Bridging the Gap Between Real-World Polar Science and the Classroom

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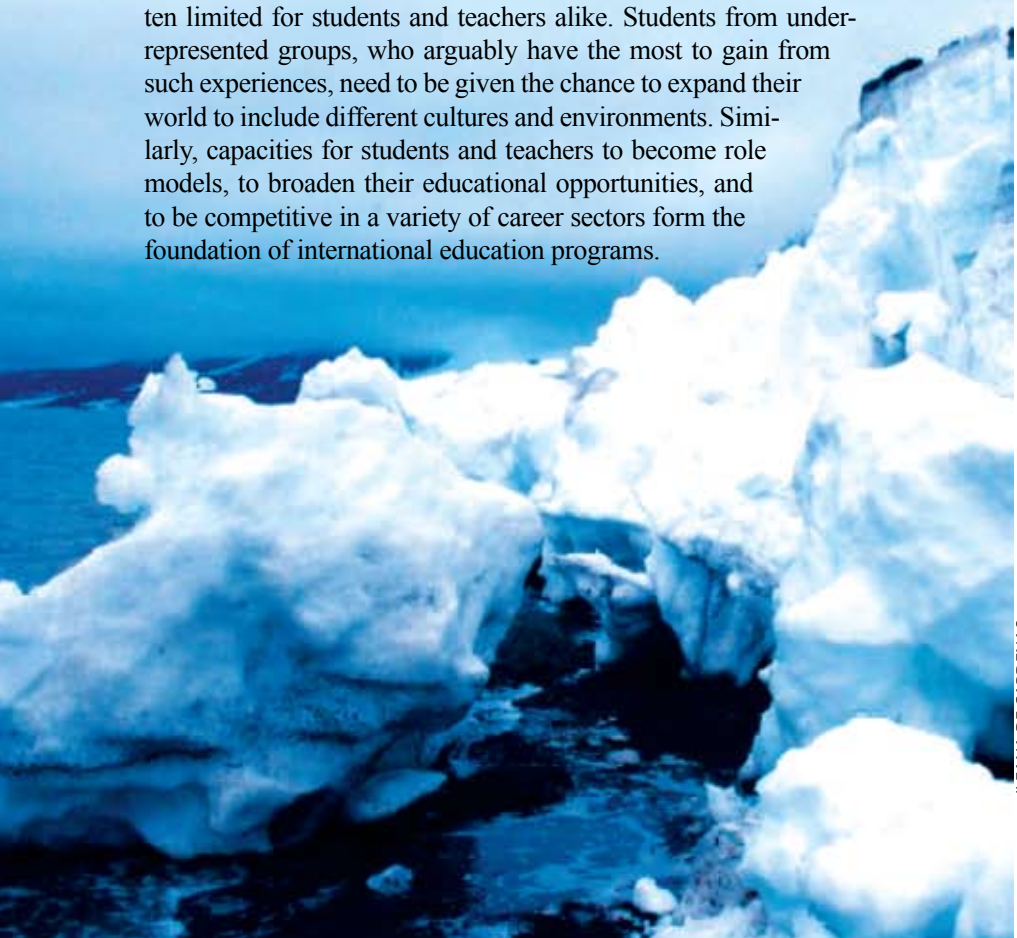
The International Polar Year—Research and Educational Opportunities in Antarctica for Minorities (IPY-ROAM) program was designed to increase minority participation in polar science by immersing participants in an academic program that included a trip to Antarctica. The IPY-ROAM program was focused on increasing public understanding of the polar regions and stimulating a new interest in polar science. This effort was coordinated by faculty from the University of Texas at El Paso (UTEP) and was implemented to positively contribute to the intense, internationally coordinated IPY scientific campaign. Through a grant from the National Science Foundation, a team of UTEP researchers developed a unique and life-changing opportunity for university students and high school teachers to travel to Antarctica. The goal of the program was for participating students and teachers to learn more about the polar regions and to acquire firsthand experience in field-based research and Antarctic system science.

The concepts associated with global climate change can often appear foreign and disconnected to students in classrooms, and research experiences that offer opportunities to be immersed in hands-on scientific experiments are often limited for students and teachers alike. Students from underrepresented groups, who arguably have the most to gain from such experiences, need to be given the chance to expand their world to include different cultures and environments. Similarly, capacities for students and teachers to become role models, to broaden their educational opportunities, and to be competitive in a variety of career sectors form the foundation of international education programs.



ILEANA DE CARDENAS

The International Polar Year (IPY) provided a momentous and timely opportunity to educate the next generation of scientists and the general public about the polar regions and their importance to the global system. This is especially important considering the large-scale environmental change occurring in both Antarctica and the Arctic (Intergovernmental Panel on Climate Change 2007). Few international scientific efforts match the opportunity presented by the IPY to significantly impact and attract the next generation of scientists.

As an extension of the IPY and in order to coincide with this momentous occasion, an educational research experience was created to extend a unique opportunity to undergraduate students, graduate students, and teachers. The International Polar Year—Research and Educational Opportunities in Antarctica for Minorities (IPY-ROAM) program was designed to increase minority participation in the polar sciences by immersing participants in an academic program that included a trip to Antarctica. This effort was coordinated by faculty from the University of Texas at El Paso (UTEP) and was implemented to positively contribute to the intense, internationally coordinated IPY scientific campaign. The city of El Paso, Texas, is a bustling urban area of 600,000 people, more than 70% of whom are Hispanic in origin. Across the river from El Paso sits the Mexican city of Ciudad Juárez, a city of more than 1.2 million people; El Paso/Ciudad Juárez represents the largest metropolitan area along the 2,000 mile U.S./Mexico border. Almost a quarter of El Paso's population is foreign born, and over 50% of El Paso's households speak Spanish as the language of preference.

The IPY-ROAM program was focused on increasing the public understanding of the polar regions and stimulating a new interest in polar science. Through a grant from the National Science Foundation (NSF), a team of

UTEP researchers developed a unique and life-changing opportunity for university students and high-school teachers to travel to Antarctica. The goal of the program was for participating students and teachers to learn more about the polar regions and to acquire firsthand experience in field-based research and Antarctic system science. Information for researchers, educators, and the general public can be found on the IPY-ROAM website (*www.ipyroam.org*).

Working with a pool of 139 applications submitted to an open national competition, a multidisciplinary evaluation team of science and education faculty and administrators used an evaluation rubric in a blind review process. Each application was scored in areas such as personal strengths, professional and academic goals, and potential impact on the participant and their community. From this group of recommended qualified participants, the UTEP faculty team accepted a total of 29 participants, which included 16 undergraduate students, 8 graduate students, and 5 high school and middle school teachers. The selected applicants came from across the nation, but over 55% came from the border community in and around El Paso, Texas.

The IPY-ROAM participants consisted of 83% minorities, which included 55% Hispanics, 14% Asian Americans, 10% African Americans, 4% Native Americans, and 4% Pacific Islanders; the gender makeup of the group was 72% female and 28% male. In general, this reflected the demographics of the applicant pool as a whole. In both the areas of ethnicity and gender, the selected group represented populations that are not historically included in polar science research experiences and represented a fundamental potential impact on both minorities and women. Additionally, many of the participants attended minority-serving institutions or served communities with high minority populations, including El Paso, Texas; Los Angeles, California; Oakland, California; and Miami, Florida.

MARISA NEGRETE

Aquatic Biology team member doing field analysis in the Antarctic nearshore zone.

Overview of IPY-ROAM

The academic program consisted of two three-credit courses at the senior undergraduate and graduate level. The first was an online content course on the fundamentals of Antarctic and polar system science. This course was delivered in the fall semester of 2007 and included such diverse topics as Antarctic geology, marine biology, research techniques, and international policy. The second course was the field-based experience occurring over three weeks at the end of December 2007 and the beginning of January 2008, during which time program participants traveled to southern Argentina and, ultimately, Antarctica.

These program elements were based on the belief that problem-based learning and hands-on experiences have the potential to increase learning and retention in the sciences. In the classroom, constructivist curriculum must be designed so that it reflects real-life situations (Bentley 1995). The use of the social context of learners as an organizer for content has been promoted by curriculum developers, who define this approach of content organization as contextualizing the concepts taught in distinct and unique disciplines of study (Hofstein and Yager 1982). Research scientists cross over the barriers between disciplines all the time and seldom operate solely on isolated areas of content but instead integrate the use of language, knowledge, and process application. Research-based programs give students the ability to retain facts through critical thinking by working through problems logically and making connections to the real world. Studies have shown that students who are involved in active learning in meaningful contexts acquire knowledge and become proficient in problem solving (Robertson 2000).

The pedagogical aspects of the program were designed to enhance the abilities of students and teachers to demonstrate a thorough understanding of the structure and function of the Antarctic system, as well as to improve students' and teachers' abilities to conduct and document field-based studies. An inquiry-based curriculum was designed in order to help lead participants to an improved understanding of fundamental scientific concepts

KATRINA WEBER

Chinstrap penquin (Pygoscelis antarctica) *in Antartica.*

and research processes. As students explored concepts, they developed a broader understanding of those concepts. When they related what they were learning, seeing, or doing to others, they began to see similarities in their understandings as well as to self-identify misconceptions they may have had about content material (Bybee et al. 2006). This sharing within cooperative groups is a fundamental strategy in the constructivist approach, as it allows the instructor to facilitate the learning process and also helps to develop a common base of experiences on which to help make connections to content. Problem-solving strategies depend on conceptual understandings, and hands-on exploration of simple topics combined with collaborative interaction among students helps to build an understanding of processes and concepts (Apple 1993).

Traveling aboard a tourist ship, the Russian-owned *M/V Lyubov Orlova*, the group visited the South Shetland Islands and northern Antarctic Peninsula, where participants engaged in hands-on, field-based research projects that they designed with the aid of the faculty. While in Antarctica, all participants worked on their independent studies projects within focal groups of four to seven people in order to address specific topic areas. These topic areas included marine biology (e.g., distribution of marine life), terrestrial biology (e.g., plant and invertebrate ecology), physical sciences (e.g., glacier retreat), ecotourism (e.g., human impacts and attitudes), and education (e.g., curriculum products for classroom use). Participants in all groups also had the opportunity to participate in a range of community outreach activities and curriculum development efforts before, during, and after their trip to Antarctica.

Participants learned the challenging yet valuable nature of interdisciplinary studies, in that each of these five topic groups had to work in an integrative manner. The participants had to address the central theme of identifying how Antarctica is responding to global change and why change in Antarctica is important to the rest of the globe. The independently crafted research projects and the integration of these projects within and between topic groups helped students to achieve personal professional goals, including poster and oral presentations at regional, national, and international conferences and the development of manuscripts suitable for publication in peer-reviewed journals. The IPY-ROAM faculty was dedicated to helping participants achieve such goals and to maximizing the success of each participant's academic and educational pursuits.

Academic preparation and integration of research in Antarctica

In this research-based academic program, students engaged in formulating original questions, collaborated to search for answers, and critically evaluated their subsequent findings. This approach to learning included a deeply involved, experiential investigation of a topic. In the context of this program, students encountered and processed content information in four primary ways: First, a lecture component in which common informational content and process information was facilitated to all involved participants in the form of online lectures, webinars, and group discussions; second, a project component in which groups of participants planned, developed, and implemented a research project that integrated problem solving and critical thinking; third, a skills component in which participants used actual field equipment safely and purposefully under the guidance of experts; and fourth, an education and outreach effort to disseminate products designed to inform K–12 classrooms and the general public about the polar regions.

During the fall of 2007, students participated in the online component of the course and were expected to begin designing their independent research projects to be undertaken in Antarctica. All students worked within project groups of four to seven individuals and each group addressed one of the preselected focal areas. The previous experience of the faculty leading study abroad experiences to Antarctica helped define focal groups that were designed to span the majority of student interests, to embrace a range of suitable individual studies projects, and to put together like-minded people with common interests. Each cooperative group consisted of one faculty member, one teacher, at least one graduate student, and a number of undergraduate students. Regular team meetings took place online during fall 2007 so that teams could share and refine their initial plans for field-based research activities and outreach efforts.

In addition, during the field portion of the research experience that began in December 2007, the teams made regular presentations to the rest of the program participants in order to allow for constructive criticism and refinement of the proposed activities. Each project team had both individual and group components that were assessed separately. Students designed individual projects within each team

and, in consultation with the rest of the group, tied together the individual projects in order to form a cohesive and overarching coverage of the focal area. When appropriate, the entire cohort of participants was asked to brainstorm solutions to problems or approaches that were challenging to a particular group or individual. Under the guidance of the faculty mentor, students were expected to consult original source literature as well as experts in the field. Throughout the process, participants were immersed in educational and research experiences that emphasized cooperative and interactive teamwork as well as the interdisciplinary nature of polar science.

For example, a central topic for the marine biology group was to understand how changes in the density and composition of penguin colonies affected nearshore nutrient chemistry, production, and aquatic organism diversity. The potential for penguin colony location and composition to change with warming of the Antarctic peninsula environment could have important implications for the nearshore aquatic environment. Similarly, the terrestrial biology group also addressed temperature and nutrient limitation and the distribution of terrestrial organisms by surveying the growth and morphology of lichen, moss, and vascular plant species and how these affected the distribution of terrestrial arthropods. The physical sciences group used historic and current photographs, together with simple image processing techniques, to investigate changes in glacial extent over time in the northern region of the Antarctic Peninsula. The ecotourism group observed and recorded tourist movement patterns and actions on the landing sites and surveyed the other tourists on the ship in order to determine their level of awareness regarding the importance of protecting the Antarctic environment.

Finally, the purpose of the education group was to develop curriculum and informational products for dissemination in schools and to the general public, thereby constructing a fundamental resource that will take polar science directly into the classroom. The team developed thematic learning units based on the research of the other groups and integrated instructional models such as the learning cycle lesson design and constructivism within the materials. The team was tasked with designing, developing, and implementing a series of educational learning opportunities for students in schools at all levels from K–12. The purpose was to have the educational group synthesize an understanding of the concepts associated with real-world polar science in a context appropriate for student learning in schools.

CRAIG TWEEDIE

Terrestrial Biology team doing field analysis of a site on Cuverville Island in Antarctica.

Classroom materials available online

A key component of the IPY-ROAM program was the development of educational materials to be made freely available online to K–12 students and teachers. The faculty team felt it highly important to develop resources that would bring the field experiences of Antarctic research to the classroom. During the expedition to Antarctica, the education group, in order to understand the scientific research process, worked collaboratively with the other IPY-ROAM members by integrating into one of the four research projects. These participants were responsible for observing field techniques, assisting in data collection, and acquiring photographs and videos. In turn, the education group of the IPY-ROAM program facilitated the development of products that would be useful to teachers, students, families, and community members in order to better understand basic concepts about polar science and more advanced lessons relating how scientific research is conducted in Antarctica.

With information gathered from the field, lesson plans were designed that allow students to explore and to recognize the importance of Antarctica. The lesson plans or learning experiences were developed utlilizing a formatted template, which allowed for consistency in the development process. The lesson plan template included the following sections: (1) a teacher preactivity that introduces and prepares the teacher for the assignment; (2) a teacher postactivity that provides answers and possible extension for the lesson; and (3) a

student laboratory activity that describes the purpose of the assignment, a description on what to do, and connections on how the contents relate to the real world. To allow for the lesson plans to be used at schools across the United States, all lesson plans were aligned with the National Science Education Standards.

As a result of this approach, the education group produced academic products that include the following:

- A glossary that describes the wildlife and geological terms, research sites, scientific field equipment, and diverse scientific disciplines involved in the project.
- A video bank with general material such as penguin behavior, images of the Antarctic environment, fieldwork done by participants, as well as instructional videos that explore the various research areas and can be used to compliment the IPY-ROAM lesson plans.
- A photograph gallery from the trip that depicts sites visited, wildlife, and geological features and that is linked to the glossary of terms.
- A series of inquiry-based K–12 lesson plans in the areas of terrestrial and aquatic ecology, geosciences, and ecotourism. Each lesson plan has a hands-on component and assists students in understanding Antarctic science from a basic to an advanced level.

The overarching goal of the education group was to instill the idea of environmental stewardship and the impact of individuals on local and global issues. The approach taken was to achieve this by creating classroom experiences that emulate those experienced by scientists in the IPY-ROAM program. Rooted in constructivist methods, the inquiry-based lesson plans allow students to experience science as the scientists did in Antarctica. Providing still photos, sound, and video also allows students to get as close to Antarctica as possible. Short movie clips are provided on the IPY-ROAM website, and teachers can use them to show students the landscape and wildlife of Antarctica. Final products developed by the education and outreach team are housed on the program's website (*www.ipyroam.org*) and can be located by choosing the "Education" link. These materials can be downloaded free of charge by students, teachers, and community members.

Conclusion

The outlined program of study and associated activities has significant intellectual merit, especially in the area of environmental education. All field-based research activities were focused on educational and professional development of the participants and were underpinned by a systems science approach. This was done in order to ensure adequate linkage between the physical, biological, and social components of the Antarctic System and how these areas relate to global climate change. Educational products are available for free on the IPY-ROAM website, and we anticipate that these products will lead to the advancement of new opportunities for teachers and students in K–12 classrooms.

Science is not just a body of facts that can be memorized and then repeated on an exam. Sadly, science instruction has become just that (Bybee and Van Scotter 2007; Conderman and Woods 2008). It is in the "doing" rather than the "seeing" of science that the faculty and participants of IPY-ROAM hope to both communicate and instill in others a love of the scientific discipline and a sense of appreciation toward scientific advancement. The IPY-ROAM program is one example of a system science curriculum that offers students the opportunity to engage in hands-on activities, problem-solving exercises, and collaborative group work. With a goal of instilling environmental stewardship via constructivist instructional methods, the program hopes to increase the awareness and understanding of polar science. And, through the training of many students from groups traditionally underrepresented in the sciences, IPY-ROAM seeks to create a new generation of role models in the polar sciences. ■

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