined interactions using network analysis. This result may also be due to the pedagogical style of the instructor, who actively encouraged participant–participant interactions.

Analyses revealed that participants were more motivated to learn during the first few weeks of the course, probably due to the initial excitement and curiosity about each other's programs. In contrast, participants'

intention to adapt ideas into practice was higher toward the end of the program, which is intuitive, as adaptation takes time. The time-rank results showed that the later a participant posted on the course website, the higher his/her “motivation to learn,” potentially because participants who posted later in the week were more likely to be influenced by others’ posts. Finally, participants with more work experience were less likely to adapt new ideas than their less-experienced peers.

### THE BOTTOM LINE:

In the context of an online professional development course on urban environmental education, this study demonstrated that different types of participant interactions (with other participants, content, and instructors) correlate with different course outcomes. Designers of online courses may wish to intentionally integrate the types of interactions that are most likely to be conducive to particular course goals; participant–participant and participant–instructor interactions, for example, may support professional networking. Moreover, since the study showed that environmental educators need time to adapt new ideas and implement changes in their practice, special attention should be given to course content and how the online course fits into longer-term professional development programs.

Li, M., Krasny, M., & Russ, A. (2014). Interactive learning in an urban environmental education online course. *Environmental Education Research*, 22(1), 111–128.

## A FRAMEWORK FOR GUIDING PRIMARY SCHOOL STUDENTS THROUGH INQUIRY-BASED SCIENCE

Inquiry-based science education (IBSE) can stimulate students’ interests and active learning, and researchers find that it can also positively affect learning outcomes. In IBSE, the teacher’s role becomes that of a facilitator, supporter, and supervisor as her/his students take on interest- and self-guided inquiry to answer their own

research questions. In primary-school classrooms, however, many teachers struggle to guide their students through the inquiry process, leading to a reliance on a top-down approach to inquiry rather than a bottom-up, open-inquiry process.

This study’s authors aimed to understand how primary-school teachers support their students through IBSE. Through analysis of in-class observations and video recordings, the authors developed a framework of successful pedagogical practices for guiding students through open inquiry. From a literature review, the authors identified four domains of scientific knowledge important for open IBSE: conceptual, epistemic, social, and procedural knowledge. They also outlined seven phases that comprise an inquiry cycle: introduction, exploration, designing the investigation, conducting the investigation, conclusion, presentation/communication, and deepening/broadening.

To develop a pedagogical framework that incorporates the four knowledge domains and seven inquiry phases, the authors observed in-class strategies and analyzed video clips of primary-school teachers who received training from a Science Education Hub in the Netherlands. The Science Education Hub at Radboud University has many IBSE projects for primary-school students (ages 10 to 12 years old), developed by teams of scientists, teacher trainers, and pre-service teachers.

The authors analyzed the video clips from seven of these IBSE projects in different primary schools. Each video clip was about eight hours long and showed five to nine inquiry-based lessons. During group work time in the video clips, an interviewer also spoke with the students about the design and conduct of their investigations. The authors qualitatively analyzed the videos to identify the domains addressed by teachers, the students’ responses, and the success of the teachers’ interventions. The authors compared video clips to identify patterns of successful (or unsuccessful) pedagogical interventions. To support the qualitative analysis, the authors compiled a quantitative overview of each of the seven phases of inquiry and the knowledge domains addressed by teachers and students.



Based on their analyses, the authors presented a pedagogical framework that describes the main goals of each phase of inquiry and the specific knowledge domains that teachers should address during each phase to support learning.

- The “introduction” phase serves mainly to spark student interest and increase their understanding of open inquiry.
- The purpose of the “exploration” phase is to connect students’ prior knowledge to the topic under investigation.
- The “designing the investigation” phase focuses on developing specific research questions, creating a research plan, and collecting materials and instruments.
- The purpose of the “conducting the investigation” phase is precise and structured data collection.
- During the “conclusion” phase, the focus is on connecting data to research questions and differentiating results from personal opinions.
- The goal of the “presentation/communication” phase is for the students to present their results to others.
- The purpose of the last phase, “deepening/broadening,” is to reflect on the inquiry process and broaden understanding of the research topic. During this last phase, teachers should elaborate on all four of the knowledge domains.

The authors found that, when teachers paid attention to the domains, the students were able to move between and within the inquiry phases. The authors also found that specific types of teacher interventions enabled students to proceed more easily through the phases; these included, for example, scaffolding students’ procedural understanding, questioning, connecting concepts, linking prior knowledge, providing hands-on science activities, connecting to everyday concepts, and facilitating collaboration and communication.

### THE BOTTOM LINE:

Open inquiry-based science education can be an effective way to teach primary-school students about different scientific topics and the principles of scientific study. When designing such an approach, using a structure based on the seven systems of inquiry and domains of scientific knowledge is often rewarding. Each of these topics must be connected together so that teachers support students at each level while also connecting each part into a cohesive whole relating to the scientific process.

van Uum, M. S. J., Verhoeff, R. P., & Peeters, M. (2016). Inquiry-based science education: Towards a pedagogical framework for primary school teachers. *International Journal of Science Education*, 38(3), 450–469.

# OTHER RESEARCH

## THE EMOTIONAL IMPACT OF ZOO ANIMALS

Zoos provide unique settings for environmental education. At the zoo, visitors can see charismatic rare and/or endangered animals, and they can experience those animals, and others, in an up-close-and-personal manner. Visitors also have relative freedom to structure their zoo visit how they wish.

Prior research suggests that zoos may serve as important places for learning about biodiversity conservation and inspiring action among visitors. Scholars have proposed that, as visitors encounter animals and their behaviors, they develop an emotional or affective connection to the animal; reflect on the encounter; and may be motivated to adopt environmentally responsible behaviors. Little is known, however, about the circumstances under which this process might occur.

Motivated by this knowledge gap, researchers surveyed visitors to three zoos. They investigated the visitors' emotional responses to animal behaviors and how visitors made meaning of the experience. The researchers surveyed 717 adult visitors as they exited the giraffe exhibit and African lion exhibit at the Brookfield Zoo in Chicago; the cheetah exhibit at the San Diego Zoo Safari Park; and the red panda exhibit at the Central Park Zoo in New York. The researchers first asked participants about their feelings toward animals, the environment, and conservation actions. Then, the researchers asked about the types of animal behaviors that visitors saw at the exhibit, their emotional responses to that experience, and the meaning they derived from the experience. Visitors answered questions using a scale from 1 to 7. To accommodate differences across sites, the researchers made slight adjustments to the survey. Ultimately, researchers hoped to map the direct and indirect paths from observed animal behavior and visitor predispositions to emotional responses and meaning-making.

The researchers found that, when visitors observed a range of animal behaviors, they reported more positive emotional experiences. Specifically, visitors who reported seeing more active animal behaviors, coming face-to-face with animals, and establishing eye contact with animals were more likely to report feeling positive



emotions and engaging in meaning-making through the experience. This positive emotional experience strongly predicted how much the exhibit contributed to the visitors' understanding of conservation issues. The researchers found similar results across all zoo sites and with different types of animals.

### **THE BOTTOM LINE:**

Zoos are important environmental education settings, as they facilitate interactions and experiences with animals. Those experiences may foster visitors' positive emotional connections with animals, improve their understanding of conservation issues, and inspire subsequent conservation behavior. Educators and practitioners wanting to facilitate more meaningful zoo experiences should strive to provide opportunities for visitors to witness a range of active animal behaviors, see the animals up close, and interact firsthand with animals, when possible.

Luebke, J. F., Watters, J. V., Packer, J., Miller, L. J., & Powell, D. M. (2016). Zoo visitors' affective responses to observing animal behaviors. *Visitor Studies*, 19(1), 60–76.

## **USING TABLETS TO INCREASE SCIENCE LITERACY AMONG NATIONAL PARK VISITORS**

Enhancing the science literacy of national-park visitors may strengthen their emotional and intellectual connections to nature and increase stewardship. Researchers have studied the use of handheld digital devices to improve science learning in schools and museums, but more research is needed on their use in parks. In addition, the U.S. National Park Service has been encouraging its staff to inform visitors about park-based research through interactive experiences with handheld digital devices.

This study was conducted as part of a project called Interpreters and Scientists Working on Our Parks (iSWOOP) at Carlsbad Caverns National Park in New

Mexico. The 13 interpreters in this study ranged in age from 20 to 40 years old, all had college degrees, and there were slightly more men than women. All participants had previous experience working in parks and expressed belief in the importance of communicating science to visitors.

As part of the iSWOOP project, the interpreters received professional development and two iPads each. The tablets contained a research-based virtual library with visualizations of the Brazilian free-tailed bats' life and environment at Carlsbad Caverns. At the beginning of the project, the interpreters attended a professional development program with seminars and field visits. Throughout the program, they learned about current research on Brazilian bats, methods for interactive science communication, and effective use of the virtual library's components, which include video, animations, pictures, and figures.

During the field implementation phase (July 2014–March 2015), interpreters stood at strategic locations inside the caverns or walked counter to visitor traffic, initiating discussions with groups and individuals. Nine interpreters used the tablets to engage visitors in informal science conversations and help address visitors' questions about the bats or caverns. The remaining four interpreters did not use the tablets but, instead, followed their traditional, personal methods (such as using a flashlight and props) to engage visitors.

Using an open-ended survey, researchers collected data on the interpreters' experiences. Interpreters who used the tablets answered survey questions about the perceived benefits of using the virtual library, strategies they used to initiate and sustain discussions with visitors, visitor responses to tablet use; and any difficulties they encountered. They asked the interpreters who did not use the tablets to respond to the question, "What were the barriers for you?"

The researchers qualitatively analyzed the survey responses to identify the main characteristics of interpreters' experiences. The researchers used



several other data sources to complete their analysis, including the interpreters' feedback on the professional development, and informal communications (e.g., emails and conference calls) between the park team and researchers throughout the iSWOOP project.

Overall, the nine interpreters who used the tablets reported that the tablets and virtual library were beneficial in reaching interpretive goals. The tablets and visualizations extended their interactive time with park visitors; and the study's authors argued that these longer conversations provided time for strengthening visitors' emotional and intellectual connections to the bats. Interpreters used the virtual library to reveal parts of the caverns that were otherwise inaccessible, such as the bat cave; and they reported that children reacted with amazement. Another perceived value of the tablets was the dynamic nature of the featured media; for example, the interpreters showed visitors an animated video of the bats' flying through the cave as seen from a bat's perspective. Finally, interpreters used the library to show how researchers used advanced technologies, such as thermal cameras and laser scanners, to create special visualizations. Interpreters also reported that most visitors seemed to enjoy their interactions. Visitors expressed gratitude for interpreters' efforts to expand the experience and explain the scientific background and expressed interest in the media and technologies used.

The interpreters also described the strategies they used to enhance the visitors' experiences. They selected strategic locations to initiate conversations with visitors, such as at the sign pointing the way to the bat cave and on benches where visitors rested. Some interpreters also personalized their methods for approaching and inviting visitors to talk, but most interpreters waited for visitors to approach them first and then used aspects of the cave or questions to initiate discussion. After showing impressive visuals, the interpreters sustained their conversations by adapting their comments and tablet displays to visitors' specific interests.

Four interpreters who participated in the iSWOOP project declined to use the tablets, and three of them reported their concerns. They worried that the attractive visualizations would divert attention from the actual caverns. They preferred to keep the visitor experience authentic, focus on the concrete features of the bats' habitat, and leave space for visitors to imagine the bats' lives inside the caverns. Other challenges were logistical, such as keeping the tablet battery charged and juggling the tablets alongside flashlights, props, and other interpretive tools.

### **THE BOTTOM LINE:**

Environmental educators and program leaders may wish to explore the use of digital devices to enhance visitors' experiences. At Carlsbad Caverns National Park, some interpreters used tablets to showcase a virtual library and engage visitors in conversations. These interpreters reported that the use of handheld digital devices helped them reach their interpretive goals and that visitors seemed to react positively to their use. However, some of the park's interpreters declined to use the tablets for a variety of reasons, including a desire to focus visitors on an "authentic" (not virtual) experience and an inability to overcome logistical challenges. Effective implementation of digital devices requires addressing logistical obstacles, as well as philosophical concerns about using the tools in teaching and interpretation.

Merson, M., Allen, L. C., Cox, P. L., & Hristov, N. I. (2016). Roving with a digital visual library: Increased learning opportunities at Carlsbad Caverns National Park. *Journal of Interpretation Research*, 21(1), 9–29.