SHARING ANTARCTIC RESEARCH IN THE CLASSROOM: AUTHENTIC OUTREACH AS A MEANS OF IMPROVING STUDENT PERFORMANCE

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For six seasons, Richard Lee has included a K-12 teacher on his Antarctic research team to coordinate outreach to U.S. classrooms. These teachers have communicated with thousands of students and their teachers and planned authentic outreach activities to improve student performance. Program success depends on funding by the National Science Foundation, passionate leadership, and five components for launching a successful outreach initiative: recruiting and mobilizing support, introducing Antarctic researchers to students and community, communication using technology, purposefully planning interdisciplinary instruction, and using media and publications to extend the outreach.

PICTURE THESE SCENES in a classroom near you:

- A boy pries a larva that has overwintered in a goldenrod gall from its case, examines it, and illustrates it in his journal.
- A girl predicts that warm water is denser than cold water and then tests her hypothesis using a density chamber.
- A group of students test whether a glacier (ice on a lid) or an iceberg (ice in the water) displaces water.
- Science club members design a penguin diving chamber and then test which body shape sinks fastest.
- First graders grasp rocks with salad tongs to represent penguin beaks as they build nests of stone.
- Middle school campers use a glove, shortening, and ice water to test how fat insulates a penguin's body.
- Sixth graders test "penguin blood" (water with red food coloring) to see whether large or small animals survive better in freezing temperatures.
- Students measure the length of the sun's shadows in Ohio, compare it to the length of the sun's shadows in Antarctica, and graph their results.
- Bright-eyed students talk animatedly to their teacher in Antarctica using live video chat technology.

What do all of these scenarios have in common? They all represent hands-on, minds-on activities by students participating in a results-based outreach program in which researchers in Antarctica shared their scientific work with students in the classroom. This collaborative partnership between scientists and schools added value for learners by enriching the curriculum and improved student performance by modeling scientific processes and careers, motivating students to inquire about the world around them and solve real-world problems, and using best practice instruction. We hope that the description of the Antarctic Outreach Program in this article will be a model for improving student performance that other school districts can easily adapt.

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By understanding the underpinning mechanisms conferring freeze tolerance, it may be possible to develop protocols for cryopreserving human organs.

Like all other success stories, ours begins with a good idea and building a passionate team to implement it. Richard Lee's early ambition was to be a high school biology teacher and coach. When his life took a different path and he became a university professor, he still had the urge to share knowledge with school-age children and provide professional development opportunities for their teachers. As an Antarctic researcher, he hit on a way to share his work with youth. In writing his National Science Foundation (NSF) grant applications, in one component of the outreach program he requests support for a teacher liaison to travel with him, participate in the research, and coordinate outreach to classrooms in the United States. As a result of this experience, thousands of children have had the opportunity to see Antarctica through the eyes of research scientists and their teachers.

It is important for learning and assessment to be authentic, that is, relate to the real world. According to education expert Grant Wiggins (1990), "Authentic assessments present the student with a full array of tasks that mirror the priorities and challenges found in the best instructional activities; conducting research; writing, revising and discussing papers; providing an engaging oral analysis of a recent political event; collaborating with others on a debate, etc." In authentic assessment, the process and thinking behind the work are valued as much as the finished product. Doing real work in school helps students to function successfully in the 21st century.

In addition to authentic learning, we coined a new phrase in education to relate to our Antarctic Research Project: *authentic outreach.* Authentic outreach brings real work, experience, and information from our polar research station into communities. A study by Mistler-Jackson and Butler-Songer (2000) found that student achievement and self-efficacy is enhanced through the "study of current and meaningful research questions, issues, or real-time phenomenon" (p. 476). In our case, we believe that improved student performance results from authentic outreach in which teachers use technology to communicate with students and communities from Antarctica and provide real-world opportunities for student inquiry through a variety of multiage, multisensory, multiability, and cross-curricular activities.

WHAT THE ANTARCTIC RESEARCH PROGRAM IS ABOUT

Belgica antarctica: A Tiny Fly With a Big Impact

The official research project is entitled, "Roles for Dehydration and Photoperiodism in Preparing an Antarctic Insect for the Polar Night." In plain English, Lee from Miami University in Ohio and his colleague, David L. Denlinger from Ohio State University, are studying a tough little wingless fly, *Belgica antarctica,* that survives in extremely harsh polar conditions (see Figure 1). As the southernmost free-living insect, this species can survive extreme dehydration to less than 30% of its normal weight (think of a raisin), weeks of immersion in saltwater or freshwater, and extensive freezing within its body. Their research objective is to understand physiological and molecular mechanisms that allow this unique insect to survive extremes of temperature, salinity, oxygen, and daylight. Although research focuses on answering basic scientific questions, understanding these mechanisms may provide clues for medical innovations. For example, currently it is not possible to freeze any human organ for long-term storage and later transplant. This fly, and some frogs and turtles also studied in Lee's lab, can naturally survive the freezing of their bodies, including all their organs, for extended periods. By understanding the underpinning mechanisms conferring freeze tolerance, it

Note. Belgica antarctica is the largest fully terrestrial animal on the continent of Antarctica. Although its lifespan is 2 years, all but the last 10 days of its life are spent as juvenile larvae. (Photo by Richard E. Lee Jr.)

FIGURE 1. ADULT MALE *BELGICA ANTARCTICA*

may be possible to develop protocols for cryopreserving human organs.

Five-person teams travel to Palmer Station (64°46' S, 64°04' W) on the Antarctic Peninsula to study and collect flies. Each year the team arrives in early January during the Antarctic summer to collect insects from nearby islands where winter snow and ice have melted. Some team members remain through May to study seasonal changes in the larvae as they prepare for the long, harsh winter. The fly lives in moist areas, under rocks or moss, or outwash areas adjacent to penguin rookeries and can be collected with a spoon and a tool called a pouter used to suck insects into a container through a straw. The insects are taken back to the research laboratories at Palmer Station, cleaned, sorted, and kept refrigerated so that experiments can be run at the base or specimens sent back to home labs for further study. (For more details about Lee's research, see Miami University's *The Antarctic Connection* at http://www.units.muohio.edu/cryolab/education/antarctic.htm.)

HOW THE OUTREACH WORKS

Successful grant proposals to the NSF require not only an innovative and detailed research plan but also a rigorous and meaningful section on broader impacts. Traditionally this section describes research opportunities for undergraduate and graduate students and postdoctoral associates. However, in recent years, NSF has placed new emphasis on providing additional activities that integrate research and outreach to schools and the public, use diverse media to disseminate research results, and foster a better understanding of the link between scientific discovery and societal benefits.

Lee invites teachers to join the field team and generally selects them from teachers who have worked with him or taken graduate courses at Miami University. Participants must be self-starters with strong organizational skills and writing ability, be willing to work hard, and, most important, be dedicated and enthusiastic liaisons who "pass the BUG" (wingless fly, that is) by communicating with and developing effective outreach programs for their school districts and communities. They must also be able to live and work under the sometimes stressful conditions of an isolated field station.

The NSF proposal includes funds to hire a substitute teacher for 6 weeks to allow a teacher from kindergarten to 12th grade to join the field team each year. Given current funding problems in schools, these monies were critical in some cases for obtaining permission from school districts to allow a teacher to take a 6-week leave from his or her classroom to participate in the field research.

Traveling to Antarctica is costly, and access is difficult. Because there is no airfield at Palmer Station, research teams must arrive by ship on an icebreaker, which crosses the Drake Passage only once a month. NSF provides all travel and living expenses for our teachers.

LAUNCHING AN OUTREACH INITIATIVE: FIVE SUCCESSFUL COMPONENTS

The Antarctic Outreach Program is an excellent model for any organization interested in improving the performance of its constituents. So far, we have successfully completed six field seasons at Palmer Station within the course of two NSF grants. During each of these field seasons, a new teacher liaison has served the dual role of scientific researcher and educational outreach coordinator for the team. Six people have worked in this capacity, including two public high school teachers, one middle, one upper elementary, and a primary teacher. Because of logistical challenges in 2010, a science educator/writer, Juanita Constible, also filled this role and connected with a local elementary grade school (see Constible, Sandro, & Lee, 2007; Constible, Williams, Faure, & Lee, 2012).

Although each field season's outreach initiatives are unique to the teacher liaison's school district and community, five main components have made the broadest impact in our outreach efforts. Here are highlights of how people from diverse backgrounds collaborated to reach a common goal: connecting students to real scientists working at the bottom of the world.

Component 1: Recruiting and Mobilizing Support

The teacher liaison is invited to join the team approximately 10 to 12 months prior to his or her Antarctic departure. This time is valuable and necessary for the teacher liaison to gain and mobilize support for the outreach initiative. It is critical for this person to guide and focus collaborative improvement by seeking support from the school board, district administrators, and fellow teachers and communicating a strong vision as to how his or her role on the team, as Antarctic researcher and outreach coordinator, along with a 6-week absence from the classroom, will contribute to student learning across the district.

Natalie Harr, the 2012 teacher-liaison from Crestwood Local Schools, called her outreach initiative the Crestwood-Antarctica Connection. To gain support from her district, Harr wrote a plan to showcase how the outreach could create a district-wide learning community by uniting approximately 2,100 students across the district with Antarctic scientists using cutting-edge technology and real-world application projects and activities.

"Lab coats, test tubes, eyeglasses," and "untamed hair" are typical phrases used by students of all ages to describe their perceptions of a scientist.

Coordinating meetings, presentations, and a written outreach plan have been especially beneficial for gaining school leaders' and teachers' participation in the project.

If it takes a village to raise a child, it also takes a community to mobilize an outreach initiative. Harr organized and managed efforts and resources through the formation of teacher committees, enlisting help from local colleges, and seeking financial support from community organizations and businesses, valuable steps in coordinating the outreach program prior to departure. For the Crestwood-Antarctica Connection, she recruited teachers and administrators to help lead specific outreach activities by forming Antarctic committees. For instance, one of the five committees formed at the primary school focused on creating a nature photography challenge. A group of six teachers organized photography contests that helped students understand how scientists use photography to document their work and discoveries. Other committees in the district helped to organize grade-level science investigations, health initiatives, book studies, and community nights to connect students with Antarctica in relevant and meaningful ways. Education majors from local colleges have participated in outreach activities during their fieldwork at schools, provided insight and training on useful technology for the outreach, and helped to connect with other school districts and teachers. Parent-teacher organizations, local businesses, and educational coalitions such as the Martha Holden Jennings Foundation have promoted the outreach by generously providing grants for the teacher liaison to purchase materials, equipment, and supplies. The outreach soon becomes a team effort from all who believed in and supported the initiative.

Component 2: Students and Community Meet an Antarctic Researcher

"Lab coats, test tubes, eyeglasses," and "untamed hair" are typical phrases students of all ages use to describe their perceptions of a scientist. Far from the truth, these misconceptions can lead to big misunderstandings about what a 21st century scientist is and the impact that scientists have on our world.

Approximately a month before departure, Lee dispels these false perceptions when he travels and donates his time to the teacher liaison's school district to hold assemblies, visit classrooms, and conduct scientific investigations with students. He typically gives a fascinating Antarctic presentation geared to each school in the district, from primary through high school levels, about his research, life as a scientist at the bottom of the world, and what to expect as their own teacher departs on the expedition.

During this time, Lee has also helped students learn about other aspects of his research, including the goldenrod gall fly. Quite similar to *B. antarctica*, this freeze-tolerant fly is commonly found living in the natural areas surrounding Ohio schools. Lee has partnered with classroom teachers during his visits to conduct investigations of the fly larvae/galls in which they live (to find out more about this work, see Sandro, Constible, & Lee, 2007). By attending the assembly and working side by side with a scientist, students begin to see themselves and their teachers as working scientists making a difference.

During Lee's one- or two-day visit, the teacher liaison also coordinates a community night talk open to the greater community to meet Lee and learn about his work, as well as visits to other school districts and colleges in the area. This visit builds momentum for the outreach by giving students and the larger community an opportunity to meet the person behind the science.

Component 3: Communication While at Palmer Station: Using Technology

Technology allows students to communicate and interact in real time with people thousands of miles away. Outreach teachers in Antarctica capitalized on the advantages of technology by creating websites, blogging, making movies, and holding live videoconferences. The 2012 outreach website, Crestwood Explores the World (http://www.crestwoodexplorestheworld.org), is a comprehensive, interactive site that incorporates many types of technology and features high-interest initiatives to motivate and inform students and the community. Launched during Lee's school visit, this website served as the primary driving force to unite the Antarctica Outreach Program with more than 30 other school districts and educational organizations nationwide.

The most popular feature on the Crestwood website was Harr's interactive blog. Harr captivated her growing audience by writing personal accounts and creating photo slideshows and movies that documented each step of the research expedition: the flights through South America,

an icebreaker voyage through the difficult Drake Passage, their arrival at Palmer Station, and their research and other activities while living at the station. Adults and children asked questions and wrote comments on the blog, and Harr made a point of answering each question personally. The website also showcased the progress of the Crestwood outreach initiative, including the Read to Walk to Antarctica campaign, Penguin Month, Nature Photography Contests, and Polar Postcard Challenges. Other schools joined the outreach by filling out a digital contact form on the Get Connected web page. The website received up to 1,650 hits per day during the expedition.

A favorite high-tech feature on the Crestwood website is Gigapan imagery. With the help of technology staff at Palmer Station, Harr used a Gigapan camera and software to create an interactive, virtual tour of Antarctica. The Gigapan system is a simple robotic platform for capturing very high-resolution (gigapixel and up) panoramic images using a standard digital camera (for more information see GigaPan.com). In the 180- and 360-degree panoramic images, observant students could zoom into this highly pixelated photo to find hidden details that would be invisible in regular photographs. With each image embedded in her blog, Harr created scavenger hunts to challenge students of all ages to explore the Antarctic environment carefully (Steinwald, Kawarasaki, Constible, Lee, & Bailer, 2010).

Ascribing to the old adage, "a picture is worth a thousand words," one outreach teacher made a movie that traces the life of an Antarctic researcher throughout one day, from waking up in the morning, to collecting insects in the field and preparing them in the lab, to bedtime by the glacier. *A Day in the Life of a Bugger* (http://www.youtube.com/watch?v=JxJyr3IzR5o) video also features college students working in Antarctica who represent different science careers and are great role models (Betteley & Lee, 2009). Positive exposure to researchers has caused some students to think about their own futures. An eighth grader commented on Betteley's video, "It's inspiring because if you work hard in life you can do these types of things and have those adventures."

Videoconferencing proved to be a powerful communications tool for the outreach teachers and their schools. Researchers Mistler-Jackson and Butler-Songer (2000) reported that "students are excited to talk . . . through interactive talk on the Internet, and . . . their content learning and . . . time on task improve as a result of . . . productive interactions with peers and scientists" (p. 476). Betteley video-chatted from Palmer Station with 650 students in her school's auditorium. Selected middle school students came to the podium onstage to ask questions that were prescreened by classroom teachers to ensure their quality and appropriateness. According to Mistler-Jackson and Butler-Songer, this "carefully scaffolded telecollaboration is important because it fosters student participation in a meaningful arena in which their voices and those of their peers are valued and respected. Our data suggest that this participation can encourage particular types of students' effort, persistence, enthusiasm, and task accomplishments" (p. 476). The experiences of our Antarctic research team corroborated researchers' findings that "predetermined labs or recorded events do not hold the same motivational power and prestige in the eyes of students, [and] telecommunications programs . . . that promote current issues and opportunities for collaboration provide valuable motivational and learning opportunities for students and teachers" (p. 476).

Component 4: Interdisciplinary Outreach: Purposefully Planning Instruction

"The National Research Council (1999, 2005) recommends that instructional planning and classroom instruction focus on maximizing student opportunity to learn" (Klentschy, 2008, p. vii). The Antarctic Outreach Program maximized student learning by integrating activities into the language arts and content areas, such as science, social studies, and math. In our experience, interdisciplinary learning increases student motivation and engagement. This cross-curricular approach helped students explore, write, think, and communicate at higher levels of learning with their classmates, teachers, and members of the community.

When students are afforded the opportunity to experience firsthand the wonders of their local natural environment, they can begin to understand other complex and foreign environments, such as Antarctica. Harr and her colleagues have worked together for several years to create an outdoor education program for their elementary school campus, where students conduct nature investigations to enhance learning across the curriculum. (Harr and Lee [2010] describe how writing can be incorporated into this cross-curricular project.) As part of the outreach initiative, she worked closely to connect the students' schoolyard activities with the remote environment she encountered at the bottom of the world. Students used books, movies, the interactive blog, and a schoolwide video-chat with Harr from Palmer Station to understand Antarctica's differences from and similarities to their Ohio environment. For instance, there are various species of trees, bushes, and grasses located on school grounds, but only a few mosses, algae, and grasses grow on the Antarctic peninsula.

As a culminating project, two second-grade teachers built a blow-up sensory room using fans and tarps

they called the Antarctic/Ohio Science Sensory Bubble. Inside, students proudly displayed the three-dimensional models they created of an Ohio or Antarctic plant or animal that they researched. An entire class of students could tour their schoolyard environment in half of the sensory bubble or the simulated Antarctic environment in the other half. Students and their families toured the sensory bubble and other Antarctic student projects at a district-wide science and technology night held jointly with Hiram College.

Global climate change is an interdisciplinary topic that spans social studies, science, and language arts. Outreach teachers described evidence for climate change in Antarctica, and their students participated in hands-on inquiry activities to investigate the problem and draw conclusions. (For articles written by outreach teachers concerning this topic, see Constible, Sandro, & Lee, 2008, and Bugg, Constible, Kaput, & Lee, 2007.)

Antarctic research is the perfect complement to the science curriculum and has been adapted at many grade levels. Related lessons are inquiry based and involve science, technology, engineering, and mathematics (STEM) activities that improve student learning and performance. "STEM skills are those skills, which support scientific inquiry and research, and the growth of these disciplines. They include: data analysis and interpretation, research and experimental design, testing hypotheses, analysis and problem-solving and technical skill" (Holt, Johnson, & Harrison, 2011, p. 5). These authentic skills tie into real-world situations and are exactly the type of learning that educational experts espouse for optimum student performance.

Student performance on outreach activities was chiefly assessed using formative assessments: "purposeful, planned, and often spontaneous teacher-to-student . . . verbal and written interactions that involve a variety of assessment techniques. These techniques are used to engage students in thinking deeply about their ideas" (Keeley, 2008, p. 3). The teachers used a number of informal assessment techniques such as having students write questions; predict, observe, and collect data; create charts, graphs, drawings, and illustrations; support claims with evidence; draw conclusions; summarize; and reflect about what they learned. Great efforts were made to create activities and assessments that reflected current research and provided opportunities for all students to achieve deeper levels of learning.

Component 5: Media, Publications, and Extended Outreach: Passing the "BUG," *Belgica antarctica*

The ultimate goal of outreach programs is to reach people. The leaders and teachers in the Antarctic Outreach Program worked to share the results of Antarctic researchers with as many students and community members as possible. Table 1 shows the estimated audience for Harr's 2012 outreach.

TABLE 1 2012 OUTREACH PRESENTATIONS

AUDIENCE	NUMBER OF PRESENTATIONS	NUMBER OF PERSONS REACHED
Students	12	3,557
K-12 teachers and administrators	9	261
General public	9	1,724
Total	30	5,542

Members of the outreach teams are accomplished writers who are eager to share their discoveries with scientific and educational communities. In addition to publishing the research results in internationally recognized journals, we also published articles related to outreach and science education in refereed professional teaching journals. Since 2006, team members have published one book and eight articles in educational publications from the primary to the college level.

Media also play an important role in the dissemination of information about our Antarctic research. School newsletters and Ohio newspapers have published articles about our work. School television stations have replayed many events and presentations that pertain to schools, and a local television station aired a story about a teacher liaison's Antarctic departure. A local radio station interviewed Lee, a teacher liaison, and students about the star of our show, that wingless wonder, *B. antarctica*. National Public Radio has also interviewed Lee.

Just as some gifts keep on giving, some outreach keeps on reaching. Once team members return from Antarctica, they continue to share their research with groups throughout the state and nation at local school board meetings, Earth Day celebrations, science cafés, church groups, public libraries, professional women's organizations, children's camps, and teacher workshops. The news of our presentations spreads quickly by word of mouth to groups interested in the environment and that like to keep current on cutting-edge research.

CONCLUSION: WHY THIS OUTREACH IS SUCCESSFUL

The Antarctica Outreach Program has inspired successful student performance because of five main components: recruiting and mobilizing support, sharing of information at school and community meetings by the lead Antarctic researcher, global communication using technology, careful planning of interdisciplinary activities, and coverage by media and publications to extend outreach. Ultimately the generous support by the NSF and positive attitudes, cooperative efforts, and hard work of the teams have converged to create a dynamic outreach that has reached thousands of students and families nationwide since 2004.

Booker T. Washington once said, "Few things help an individual more than to place responsibility upon him, and to let him know that you trust him." This maxim sums up the implications for designing effective professional development for instructors. When teachers are afforded opportunities to participate in real-world research, work with top-notch professionals in a given field, supported by leadership, and treated as valued members of the team with important roles to play, their abilities to design authentic learning materials and make real-world tie-ins with existing curriculum are markedly enhanced. By collecting and interpreting student performance data, designing best practice instruction, and drawing conclusions based on student assessment evidence, teachers can create and share model instructional programs that will improve student performance. With regard to the impact on students, our experiences suggest that performance improves when they are provided with real-world opportunities to interact in authentic situations that prepare them for life in school and beyond. That's quite an impact for a tiny, wingless fly.

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