Arctic Science Education

Recommendations from the Working Group on Arctic Science Education to the National Science Foundation

Proceedings from the Meeting

30 March — 1 April 2000

Fairbanks, Alaska

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Foreword

KIA WHAKARONGO AKE AU
I am listening
KI TE TANGI A TE MANU NEI
To the song of the tui
A TE TUUI, TUUI, TUI TUIA.
crying let us unite, let us unite
TUIA RA TAATAU E TAU NEI
and here we are today united
TI-HEEI MAURI ORA!

TE WHARE E TUU NEI, TEENAA KOE.
To this house greetings
PAPATUANUKU, TEENAA KOE.
To the land greetings

E NGAA MANA
To each tribal authority
E NGAA REO
To all languages
E NGAA HAU E WHAA
Of the four winds
TEENA KOUTOU KATOA.
Greetings (welcome) to you all

TEENAA KOUTOU.
Greetings to you all
NO REIRA
Again I bid you
TEENAA KOUTOU,
Greetings
TEENAA KOUTOU,
Greetings
TEENAA KOUTOU KATOA.
Thrice greetings (welcome) to you all

Welcome by Working Group Chair

In this traditional Maori welcome I spoke of the tui: a popular New Zealand native bird. There are three special characteristics of the tui I would like to share with you:

1. The tui is an attractive, small, black bird with a distinctive bell of white feathers under its neck.
2. It has a delightful song. Hearing a tui duet in the dawn chorus is an indicator of the health of our New Zealand forest ecosystem.
3. It is a nectivorous bird feeding on, amongst others, the yellow flowers of our native kowhai tree.

It is this last characteristic that I think has some significance to this working group.

In slurping back nectar with its long tongue, the tui covers its head with kowhai pollen, eventually spreading it from flower to flower and tree to tree.

The success of the kowhai species is dependent on this cross pollination by the tui. The resultant seeds develop and germinate, with a few growing on to become large kowhai trees providing nectar for future generations of tui.

Perhaps the tui is a symbol of how the success of this working group relies on the cross pollination of ideas: a few ideas we hope will develop and grow into programmes, partnerships, or projects for young people. These young people will grow and mature, taking on new knowledge, attitudes, and values to better understand the physical, biological, and cultural landscapes of the Arctic.

– Pete Sommerville
Heurisko, Ltd.

Introduction

> What the future holds in store for individual human beings, the nation, and the world depends largely on the wisdom with which humans use science and technology.
>
> —AAAS, 1990

In 2001, The National Commission on Mathematics and Science Teaching for the Twenty-first Century published a report, *Before It's Too Late,* that focuses on the state of math and science literacy in the United States. Although this report specifically addresses educational issues in the United States, it contains the global message that the "most direct route to improving mathematics and science achievement for all students is with better mathematics and science teaching. . . . Students must improve their performance in mathematics and science if they are to succeed in today's world" (National Commission on Mathematics and Science Teaching for the Twenty-first Century, 2000). The burden of teaching shouldn't rest solely on the "formal" educators of our societies. As scientists, we also bear the responsibility for teaching, and in particular, teaching scientific literacy.

An Arctic Science Education Working Group (ASEWG), sponsored by the National Science Foundation, met in Fairbanks, Alaska, in March 2000 to explore the challenges of teaching science and connecting to the global communities about arctic science. The ASEWG recommended approaches to the National Science Foundation Office of Polar Programs to help arctic researchers to work more closely with the communities and schools near their research areas. The results of the working group's recommendations, if implemented, will further the partnerships and involvement of the public and arctic residents in arctic research.

Scientific Literacy

> The real world is what we live in. It is our home. There is no place like it in the universe. It's the only planet that has plants or animals. It is a cool place.
> —Alex
> (Second Grade, Emerson Elementary School Westerville, Ohio. In Thorson, 2002)

As human knowledge has advanced in the last century, so has the importance of science education. Everyone uses scientific information to make choices that arise every day. As stated in the United States *National Science Education Standards,* "in a world filled with the products of scientific inquiry, scientific literacy has become a necessity for everyone" (National Research Council, 1996). Because scientific literacy is becoming more important in the workplace as well as in all of our daily lives, the National Research Council of the National Academy of Sciences published the *National Science Education Standards* in 1996. The purpose of the science education standards was to help schools integrate science into their academic standards (under the Improving America's Schools Act of 1994). State governments and schools are held accountable to produce effective teaching strategies for all children to reach those standards (Figure 1).

Schools are not the only entities that have an important role in scientific literacy. Carl Sagan, an astronomer, once said, "Everybody starts out as a scientist. Every child has the scientist's sense of wonder and awe. It's our responsibility to sustain the wonder and awe and nurture the natural scientist in all of us."

To understand how we can support programs and projects that work toward scientific literacy, we need to fully understand three important questions:

1. **What is currently happening in education and in particular, the relationship between economics and education?**
2. **Why do we need science education?**
3. **Why is the Arctic important and, in particular, the relationship between the Arctic and science education?**

The Economics of Education

Johon Glenn, chairman of the National Commission on Mathematics and Science Teaching for the Twenty-first Century, stated that "the future well-being of our nation and people depends not just on how well we educate our children generally, but on how well we educate them in mathematics and science specifically" (National Commission on Mathematics and Science

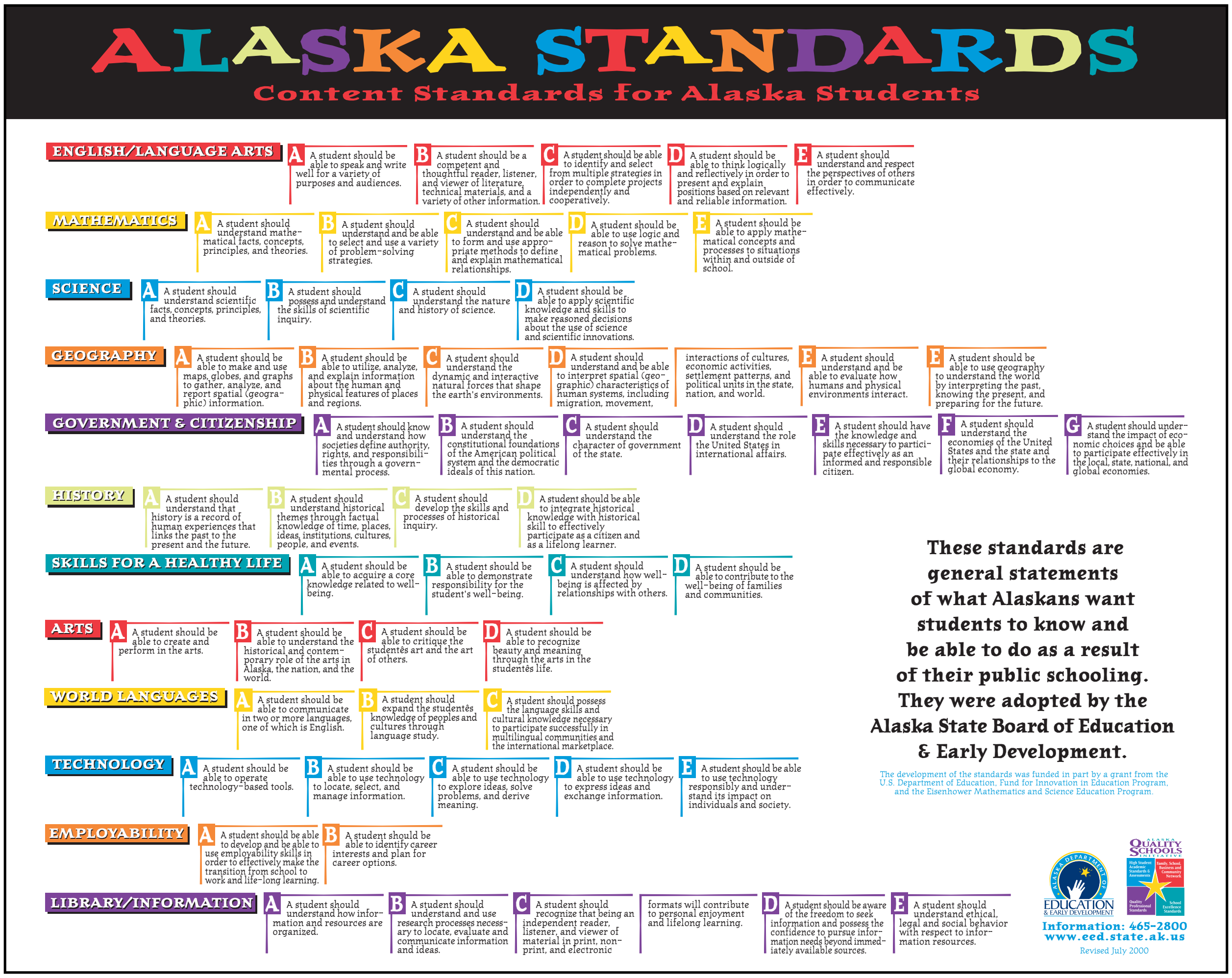

Figure 1. Alaska State Content Standards.

Teaching for the Twenty-first Century, 2000). Scientific literacy is not only important for day-to-day living, it is directly tied to economics. In fact, most of the reform and national initiatives seen in education today are changes driven by circumstances of economics.

The Changing Workforce

Most of the United States employment trend data comes from the U.S. Department of Labor. The Bureau of Labor Statistics used data on long-term trends to predict the types of jobs Americans will perform in the next century. The bureau released the 2000–2010 employment projections for the American work force, providing information on where future job growth is expected. According to their report, professional specialty occupations are projected to increase the fastest and to add the most jobs (5.3 million). The seven fastest-growing occupations are computer-related occupations, commonly referred to as "information technology occupations" (Table 1).

> Americans are not fully able to participate in our new economy. As a nation, we are not investing sufficiently in education and training. Employers report difficulty finding the skilled workers that they need.
> —U.S. Department of Labor, 2000

How Do the Changes in the Workforce Change Education?

According to the Department of Labor, the demand for higher-skilled employees is a fifty-year trend that has become increasingly important. Strength and manual dexterity used to be sufficient to ensure employment. Now most jobs require verbal and mathematical, as well as organizational and interpersonal, skills. Emerging technologies, globalization, and the information revolution have also increased the demand for high-tech skills.

High-school diplomas, once a sure ticket to a job, are becoming little more than a certificate of attendance. As a result, most employers require both advanced education and skills (U.S. Department of Labor, 2000). In 1989, the Secretary of Labor's Commission on Achieving Necessary Skills

Table 1. Fastest Growing Occupations in the United States, 2000–2010

Occupation	Employment (Numbers in thousands)		Change (%)
	2000	2010	
Computer Software Engineers, Applications	380	760	100
Computer Support Specialists	506	996	97
Computer Software Engineers, Systems Software	317	601	90
Network and Systems Administrators	229	416	82
Network Systems and Data Communications Analysts	119	211	77
Desktop Publishing Specialists	38	63	67
Database Administrators	106	176	66
Paralegals and Legal Assistants	36	220	62
Personal Care and Home Health Aides	414	672	62
Medical Assistants	431	689	60
Computer Systems Analysts	329	516	57
Source: Bureau of Labor Statistics (2000)			

(SCANS) was asked, primarily at the request of the business community, to examine the demands of the workplace and whether young people are capable of meeting those demands. Specifically, the commission was directed to advise the secretary on the level of skills required to enter employment. In carrying out this charge, the commission was asked to

- ◊ define the skills needed for employment;
- ◊ propose acceptable levels of proficiency;
- ◊ suggest effective ways to assess proficiency; and
- ◊ develop a dissemination strategy for the nation's schools, businesses, and homes.

The process initiated by the commission over twelve years ago because of global economics has catalyzed education reform and has had a major impact on the business of schools.

Where Does Science Education Fit?

The job market has changed, and consequently the skills needed for those jobs have changed. They are more complex and high-level skills than in the past. Many of the learning processes used in science and math education are similar to the advanced skills needed for future jobs, even if those jobs are not in math and science occupations.

For example, the SCANS Commission identified five competencies that people in the workplace require to be effective and productive in their jobs (Box 1). Along with these basic workplace competencies, people will need additional skills to perform in future jobs. Some of these skills may seem obvious, yet only with recent education reform have schools been incorporating the foundation skills into curriculum. The skills are:

Basic Skills: People need to have skills in reading, writing, arithmetic and mathematics, and speaking and listening.

Thinking Skills: People need to have the ability to learn, to reason, to think creatively, to make decisions, and to solve problems.

Personal Qualities: People need to have individual responsibility, self-esteem and self-management, sociability, and integrity.

Many of the workplace competencies and foundation skills are integrated into scientific activities naturally. In addition, if science is made relevant to a child's world, he or she becomes curious and science becomes meaningful and connected. After all, "scientific thinking" is how we all explore and make sense of our world.

Why the Arctic?

The Arctic is naturally an engaging environment. For many, the Arctic is interesting because of the extreme nature of the environment and the diver-

Box 1. The Five Competencies

Resources: Employees know how to allocate time, money, materials, space, and staff.

Interpersonal skills: Employees can work on teams, teach others, serve customers, lead, negotiate, and work well with people from culturally diverse backgrounds.

Information: Employees can acquire and evaluate data, organize and maintain files, interpret and communicate, and use computers to process information.

Systems: Employees understand social, organizational, and technological systems; they can monitor and correct performance; and they can design or improve systems.

Technology: Employees can select equipment and tools, apply technology to specific tasks, and maintain and troubleshoot equipment.

sity of the resources it possesses. The Arctic region (Figure 2) is a dynamic and complex environment projecting a sense of mystery and awe, particularly for those who have not experienced it firsthand.

In the last few decades, the scientific community has expressed concern about the vulnerability of the Arctic and its residents to environmental, social, and economic changes. Climate models indicate that the arctic environment may react particularly sensitively to global climate change. Now, research results show that arctic climate and ecosystems are indeed changing substantially, with impacts on people living in and outside the Arctic. Some changes appear to have begun as early as the 1970s, but many have only become significant in the 1990s. Moreover, these changes and the processes that cause them appear to be linked to changes in the whole Northern Hemisphere, involving physical characteristics in the atmosphere, ocean, and on land.

Early indications suggest that the physical changes are also causing changes in the biosphere. Because many of the Arctic's human populations are closely tied to the natural environment, they are vulnerable to changing conditions. In fact, many arctic residents, particularly subsistence users, are

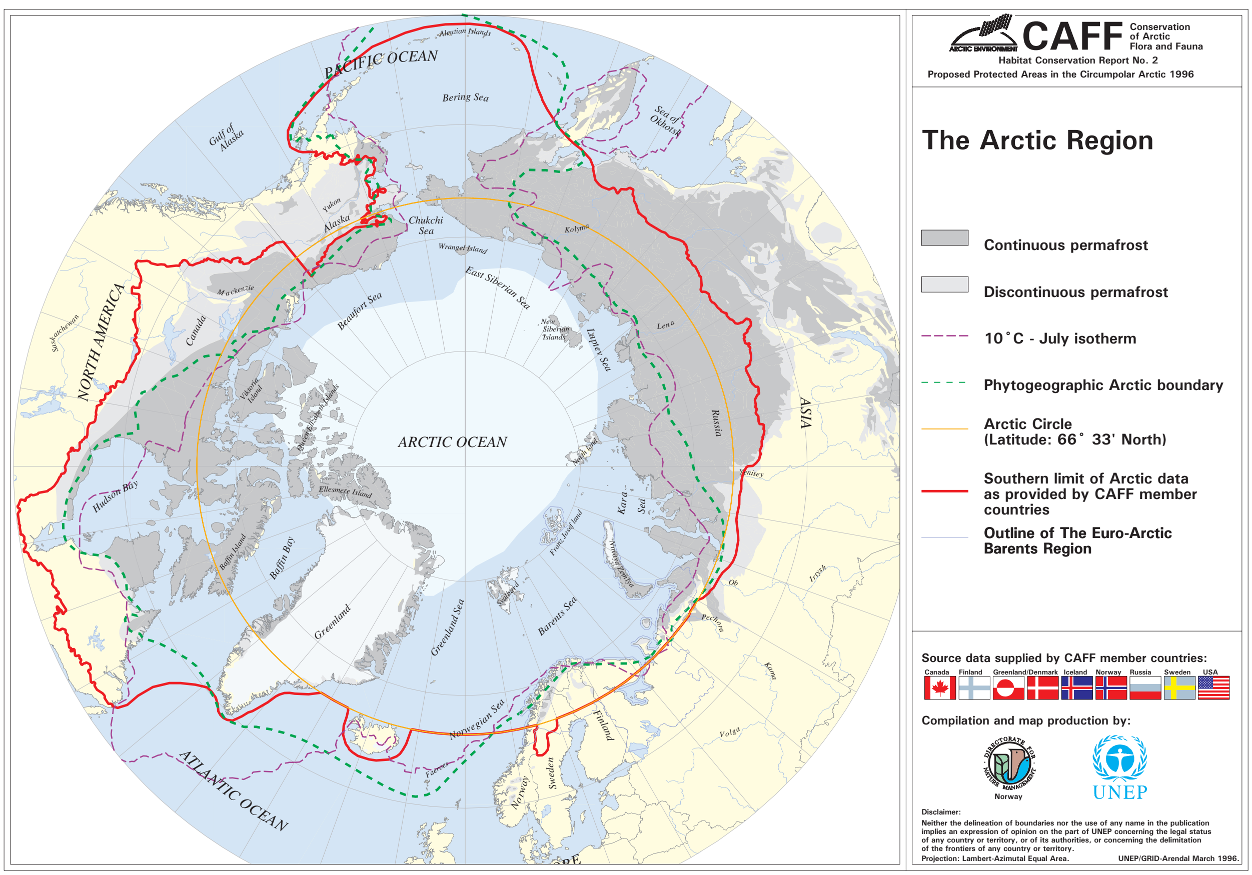

Figure 2. Map of the Arctic Region.

already reporting ecosystem changes and believe that these changes are affecting their lives. Concern about the impacts of physical and biological change is heightened by new evidence that contaminants are spreading and accumulating in arctic ecosystems. Although the connections with the rest of the environment are not clear, there have been changes in the upper atmosphere as well. We know that many of the phenomena we study in the Arctic, from deepest oceans to space, are part of global processes that have effects on our citizens. Arctic research is clearly of national and global importance.

The arctic region includes some of the most extreme environments on the planet, where radical changes in photoperiod and extremes in temperature affect growing seasons alternately to constrain and stimulate terrestrial and marine ecosystems. People around the circumpolar North have coped successfully over millennia with this environment, accumulating an extensive body of environmental knowledge as well as keen awareness of ecosystem changes. For hundreds of generations, residents have relied upon summer's departure of snow and ice and the return of salmon, birds, whales, berries, and other plants for survival. Within these seasonal cycles are subtle patterns and changes observed by those whose livelihood depend on the close understanding of their surroundings. Local knowledge, oral histories, and Native ways of knowing have an important part in educating the world about life in the Arctic and its history.

The Arctic offers many opportunities to link research and education. The need for research-education partnerships is particularly clear. On the one hand, students living in the Arctic may feel remote from modern scientific research, although they inhabit an under-investigated region that attracts talented researchers. On the other hand, most students and members of the public outside the Arctic have a limited and often inaccurate understanding of the region and the information arctic researchers and communities can provide. Both groups, however, find research in the Arctic a compelling subject to explore when given the chance. The Arctic is, by nature, an intriguing topic and with enough mystery to engage students. It is through engaging science education projects that students are not only stimulated to learn about the Arctic system but also are enabled to see its value and connection to the rest of the world.

Science Education in the Arctic

> Schools reflect the society in which they exist....Indeed, education can be thought of as a subsystem of a social-political-economic system.
>
> —AAAS, 1997

The Challenges

The ASEWG met at a challenging time for K–12 education. Currently, K–12 teachers face increasing pressure to deliver the curriculum and meet the myriad demands placed upon them by parents, students, administrators, and society. Increasingly, teachers are looking for opportunities and tools to engage students in learning. The opportunity to include aspects of Arctic research is becoming more widely recognized by teachers as an avenue to engage students in science. Agencies that fund research and some researchers are directing their attention toward K–12 classrooms to foster an interest in and basic knowledge of science. Many funding agencies require researchers to incorporate education and outreach plans in their funding proposals. In particular, the NSF Office of Polar Programs Arctic Sciences Section seeks ways to engage teachers, students, and the public in arctic science. However, few researchers have the connections to schools and communities to effectively satisfy these requirements.

The ASEWG identified numerous challenges impeding the success of current and future arctic science education programs. They were:

- ◊ limited time,
- ◊ funding issues,
- ◊ supervisor approval and support,
- ◊ obtaining credit for involvement (e.g., college credit, future funding opportunities, promotion),
- ◊ knowledge (of, for example, technology necessary to communicate or conduct research, arctic cultures, the arctic environment), and
- ◊ access to the other relevant groups (e.g., teachers isolated from researchers, researchers isolated from schools, students isolated from researchers, schools isolated from community members).

The impediments seem to be similar from both the perspective of the educators and the researchers. For instance, the ASEWG identified that educators have problems with:

- ◊ time away from the classroom (particularly if the activities are not integrated into the classroom setting),

◊ obtaining summer salaries (if the activity is not part of the school year),
◊ fulfilling career enhancement requirements or getting credit for the activity,
◊ appeasing parents, colleagues, and school administrators, and
◊ connecting the K–12 classroom with the research institutions.

Educators who try to work with researchers often must develop new curriculum materials that balance innovation with education standards. This is a challenge for teachers who want to involve their students in field research projects or to incorporate Native knowledge. In many cases, teachers do not have access to programs that provide field experience nor do they have the time to make the experiences practical for further classroom instruction.

Researchers face many of the same constraints (Box 2). Time necessary to mentor teachers and arrange additional logistics is time taken away from research, teaching, and publishing. There are few rewards for academics participating in education programs, although some funding agencies have recently instituted requirements for educational outreach in proposals to

Box 2. An Arctic Researcher's Perspective

"Although the long-term goals of groups participating in arctic research and education are not in conflict, the short-term goals may be. My field seasons are characterized by being short and intense (true of most arctic summer work). Having enough trained workers to accomplish what I need in a short time period is of paramount importance. Transportation is also expensive, so if I am to incorporate an untrained teacher or student into my program, I need to be sure that this does not result in "bumping" a more experienced person from the crew. So, one of the most important aspects of funding needs is to provide travel money.

As a researcher, it takes considerable time and effort to incorporate teachers and/or students into my program. The researcher obviously must be willing to put the time into the training and academic component of the experience. There are other tasks that are not necessarily most efficient for the researcher to take on.

Another task, which is best not left to the researcher, is selection of participants. In my case, the teachers and students have been "self-selected" with some guidance from me and from other cooperators. If there is going to be a sustained effort with a particular school district, it would be very valuable to have a local liaison to facilitate processes such as participant selection.

Finally, when a project is new, out of the ordinary, and involves partnerships with other entities, finding funding can be difficult. Getting funding from my own agency was much easier the second year, after people saw value in the program. Perhaps this provides a useful model, in terms of providing "seed money" for new starts. Those that are recognized as successful could be expected to take root and generate their own funding sources."

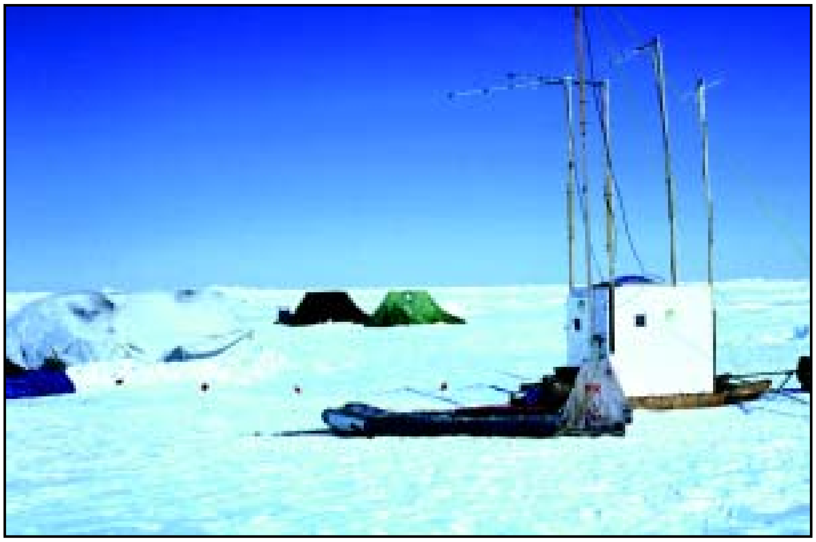
Figure 3. Arctic research field site on the sea ice (photo by Lori Quakenbush).

fund arctic research. This outreach requirement can be daunting to researchers who do not have connections with schools, teachers, and communities. If a researcher does incorporate a science education component, he or she is faced with the complications of arranging travel, lodging, and other logistics in the Arctic, which are expensive and subject to change due to weather and availability. Researchers who do incorporate educational programs as part of their project find it difficult to track progress or outreach success, especially when requesting additional funding. Often these interactions have no quantifiable result (e.g., scientific literacy, public understanding of the Arctic).

The arctic region itself poses other inherent challenges. These include logistical challenges associated with travelling and working out of remote locations (e.g., limitations on communications and travel, and extreme and unpredictable environmental conditions such as cold, wind, fog, rain, ice, and insects). In addition, there are often language, cultural, and political barriers.

As the working group came to understand other perspectives, participants agreed that both practicing scientists and K–12 educators find themselves in unfamiliar territory when developing partnerships between research and education. The gap in understanding between the culture of teaching and the culture of research is an intimidating obstacle. The working group also recognized the difficulty some scientists have in developing quality working relationships with local communities, both near their academic institution and in the region of their research sites in the Arctic. This lack of connections can isolate a research team and prevent the exchange of knowledge and understanding.

Keys to Success

Many K–12 education programs have been successful at engaging students in science. The ASEWG looked at existing programs as well as the challenges faced in implementing such programs. The ASEWG specifically examined:

◊ Designs of successful programs that involved students in research (i.e., the fundamental principles of arctic science education programs, target audiences, what programs should accomplish, and how they could be evaluated for success).
◊ How to continue the involvement of students, teachers, and researchers long after the first program.

Engaging the Students

After reviewing several successful programs (Appendix A), the ASEWG identified a key feature: engaging students in the activity. To engage students is to make their experiences relevant and real. According to Robert Yager (2000), "science teachers must teach in ways that actively engage students—by emphasizing issues that are familiar and relevant to students rather than ones that are abstract and alien."

But we need to go one step further—beyond providing real-life experiences. Science education must provide engaging problems so that students experience science as it is used on a daily basis. The role of science is often ignored and the view of what an actual scientist "does" is abstract. This type of learning is called "inquiry-based" education and it is both process-oriented and content-oriented learning. In the real world, scientists make actual decisions based on current data. Science and research are part of an ongoing process. When scientists draw conclusions, they are based on the best data available, which is not always complete or ideal. Successive hypotheses, data, and conclusions are part of the problem-solving process all people use in their daily lives, though in typical science courses these aspects of the scientific process are not always obvious.

Educators are becoming aware of the practical uses of providing students with relevant resources and real-life (sometimes called "place-based education") examples from the region in which they live. Providing relevancy to a student's education adds meaning as well as local context. As a result, students can better relate to the education material and to their local surroundings. As stated previously, under the Improving America's Schools Act of 1994, states are required to have a plan for aligning their curriculum to a set of academic standards. Many states, such as Alaska, also have implemented performance standards, which means students not only need to know *why* they are learning something but how to *apply* what they are learning. Place-based education makes teaching to standards easier for both the student and educator, but developing the appropriate curriculum can be a challenge. Curriculum development frequently lags behind developments in the ever-evolving education movement. For that reason, it is vital that arctic science education programs provide a resource connection to educators. This provides an exciting opportunity for educators to seek

The word "science" can be avoided, but the practice of it is a part of everyday. The questions seem to mount faster than the answers.

—Alan Dick (1998)

resources outside the classroom and a great opportunity for researchers to become a valuable resource with the local schools and community. Place-based scientific education usually addresses specific needs of communities, such as clean water, pollution, habitat preservation, waste disposal, and cultural heritage, which creates a connection between students and their surroundings while they learn. If students learn to act locally they can then begin to think globally, and place-based education will become a launching point for educators to introduce regional and global issues.

In Alaska, the Alaska Science Consortium (ASC), the Alaska Rural Systemic Initiative (AKRSI), and the Alaska Department of Early Education and Development (EED) have gone one step further. These organizations partnered together to develop a standards-based, culturally relevant curriculum guide that integrates indigenous and Western teaching and learning methodologies and how they apply to science. The result is a handbook for educators entitled *Handbook for Culturally Responsive Science Curriculum,* by Sidney Stephens (2000).

In the handbook, the Alaska Science Consortium developed a "learning cycle model" (Box 3, Figure 4) that was adopted by AKRSI (Figure 5) and modified to incorporate Native ways of teaching and learning, thus becoming more appropriate for working with Alaska Native students. Both learning cycle models use inquiry learning and place-based examples to engage students in the scientific process, meaning that the students are doing the experiments, the exploration, and the data gathering rather than being disengaged from the activity. Teachers become facilitators of a learning process and students become active learners (e.g., constructivist learning). According to Stephens (2000), "This emphasis on practical knowledge is so critical to Native teachers that they advocate beginning instruction with the 'apply' phase and then working clockwise through the other steps."

These models allow both the teachers and the students to use science in an engaging and relevant way. Researchers then will have opportunities to provide real-life examples to the educators for use in their classrooms.

Effective Partnerships

Communication and partnership development are other key components of a successful science education program. The challenge for researchers is to figure out how to provide educators with the resources and information they need for developing an engaging program that still meets school objectives.

The exchange of knowledge between arctic researchers and residents of arctic communities is as important as it is mutually beneficial. Arctic residents have observed the distribution and abundance of wildlife and usable plants, weather, and ice patterns for generations. Within these

Box 3. Alaska Learning Cycle Models

Gear-Up: Mentally engages and motivates students. Excellent time to gain information on students' preconceptions. Similar to "anticipatory set" or "engagement."

Explore: Hands-on, minds-on activities that provide an opportunity for the students to discover a newer explanation for an event or concept.

Generalize: Questioning strategies help students to verbalize their new discoveries and identify questions to be tested.

Experiment: Students design and conduct an experiment (a fair test).

Interpret: Students display and interpret the data that they have collected.

Apply: Students apply the newly learned concept. Activities should help the students to recognize the universal nature of the concept.

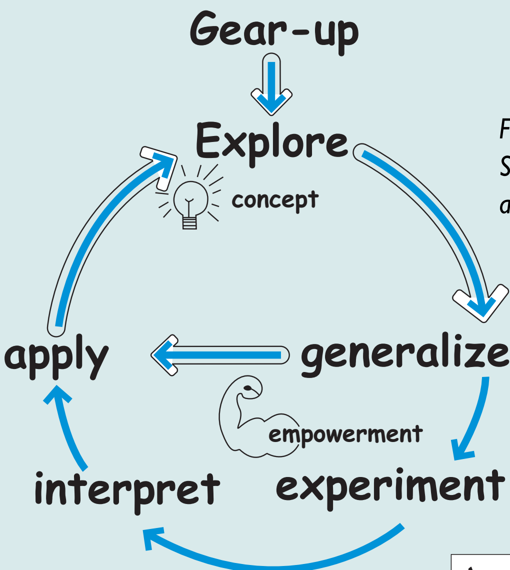

Figure 4. The original learning cycle model developed by the Alaska Science Consortium. (Courtesy Alaska Department of Early Education and Development.)

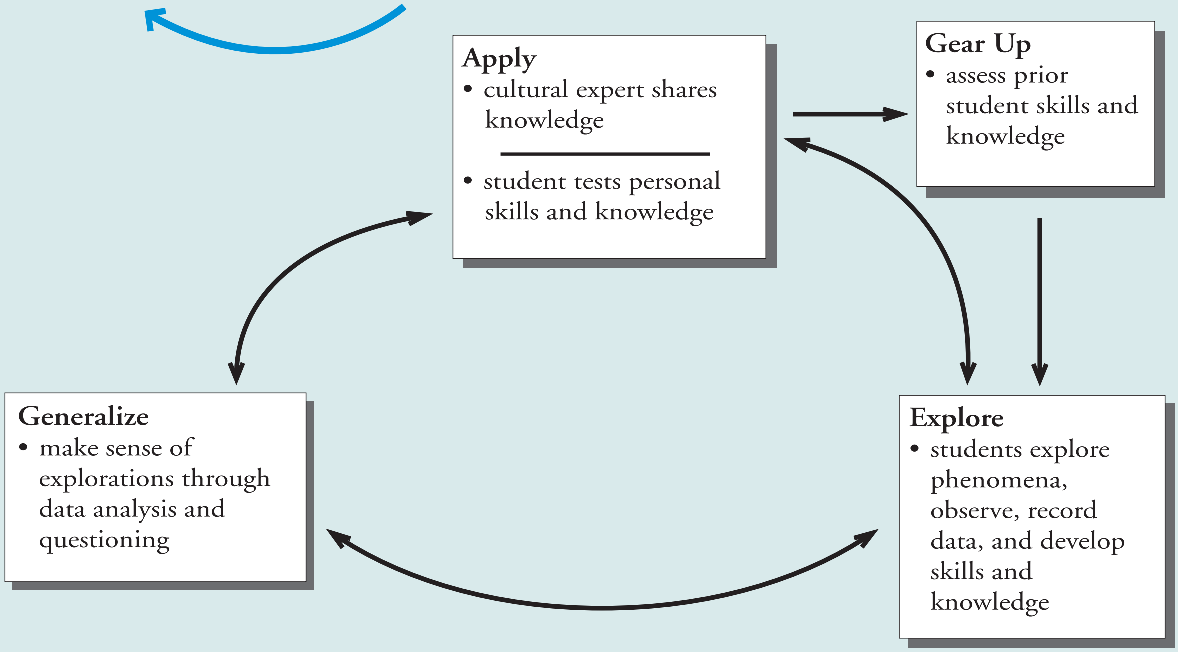

Figure 5. A modified learning cycle model developed by Native teachers to incorporate Alaska Native ways of teaching and learning (courtesy of Alaska Rural Systemic Inititative, Stephens, 2000).

seasonal cycles lie subtle patterns and changes observed by those whose livelihoods depend on a close understanding of their surroundings. Local knowledge, oral histories, and Native ways of knowing can play an important part in the design and execution of research activities. For example, stories from elders about ice thickness have added important information to research about climate changes. Current arctic research also addresses many issues relevant to the health and livelihood of its residents, such as marine contaminants in traditional foods. Working together, scientists and residents will learn from one another, improve our understanding of the Arctic, and solve problems important to arctic residents.

The ASEWG examined strategies for developing relationships among groups that will allow for sharing of information, the development of research, and teaching partnerships that lead to successful programs. The process of developing and maintaining relationships among the groups involved in arctic science education while alleviating the challenges includes:

- ◊ identifying key people in research, education, and communities who are interested and willing and bringing them together,
- ◊ providing a liaison to link the various interest groups,
- ◊ providing technological support for the communication of research information to schools,
- ◊ providing specialist support in writing curriculum materials,
- ◊ communicating with funding agencies and preparing proposals to link education and research,
- ◊ providing a marketing and promotional role to advertise opportunities and generate support,
- ◊ providing office and business administrative support,
- ◊ facilitating peer review,
- ◊ providing advisory services, and
- ◊ providing logistics support by making arrangements and supplying equipment.

The working group recommends strongly that these characteristics are important to the success of programs integrating research and education in the Arctic.

Box 4. Examples of Successful Science Education Programs

The PISCES Program

The Partnerships Involving the Science Community in Elementary Schools (PISCES) program at San Diego State University (SDSU) incorporates both place-based education and research. One of their programs is centered around arctic research.

A unique aspect of the Arctic Expedition program takes the San Diego Science Corps and PISCES Program to arctic Alaska. The objectives of this program include:

- ◊ Offering Science Corps fellows exposure to a new ecological environment.
- ◊ Bringing near-real-time data and video on contrasting ecosystems and climates to K–6 students.
- ◊ Offering teachers the chance to link science (including environmental science) to other subject areas including social studies, geography, and literacy.

<http://www.sdsa.org/pisces>

Hawaiian Studies Program—Wai'anae High School

The Hawaiian Studies Program at Wai'anae High School in Wai'anae, Hawaii, incorporates Native Hawaiian knowledge and traditions in the standard curriculum. Students in this program learn different units based on the local ecosystems, Hawaiian subsistence practices, conservation, and traditional knowledge. Teachers who work within the Hawaiian Studies Program framework can develop units for the program that teach aspects of the general curriculum using the surrounding area and local experts as resources. This program gives students the opportunity to learn about traditional foods, traditional methods of navigation, and environmental sciences in their local region. <http://www.k12.hi.us/~waianaeh/waianhi/hawaiian.html>

Figure 6.

Summer Camp Programs

There are numerous summer field camps that immerse students in intensive field experiences. Camps are an important way for organizations outside the traditional school setting to share their perspectives and knowledge. Old Minto Cultural Heritage and Education Institute operates in the old village site of Minto, Alaska, an Athabascan community. The institute has four camps: High Risk Youth Camp, Recovery Camp, Youth and Elder Spirit Camp, and Athabascan Culture Learning Camp. All of the camps incorporate and instill Native cultural values and traditional practices. The Old Minto Cultural Heritage and Education Institute is also developing a cultural atlas of Native place names. This information and other information preserved through traditional oral history is valuable to researchers. <http://www.ankn.uaf.edu/chei/programs.html>

The Workshop

In March 2000, a group of scientists, educators, and Alaska Native education specialists came together, in Fairbanks, Alaska, to focus on how the arctic environment and arctic research might help in scientific literacy (Appendix C). The Arctic Science Education Working Group (ASEWG) was charged to develop a set of recommendations for the National Science Foundation Office of Polar Programs (NSF OPP) Arctic Section to use to effectively integrate arctic science and education in ways that would fully involve arctic residents in the research and education process. The Arctic Section of the NSF OPP seeks ways to engage teachers, students, and the public in arctic science. However, few researchers have the connections to schools and communities to effectively:

- ◊ satisfy funding and public outreach requirements;
- ◊ include the community in their research; or
- ◊ incorporate local traditional knowledge.

This was the second workshop focusing on the Arctic and education. The first workshop, *Building Partnerships in Polar Research and Education,* was held in 1997 in New Orleans, Louisiana. The first workshop primarily focused on a range of science education concerns; this working group specifically focused on ways in which the NSF could support the development of programs in the Arctic that help integrate research and education and that help researchers collaborate with arctic residents.

The ASEWG explored several key questions throughout the workshop (Box 5).

Box 5. Key Questions

- ◊ How do we engage students, teachers, and residents of arctic communities in scientific research?
- ◊ How do we build effective partnerships among academic, agency, arctic community, and education participants? And,
- ◊ How do we increase public awareness of arctic research and the importance of the Arctic region?

Process

The schematic in Figure 7 illustrates the working groups questions, and topics during the three day meeting. The workshop agenda and list of participants are in Appendix C and D.

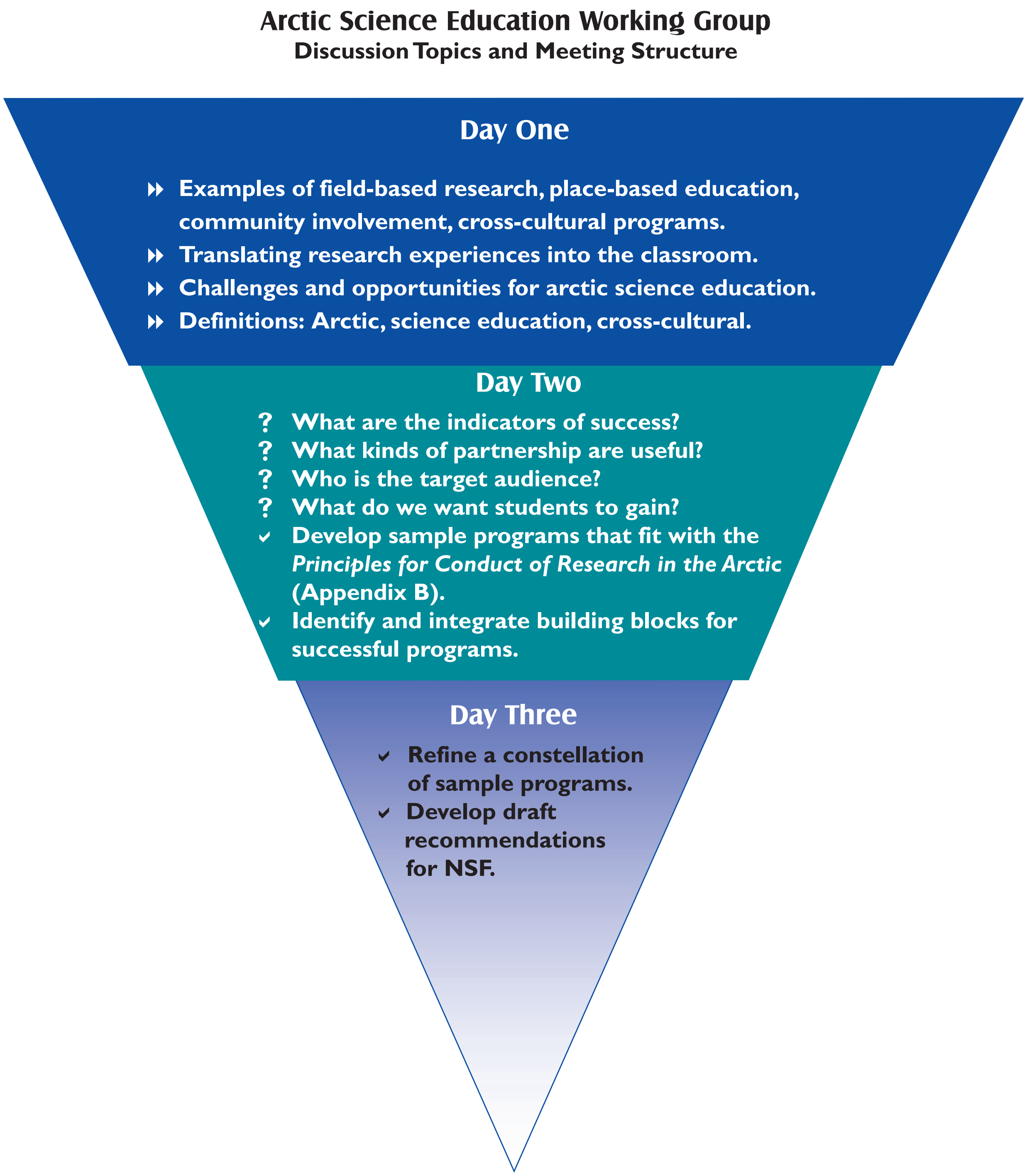

Figure 7. Schematic of the three-day Arctic Science Education Working Group meeting.

Day One

To identify key elements of successful arctic science education programs, the ASEWG began with the exploration of several existing programs in science education. Members of the working group made presentations about relevant programs, providing the working group with a foundation from which to:

◊ Discuss the design of successful arctic science education programs that involve students in research, and

◊ Determine how to continue long-term involvement of students, teachers, and arctic residents in the research.

Figure 8. Members of the ASEWG in a break-out group discussion (photo by ARCUS staff).

Workshop participants emphasized the need for researchers to connect with the communities in the regions where they conduct their research, and also reiterated that many researchers require help to make that connection. Participants also stressed that scientists must not only communicate about their research with local residents but also should incorporate local and traditional knowledge from arctic residents. Descriptions of the education programs presented plus other examples are available in Appendix A.

Figure 9. ASEWG participant Brian Barnes explains ideas from his break-out group session (photo by ARCUS staff).

Days Two and Three

After discussing the common elements of successful, high-quality science education programs, the working group began brainstorming the challenges and opportunities of science education programs specific to the Arctic. The group divided into three smaller working groups. Each small "break-out" group addressed the topics illustrated in Figure 10.

Each break-out group devised a sample science education program that incorporated target audiences, goals, activities, indicators of program success as well as incorporating NSF OPP's *Principles for Conduct of Research in the Arctic* (Appendix B), which they presented to the workshop as a whole. Each group developed remarkably similar and plausible arctic science education program prototypes. The working group discussed in depth the similarities and potential implementation strategies that emerged from these program models.

Taken together, the attributes of the three sample programs form the basis of the recommendations of the ASEWG for the development of arctic science education programs.

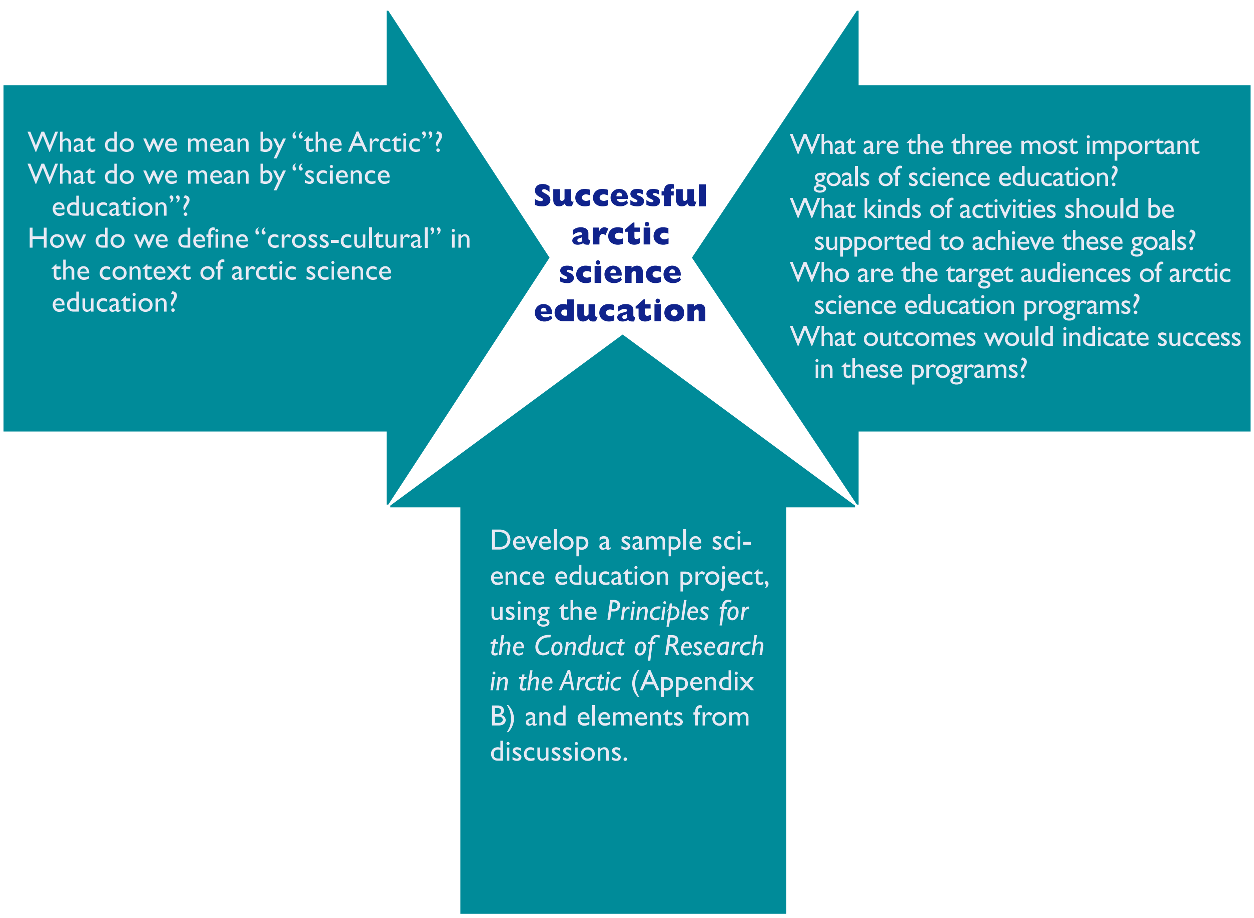

Figure 10. Flowchart of break-out group discussions and sample program development.

Key Findings and Recommendations

Building arctic scientific literacy is a complicated and long-term process. The Arctic Science Education Working Group (ASEWG) approached this issue by examining the elements of successful science education programs along with the components for long-term partnerships with the communities that researchers work in and around. This process helped the working group suggest solutions for three initial questions:

- ◊ How do we engage students, teachers, and residents of arctic communities in scientific research?
- ◊ How do we build effective partnerships among academic, agency, arctic community, and education participants?
- ◊ How do we increase public awareness of arctic research and the importance of the Arctic region?

The lack of resources prevents the long-term success of many arctic science education programs. In addition, each project or program has its own goals and is held accountable to widely differing criteria. The long-term goals of each group participating in arctic research and education are not in conflict, however. On the contrary, by working together, these groups can develop and expand educational synergism and support for research among knowledgeable and curious citizenry, students, parents, and teachers. The ASEWG also recognized the need to formulate strategies for the National Science Foundation Office of Polar Programs Arctic Sciences Section that aren't totally new but that integrate with NSF OPP goals and objectives as well as existing and proven education programs.

The ASEWG recommends that an important solution to pull these existing diverse components together would be the establishment of a facilitating structure dedicated to providing support and coordination to ensure the growing success of NSF-funded and other science education programs. The mission of the facilitating structure (Figure 11) would be to facilitate arctic science education. Its goal would be to create and support partnerships between schools, researchers, science agencies, local communities, and a constellation of arctic science education programs by alleviating the challenges (as previously outlined) and providing necessary support to programs as needs arise.

The facilitating structure would identify, contract, employ, or recruit people possessing the skills and experience required to support existing and new programs. Such an organization would not replace or duplicate existing services but would network with and, if possible, assist program structures already in place. The organization would serve a multitude of needs in a variety of capacities (Box 5). From a central location with centralized business, administration, and specific technical and educational services, the organization would operate a distributed network of contacts. This necessitates that the organizational structure be flexible and adaptable. In some cases, the organization would leave these duties decentralized at a local level and provide only requested support.

Box 5. Key Elements of Arctic Science Education Facilitating Structure

- Located in the Arctic.
- Staff (4–6 people): provides administrative, technical, logistical, and curriculum assistance.
- Overseen by an advisory board of researchers, educators, community members.
- Act as a clearinghouse of information and opportunities and an archive for activities and local knowledge.
- Recruit participants: researchers, teachers, students, experts.
- Translate research results into educational materials that mesh with both national and state education content standards and that contain actual scientific data.
- Provide information on local cultures to researchers, teachers, and students.
- Help in production of resources from project: pamphlet, demonstration, poster, journal article.
- Solicit and manage funding for education participants on research projects.
- Provide avenue for training certificates or education credits.
- Circulate information via publications or the Internet announcing opportunities and achievements.
- Involve community in project by organizing activities and meetings.
- Locate elders with interest and expertise relevant to project.
- Help researchers adopt methods that are sensitive and useful to local communities.
- Inform communities and explain the significance of research to local communities,
- Share research results with local communities in an effective way.
- Arrange logistics for participation of teachers and students on research project.
- Possess, maintain, and provide access to technology necessary for communication and distribution of learning materials.

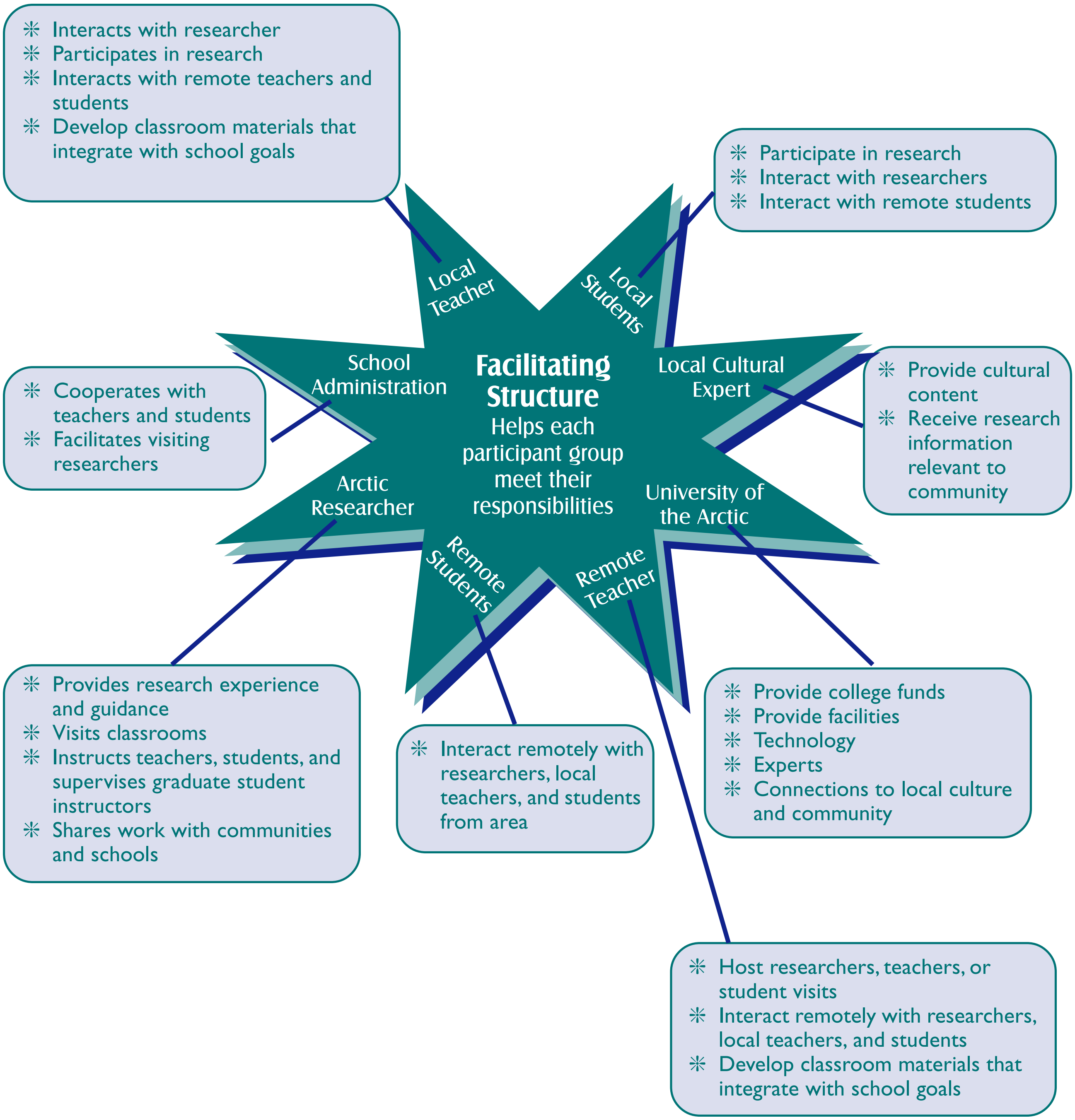

Figure 11. Recommended relationships managed by a facilitating structure for constellation of arctic science education programs.

Recommendations

In addition to having a facilitating structure, the ASEWG also recommended the following to specifically address each of the three challenges.

Engaging Everyone in Arctic Research

- ◊ All science education programs must incorporate the principals of successful science education programs:
  - relevancy,
  - inquiry-based, and
  - aligned with National and state science content standards.
- ◊ Arctic science education programs must be sensitive to the geographic location of their audience as well as the audiences' prior knowledge.
- ◊ Programs should include both traditional Native knowledge and Western science perspectives.
- ◊ Researchers need to communicate with arctic communities about upcoming research activities and names and information about researchers.

Effective Partnerships

- ◊ Provide researchers a "key" contact (a designated person or organization) in communities for assisting researchers with public outreach to the community.
- ◊ Provide communities with information about upcoming research activities and names of researchers.
- ◊ Supplement funding for research projects that develop education or outreach components as a part of their research project.
- ◊ Promote and highlight research projects that are collaborating with communities as models of success.

Increasing Public Awareness

- ◊ Provide communities with information about upcoming research activities and names of researchers.
- ◊ Add language to the Request for Proposals process that encourages researchers to develop community connections where they conduct their research before submitting their proposals.
- ◊ Use current web sites (such as ALIAS, ARCUS, BASC) to (a) encourage researchers to incorporate public outreach while doing research; and (b) gather information about what types of public outreach researchers are already doing.

Specific Recommendations for NSF OPP

The following are specific recommendations from the working group to the National Science Foundation, Office of Polar Programs Arctic Sciences Section to develop arctic science education programs.

◊ NSF OPP should identify or establish an appropriate group to serve as an arctic science education hub, or facilitating structure, for the coordination and development of arctic science education programs.

NSF-funded education programs would become better networked and coordinated, resulting in long-term improvements and effectiveness of education and outreach programs.

◊ NSF OPP should task the arctic science education hub with the following responsibilities:

- Link NSF/OPP-funded researchers with potential teacher placements for field experiences.
- Provide technical support for Internet-based exchanges of teachers in the field with classrooms and schools worldwide.
- Provide field-based research experiences for students where appropriate.
- Provide logistical and administrative support to research projects including teachers as needed.
- Track the success of teachers and students who participate in field research experiences.
- Develop and disseminate formal education materials based on teacher/researcher interactions.

◊ NSF OPP should establish a Request for Proposals (RFP) to supplement funded research projects that develop education or outreach components to include in the research project.

◊ NSF OPP should add language to the RFP process that encourages researchers to develop connections with the communities in which they conduct their research before submitting their proposal.

This may include bringing the results of research back to the community as presentations, publications, or through the direct involvement of community members in mentoring programs with teachers, students, or citizens, or by school classroom participation in the collection of data. Furthermore, researchers not working in communities directly should be encouraged to participate in mentoring programs involving the participation of school teachers and students in field research.

References

Alaska Science Consortium, Learning Cycle Model. http://www.eed.state.ak.us/tls/aksc/LCM.html.

American Association for the Advancement of Science (AAAS). 1990. *Science for all Americans*. New York: Oxford University Press.

American Association for the Advancement of Science (AAAS). 1997. *Blueprints for Reform.* Blueprints Online: Project 2061. Washington D.C.

Bureau of Labor Statistics, U. S. Department of Labor. Fastest growing occupations, 2000–10. http://www.bls.gov/news.release/ecopro.t06.htm.

Dick, Alan. 1998. Village science: Science unavoidable. *Sharing Our Pathways: A newsletter of the Alaska Rural Systemic Inititative,* 3(5): 16.

Improving America's Schools Act of 1994. Public Law No. 103-382, October 20, 1994.

National Commission on Mathematics and Science Teaching for the Twenty-first Century. 2000. *Before it's too late: A report to the nation from the National Commission on Mathematics and Science Teaching for the Twenty-first Century.* Jessup, Maryland: U.S. Department of Education Education Publications Center.

National Research Council, National Academy of Sciences. 1996. *National Science Education Standards*. Washington, DC: National Academy Press.

National Research Council, National Academy of Sciences. 1998. *Every child a scientist: Achieving scientific literacy for all.* Washington, DC: National Academy Press.

Stephens, S. 2000. *Handbook for Culturally Responsive Science Curriculum.* Fairbanks, AK: Alaska Science Consortium and the Alaska Rural Systemic Initiative.

Thorson, A. 2002. *Beyond Curriculum: Getting Real with our Students.* Eishenhower National Clearinghouse. http://www.enc.org.

Toolik Field Station: The second twenty years. Recommendations on the development of Toolik Field Station. September 1996. Arctic Research Consortium of the United States (ARCUS).

U. S. Department of Labor, Secretary's Commission on Achieving Necessary Skills. 2000. *Learning a Living: A blueprint for high performance*. A SCANS report for America 2000.

Yager, Robert. 2000. A vision for what science education should be like for the first twenty-five years of a new millennium. School Science and Mathematics, 100(6): 327–41.

APPENDIX A: Arctic Science Education Programs

The working group heard presentations on the future of arctic science education from several workshop participants. Two main strategies were discussed that link scientific research and education: virtual field trips and place-based education. Some programs are field-based experiences for teachers while others are for students. Many programs rely on the Internet and other technologies to transmit virtual field trips and research experiences to a vicarious audience. While a plethora of programs provide opportunities for teachers to bring scientific research alive for their students, integration of such experiences into the classroom often requires a prohibitive investment of time. Busy teachers seek ways to bring research into classrooms that are relevant and simple. This appendix includes information about many of the field, Internet, and classroom-based science education programs that address arctic research. Representatives of many of these programs participated in the working group. This list is in no way comprehensive.

Alaska Native Knowledge Network: Fairbanks, Alaska

http://www.ankn.uaf.edu/

Alaska Native Knowledge Network is designed to serve as a resource for compiling and exchanging information related to Alaska Native knowledge systems and ways of knowing. It has been established to assist Native people, government agencies, educators and the general public in gaining access to the knowledge base that Alaska Natives have acquired through cumulative experience over millennia. The Alaska Federation of Natives and the University of Alaska, with support from the National Science Foundation, have formed the Alaska Native/Rural Education Consortium to provide support for the integration of Alaska Native knowledge and ways of knowing into the educational systems of Alaska. Anyone wishing to participate in the Alaska Native Knowledge Network or contribute to the development of the resources in this knowledge base is encouraged to contact the ANKN coordinator at (907) 474-5086, or send an email message to fyankn@uaf.edu.

Alaska Native Student Wilderness Enrichment Retreat (ANSWER Camp): Alaska

http://www.serrc.org/AnswerCamp/

ANSWER Camp is two-week summer retreats to meet the need for culturally relevant science and math enrichment for seventh- and eighth-grade students living in rural Alaska Native villages and communities. ANSWER Camp will help make math and science more meaningful by connecting local values, cultures, and concerns to Western scientific principles. Traditional Native ways will be honored, and scientific concepts will be explored in the context of village life. Alaska Native students will be better prepared to enter village high schools and to meet the challenges of a rapidly changing world. SERRC, in concert with Louden Tribal Council and Galena City Schools, will provide camp experiences that will positively impact "long term well-being and preservation of the culture of Alaska Natives." ANSWER Camp will use the experience gained during the first highly successful ANSWER Camps to perfect a model that may be replicated in other rural areas of the nation and continue past the funding period of this project. This project will build upon past successes and lessons learned and will strengthen partnerships between school districts, Native organizations, and middle-school students and their parents. ANSWER Camp is a proven summer enrichment project designed to provide cultural relevance and cultivate high interest in math and science, increase academic success, build parent support skills, and have a positive impact on the educational aspirations of rural Native middle school students.

Alaska Native Studies Curriculum and Teacher Development: Fairbanks, Alaska

http://www.alaskool.org/

The Native Studies Curriculum and Teacher Development Project (NSCTD) brings together teams of teachers, elders, and community members in various parts of Alaska with university-based specialists to develop curricula on Alaska Native studies and language that are available to all schools through the Internet or on CD. The project is supported by a grant from the U.S. Department of Education.

Alaska Reform in the Classroom Through Technology Integration and Collaboration (ARCTIC): Marion, Ohio, and Alaska

http://www.treca.org/m_home.html

ARCTIC is a five-year federally funded collaboration between Tri-Rivers Educational Computer Association (TRECA) and Ashland University in Ohio and in Alaska the Alaska Department of Education, the South East Regional Resource Center (SERRC), the University of Alaska Southeast, and Chugach Schools. It is an intensive training and support program for all school districts in Alaska, facilitating the application of technology as a tool for change in the classroom and improving the way teachers teach and students learn. The development and implementation of a self-sustaining statewide technology consortium will cultivate school improvement and change beyond the five-year grant period. Five essential components of the program include internships, mentor support, outreach, summer institutes, and on-site support.

Alaska Rural Systemic Initiative (RSI): Fairbanks, Alaska

http://www.ankn.uaf.edu/arsi.html

The Alaska Native/Rural Education Consortium has been implemented under the auspices of the Alaska Federation of Natives, in cooperation with the University of Alaska and schools and communities in rural Alaska, with funding from the National Science Foundation, to initiate a five-year effort to systematically document the indigenous knowledge systems of Alaska Native people and develop pedagogical practices that effectively integrate indigenous knowledge into educational programs. The focus of the initiative is on providing an opportunity for the people of Alaska, particularly Alaska Natives, to formulate a renewed educational agenda regarding the structure, content, and processes that are needed to increase the involvement of Alaska Native people in applying Native and non-Native scientific knowledge to the solution of human problems in an arctic environment. The overall project is organized into the following five major initiatives: (1) Native Ways of Knowing and Teaching, (2) Culturally Aligned Curriculum Adaptations, (3) Indigenous Science Knowledge Base, (4) Elders and Cultural Camps, and (5) Village Science Applications. Each of the five initiatives will be implemented in one Native cultural region at a time on a rotational schedule over the next five years.

Arctic Circle: University of Connecticut, Storrs, Connecticut

http://arcticcircle.uconn.edu/

The idea culminating in Arctic Circle originated during a symposium on the Use of the World Wide Web in Education, sponsored by the Faculty Resource Laboratory at the University of Connecticut in February of 1995. Following a presentation by Thomas Plunkett and Jonathan Lizee, co-developers of ArchNet, the WWW Virtual Library for Archaeology, they were joined by Norman Chance, an arctic anthropologist interested in finding ways to expand knowledge of the circumpolar North to a wider audience of students, educators, policy makers, environmental planners, and others. Together, we came up with the concept of an electronic Arctic Circle. After a month of planning, we sought the support of the director of the University of Connecticut's Homer Babbidge Library. Shortly thereafter, Arctic Circle settled into its new home on the "Spirit of Uconn" library server.

The overall goal of Arctic Circle is to stimulate among viewers a greater interest in the peoples and environment of the Arctic and Subarctic. As stated on the welcome page, this "electronic circle" has three interrelated themes: natural resources, history and culture, social equity and environmental justice. In addressing these issues, the presentations use a range of textual and photographic materials and, in the near future, sound and short video recordings. Specific topics include discussions of sustainability, equity, and environmental protection; northern development and the global economy; ethnographic portraits of indigenous peoples in Alaska, Canada, Northwest Siberia, etc.; and specific studies dealing with the impact of petroleum, gas, hydroelectric, and other forms of large-scale natural resource development in selected regions of the circumpolar North. New material is being added on a regular basis.

Also, with the assistance of Native northerners and other contributors, we are writing up a series of case studies comparing the social and cultural impact of natural resource and other forms of development in regions with substantial indigenous populations. This year, these initial case studies—including additional material drawn from the Web—are being used in our virtual classroom, designed for high school, college, and university students wishing to learn more about the North, its peoples, and environment. Several educational institutions in the United States and Canada are assisting in the development of this experimental form of distance learning.

Barrow Environmental Observatory (BEO): Barrow, Alaska

http://www.sfos.uaf.edu/basc/beo/

The Barrow Environmental Observatory (BEO) is a contribution by the Ukpeagvik Iñupiat Corporation (UIC, the Barrow village corporation) to the long scientific research tradition on Alaska's North Slope that is exemplified by the former Naval Arctic Research Laboratory (NARL), now the UIC-NARL Facility. The BEO research preserve consists of 7,466 acres of arctic tundra near Barrow, Alaska, permanently set aside for arctic research projects. The BEO currently plays host to several important investigations. The goals of the BEO are: (1) to provide for the long-term year-round study of natural phenomena and their variation on a 7,466 acre preserved site and the surrounding arctic terrestrial, marine, and atmospheric environments; and (2) to provide opportunities for long-term interaction in the Arctic among scientists, the indigenous community, and national and international organizations.

Ongoing projects on or adjacent to the BEO include the Climate Monitoring and Diagnostics Laboratory (CMDL) of the National Oceanic and

Atmospheric Administration (NOAA), the Atmospheric Radiation Measurement (ARM) project of the U.S. Department of Energy (DOE), the International Tundra Experiment (ITEX), Global Change Research Group projects of the University of San Diego, the annual BEO Snow Survey, and the Spectroradiometer Network (Ultraviolet Spectrophotometer Ground Station). Numerous other single-season scientific projects take place throughout the year, including institutional activities from the U.S. and from abroad, such as Japan's Earth Science and Technology Organization (ESTO) and China's Institute of Geography of the Chinese Academy of Sciences. On lands and waters adjacent to the BEO there are significant ongoing research activities by organizations such as the North Slope Borough's Department of Wildlife Management, the Alaska Department of Fish and Game, the U.S. Bureau of Land Management, and the U.S. Fish and Wildlife Service.

BEO researchers participate in BASC's North Slope of Alaska educational activities. This includes direct participation in K–12 classroom activities under a memorandum of understanding between the North Slope Borough School District and BASC, guided class field trips to research locations and laboratories, circulation to schools of travelling science exhibits as well as in-school development of travelling exhibits, facilitation of student and teacher participation in scholarly symposia and workshops, development of materials for use by teachers, assistance in proposal writing for teachers, and addition of scientific components to exhibits at the Iñupiat Heritage Center. Informal science education by BEO researchers is facilitated by their participation in BASC's Community Outreach program. Researchers make public presentations and go "on air" at the North Slope's public (and only) radio station, KBRW.

The BEO is managed by the Barrow Arctic Science Consortium (BASC) with support through a multiyear cooperative agreement between BASC and the National Science Foundation.

Camp Habitat: Fairbanks, Alaska

http://www.northern.org/camp/chab.htm

Camp Habitat is a summer nature education program for young people sponsored by the Northern Alaska Environmental Center, Friends of Creamer's Field, and Alaska Department of Fish and Game. Skilled instructors and resource specialists lead small groups in outdoor activities focusing on the ecosystems of interior Alaska, its native flora and fauna, and human interactions with the environment. Camp Habitat emphasizes hands-on, outdoor learning experiences. Along with all of the exploring and learning, the participants will share hours of fun, laughter, and singing.

Ecology Curriculum Reform: Integrating innovative teaching and global change technology: San Diego State University (see also the PISCES program)

http://www.sdsu.edu

We propose to reform curriculum in the ecology program area within the Biology Department at San Diego State University (SDSU). Our goal is to provide biology majors and nonmajors with a greater understanding of ecological concepts by fusing innovative teaching with cutting-edge technology. Three ecology faculty are collaborating to bring scientific inquiry, field studies, and real-time global change technology into a nonmajors' ecology course and six biology majors' core and advanced ecology courses. To do this we request funding for two dedicated teaching instrument towers to be located at two field stations and one portable campus tower. These activities will bring real world experiences and research opportunities into the classroom as students learn about the effects of global change, using Mediterranean ecosystems as a model. We propose to do this by having students measure atmospheric CO_2 concentrations, as well as microclimate, net radiation, and energy balance. As a result of this exciting innovation we expect our students to better understand the process of scientific inquiry, data acquisition and analysis, and how to communicate scientific information, both orally and in writing. Dedicated teaching towers with instrumentation will enable us to bring real-time data from field stations and campus into the classroom where students will construct hypotheses, collect the data, and make scientific inferences from their results. Active learning strategies will enhance students' higher order skills for understanding ecological concepts. At SDSU, we have sizable enrollments of underrepresented minorities who will benefit from these innovations. This educational enhancement will reach about 650 students per year, including prospective teachers.

Global Learning and Observations to Benefit the Environment GLOBE): Worldwide

http://globe.fsl.noaa.gov/

Global Learning and Observations to Benefit the Environment (GLOBE) is a worldwide network of students, teachers, and scientists working together to study and understand the global environment. Students and teachers from over eight thousand schools in more than eighty-five countries are working with research scientists to learn more about our planet.

GLOBE students make environmental observations at or near their schools and report their data through the Internet. Scientists use GLOBE data in their research and provide feedback to the students to enrich their science education. Global images based on GLOBE student data are displayed on the World Wide Web, enabling students and other visitors to visualize the student environmental observations. GLOBE science and education activities help students reach higher levels of achievement in science and math. GLOBE helps to increase the environmental awareness of all individuals while increasing our scientific understanding of the earth.

Hawaiian Studies Program: Waianae, Hawaii

http://www.k12.hi.us/~waianaeh/HawaiianStudies/main.html

The Hawaiian Studies Program was formed in 1996 with the help of the Ka'ala Learning Center, Queen Liliu'okalani Children's Center, O.H.A., and the Department of Education. The purpose of this program is to provide the students of Wai'anae High School with classes that integrate the knowledge of Hawaiian culture, language, and history with the related studies of anthropology, archaeology, ecology, agriculture, food production, nutrition, and communications. The program has a strong career component, so that students learn and practice skills they can apply to future employment and further education.

Institute for Field Education: Boulder, Colorado

http://www.muskox.com/

The Institute for Field Education offers a variety of field ecology courses to graduate and undergraduate students from around the world. We focus on Arctic field ecology and integrate Western and indigenous ecological knowledge into each course. Our courses introduce students to quantitative field science, regional natural history, current research issues, and traditional ways of knowing the land. The format gives students a chance to gain practical field skills as well as tools to develop their own research ideas and proposals. Our current courses take place along the rivers and lakes of Nunavut, the Inuit territory of Canada. We camp and travel along these waterways as we learn. Each course involves study of arctic natural history as well as ongoing research of landscape ecology and riparian ecosystems.

Our mission is to provide a unique educational experience that immerses each student in the arctic landscape and the research practices associated with field ecology. Our goal is that each student comes away with a practical understanding of the capabilities and limits of field research, a confidence to apply themselves to graduate study or field work in the natural sciences, and an enhanced appreciation of the Arctic. It is a great opportunity for students to have a four-week experience that will give them a lifetime of unforgettable memories. Our aim is to pass on our knowledge and love of a land that is rich in Inuit history and home to musk oxen, wolves, moose, caribou, and tundra flowers.

LEARNZ: Christchurch, New Zealand

http://www.learnz.org.nz/

LEARNZ originated in 1995 from the International Antarctic Centre as an Antarctic Science Education program with the acronym LEARNZ—Linking Education and Antarctic Research in New Zealand. During 1995–1997, a program of study was developed around Antarctic research projects and during a two week period in October/November the LEARNZ teacher visited research sites in Antarctica, facilitating a virtual field trip for thousands of prepared students around the world. During the southern winter of 1998, an educator travelled with the research icebreaker Nathaniel B. Palmer into the Antarctic winter pack-ice, taking with him learners from around the globe. On each of these virtual field trips, e-mail, web technologies, and audioconferencing support classroom teachers in creating motivating science, math, and technology lessons.

The model adopted by LEARNZ for creating virtual field trips uses a facilitating teacher: someone who experiences the reality. The LEARNZ teacher works alongside research staff, assists in creating resources, stage manages audioconferences, uploads a daily diary and digital imagery to the web site and answers e-mail. It is their accounts of what they saw, smelt, heard, and felt that add to the impression of the experience for remote learners. This person, as a teacher, acts as a mentor for other teachers and as the eyes and ears of the learner. It is their task to ensure that resources are curriculum targeted, pedagogically sound, and relevant.

Since 1999 LEARNZ has adopted a conservation research focus in World Heritage Areas of New Zealand. Each year, in partnership with conservation and research organizations, background information and student activities are developed to prepare teachers and students for two, three-week virtual field trips. During each field trip, the LEARNZ Teacher schedules field work with research staff, stopping several times a day to run audioconferences with schools. Summaries of audioconferences are provided by schools on the web site. "Class Ambassadors" are sent by many schools to "participate" in the learning adventure; these soft toys have their own web page, e-mail their classes, and return with a booklet detailing their personal experiences.

Live From the Poles: Nationwide

http://www.passporttoknowledge.com/ptk_poles.html

Live From the Poles will feature real-time interaction between students in the U.S. and researchers at America's South Pole station, and also between youngsters at the Imaginarium in Anchorage, Alaska, and scientists and polar experts from the Smithsonian's Arctic Studies Center and NSF's Office of Polar Programs, live on camera in Washington, D.C., at the National Museum of Natural History. Viewers of the live program will also be able to send in questions via the Internet and have them answered in close to real time during the program and for the hour following. Documentary sequences from the Smithsonian's unparalleled film archives of arctic peoples and places and from Passport to Knowledge's two field seasons in the Antarctic will show the similarities and differences of these two unique and fascinating environments. Yup'ik educator Theresa John will explain, through a translator, something of the meaning of the clothing and art work of the North, and Arctic Studies Center director William Fitzhugh will show us close-ups of canoes and hunting tools. From the South Pole, Katy Jensen will answer questions about the ozone hole, and students will meet many others of the twenty-eight hardy souls spending this southern winter at the literal end of the Earth. Viewers will see science and technology at work—both the traditional knowledge of the North that has made human survival here possible for millennia and the innovations that have allowed twentieth century explorers and researchers to be able for the first time to endure the extremes of Antarctica. Science and technology with a human face—real science, real scientists, real locations, real time.

Math and Science Enrichment Program: Fairbanks, Alaska

The Math and Science Enrichment Program is funded by a three-year grant from the U.S. Department of Education to the Information Office at the Geophysical Institute at the University of Alaska Fairbanks (UAF). Thirty middle-school students from Galena and Nunam Iqua travelled to Fairbanks to work with researchers from the Geophysical Institute and UAF. The students attended workshops on volcanoes and the aurora borealis, launched rockets from the UAF Poker Flat Research Range, used radio telemetry, and analyzed data to forecast volcanic ash plume paths and earthquake epicenters. All of the hands-on lessons in the enrichment program are based on recent geophysical research and are designed to show students how math and science skills are used by professionals to solve real-life problems in Alaska.

National Snow and Ice Data Center (NSIDC): Boulder, Colorado

http://www.nsidc.org

The National Snow and Ice Data Center receives many questions about snow, ice, and climate from teachers and students at all levels—primary school through university undergraduates. Though our data products are targeted for the science research community, we have created and compiled some education resources for teachers and students. As we develop new resources, we will list them here. Also try the educational sites listed in ColdLinks, our hotlist of World Wide Web sites offering snow and ice information.

Old Minto Cultural Heritage and Education Institute (CHEI): Minto, Alaska

http://www.ankn.uaf.edu/chei/

The Cultural Heritage and Education Institute's mission is threefold—to share, educate, and restore: share Athabascan cultural knowledge and skills; educate youth and adults on how to be sober, productive participants in Native Athabascan and non-Native Western cultures; and restore the spiritual site of Old Minto and the history of a past village.

In pursuing this mission, CHEI's programs have given people the world over awareness of the Athabascan "ways of knowing." They have instilled pride in community children and given them tools to overcome the crippling presence and lure of substance abuse. These programs have also helped bring the Minto community together into a more cohesive unit, empowering the youth with abilities and confidence and enabling all to be more capable of coping with the diversity between Native and non-Native value systems.

Partners in Science: Fairbanks North Star Borough School District (FNSBSD), Alaska

http://www.northstar.k12.ak.us/

A project to link K–12 students and teachers to practicing university, industry and agency scientists using networked technology, with the aim of increasing the practice of authentic, project-based math and science. A significant portion of science and math teaching, inquiry, and application at the primary and secondary grade levels can be furthered by the virtually unlimited possibilities for information gathering and sharing via computer networking. Yet teachers and their students often do not take advantage of the facilities available or do not have access to the technology that would make this possible. Alaska, with its far-flung population and limited road system, can especially benefit from networked technology. We should morph into the virtual classroom where students, teachers, and practicing scientists from throughout Alaska and the world engage in animated conversations, conduct experiments, and exchange information using information networking. The main goal of the Partners in Science project is to further math and science learning in grades K–12 in the Fairbanks North Star Borough School District (FNSBSD), two rural Alaska school districts (Iditarod and Gateway), and among isolated home-schoolers. In addition, the project will share the educational experiences and new concepts developed on a statewide, national, and global level. To accomplish this, the proposed project has been broken down into objectives that focus on its three main components: the students, the teachers, and the technology. In order to achieve these objectives, the proposed project will link practicing scientists from higher education, government, and industry with teachers and students, using the latest information networking technology. It will be instrumental in igniting a redefinition of technology's place in the education process in the targeted school districts. We are very hopeful that Partners in Science is very effective in pulling in the most isolated students in our state—students in rural districts and students being taught at home by their parents (home schoolers). A central feature of this project is the creation of virtual science and math classrooms at the elementary, junior high, and high school level. Teachers will be intensively trained in these classrooms in the best practices used to achieve the math and science standards expressed in Goals 2000 and Alaska 2000, using electronic and person-to-person networking to practicing scientists.

Partnerships Involving the Scientific Community in Elementary Schools (PISCES): San Diego, California, and Barrow, Alaska

http://www.sdsa.org/pisces/

The PISCES Project is a district-based, community-supported elementary science improvement program for grades K–6 that will work with collaborative higher education faculty and students, practicing scientists, and classroom teachers. The vision in San Diego County is for all elementary students to participate in an engaging science learning program so that they are prepared for advanced secondary courses and a full range of post-secondary education employment opportunities. This National Science Foundation project features three years of fellowship support for a Science Corps of sixteen graduate students in San Diego area universities and Ilisagvik College of Barrow, Alaska, to expand the San Diego County PISCES Project.

POLARIS: Alaska

http://www3.northstar.k12.ak.us/

The National Science Foundation is partnering with Alaska Gateway Schools, Anchorage School District, Fairbanks North Star Borough Schools, Kenai Peninsula Borough Schools, and Mat-Su Borough Schools in a science education restructuring effort, POLARIS. POLARIS will build on a successful process model that enhances teacher development for the teaching and assessment of standards-based science through updated, nationally tested, research-backed pedagogy. The direction that defines POLARIS is the initial focus on teachers who are both capable of and committed to being science education leaders. It is essential that teacher-leaders and school science staff facilitators be identified, prepared, and provided the opportunity to focus on restructuring in the science classroom. POLARIS will provide preparation for this cadre of knowledgeable proactive teachers (Tier 1) who then will serve as resource persons for their colleagues (Tier 2). The selected teachers from grades seven through nine in five school districts will participate in one summer institute (six days), three school year institutes (three days each), and follow-up meetings throughout the school year. They will acquire innovative instructional practices, science content, appropriate assessment techniques, applications of technology, and leadership skills. The selected teachers are enthusiastic advocates willing to dedicate themselves to three years of preparation and local implementation, so that statewide dissemination and systemic change can occur. The program will spread to a greater number of school communities and provide for more cost-effective restructuring implementation in future years.

POLARIS will incorporate recommendations from other leading national science education projects. The new program will incorporate more science content, be Alaska specific when possible, and developmentally appropriate. Science content and pedagogy will merge so that teachers will simulate the form that is used for their students' learning. Teachers from POLARIS schools will personally experience and learn a change process described by the Concerns Based Adoption Model (CBAM).

The change process incorporates a hands-on, research-based pedagogy and delineates steps appropriate for developing leaders. Simultaneously, teachers will implement a new science scope and sequence based upon state and national standards. Appropriate assessment models will be designed and used. Students will receive improved science instruction, resulting in higher achievement and more positive attitudes toward the sciences. This includes the challenge of enticing traditionally underserved student populations into science courses and science-related career considerations.

Prince William Sound Science Center (PWSSC): Alaska

http://www.pwssc.gen.ak.us/pwssc/pwssc.html

The Prince William Sound Science Center is an independent, nonprofit research organization located in Cordova in southeastern Prince William Sound, Alaska. The science center was established in 1989 to conduct and facilitate scientific studies on the ecology of the region. The center's programs take an ecosystem approach to research, monitoring, and management of natural resources. The mission of the Prince William Sound Science Center, an independent research and education institution, is threefold: (1) to contribute to the comprehensive description, sustained monitoring and ecological understanding of Prince William Sound, the Copper River, and Gulf of Alaska; (2) a commitment to maintain self-regulating and long-term biodiversity, productivity, and sustainable use of renewable resources; and (3) To educate and inform youth and the general public about the critical interdependence of the biology and regional economies of Alaska.

The center hosts international workshops on regional scientific issues and encourages public interaction with resident and visiting scientists through a public lecture series. The center also has an active education program for school-age children. The Science of the Sound program provides an excellent model for other coastal communities in the region and facilitates exchange of ideas among the communities. A primary focus of the program is to cooperate with other agencies (the U.S. Forest Service and Alaska Department of Fish and Game), the school system, Prince William Sound Community College, and parents in order to make the most use of local resources already existing in the community (i.e., staff and equipment).

One element of the program is a Discovery Resource and Reading Room where monthly programs are organized around themes incorporating the local environment. These programs are also offered to the remote village communities in Prince William Sound through outreach workshops. The science center is participating in the Youth Area Watch program, where high school students collect data in collaboration with scientists working on projects related to the region.

Rural Alaska Honors Institute (RAHI): Alaska

http://www.uaf.edu/rahi/

The Rural Alaska Honors Institute (RAHI) is a bridging program that helps students in rural Alaska make the academic and social transition between high school and college. RAHI is for college-bound students who are willing to work hard and who are dedicated to excellence. Admission to RAHI is competitive, that is, not all who apply are accepted. Students who are accepted are awarded full scholarships that cover all summer program expenses including travel, room, board, supplies, and tuition. RAHI students are rewarded for their hard work with up to nine college credits towards a degree, as well as a wonderful group of staff, students, and alumni who will serve as an Alaska-wide network of supportive friends for the rest of their lives.

Steller's Eider Science and Education Partnership: Alaska

This cooperative project to involve Alaska communities with the conservation of the threatened Steller's eider involves the Department of Wildlife Management in Barrow, Alaska, the U.S. Fish and Wildlife Service (USFWS) Ecological Services office in Fairbanks; Izembek National Wildlife Refuge in Cold Bay, Alaska; the Arctic Research Consortium of the U.S. (ARCUS). Biologists have been studying the Steller's eider, which in the U.S. nests only near Barrow in any significant numbers. Steller's eiders that breed in the Barrow area winter in Izembek Lagoon, together with thousands of other Steller's eiders from populations along the Siberian coast. Steller's eiders were listed as a threatened species in 1997. Since then, there have been several years in which very few pairs successfully bred in Alaska. This research project is collecting basic information on the breeding biology and population of Steller's eiders in the U.S. while incorporating students and teachers from Barrow and Cold Bay. These teachers and students learn a great deal about biology and the serious issues confronting the Steller's eider and share them with their communities and colleagues. Support for this program has been provided by USFWS, NSF, and Alaska Airlines.

Teachers Experiencing Antarctica and the Arctic: Nationwide

http://tea.rice.edu

The centerpiece of the Teachers Experiencing Antarctica and the Arctic (TEA) Program is a research experience in which a K–12 teacher participates in a polar expedition. The TEA teacher works closely with scientists, participates in cutting-edge research, and is immersed in the process of science. Enveloping this field experience are a diversity of professional development opportunities through which TEA teachers increase content knowledge, enhance teaching skills, transfer the experience to the classroom, assume leadership roles, and collaborate with a network of researchers and education colleagues. TEA is a partnership between teachers, researchers, students, the school district, and the community.

TEA is sponsored by the Division of Elementary, Secondary, and Informal Education (ESIE) in the Directorate of Education and Human Resources (EHR) and the Office of Polar Programs (OPP) of the NSF and facilitated by Rice University, the Cold Regions Research and Engineering Laboratory (CRREL), and the American Museum of Natural History (AMNH).

Toolik Field Station: University of Alaska Fairbanks

http://www.uaf.edu/toolik/

The Toolik Field Station (TFS) is administered by the Institute of Arctic Biology, University of Alaska Fairbanks (UAF). The station is located in the northern foothills of the Brooks Range on the southeast shore of Toolik Lake (68°38'N, 149°38'W, elevation 720 m). This location affords access to three major physiographic provinces, including the Brooks Range, the Arctic foothills, and the Arctic Coastal Plain (Toolik Field Station, 1996). Over the last two decades the Toolik Field Station has played a central role in terrestrial and aquatic research in the U.S. Arctic. Research has significantly increased our understanding of the circumpolar Arctic and of basic biology, physiology, climatology, hydrology, and ecology. The TFS is a central monitoring and testing ground for investigations into global climate change.

TFS has a small but expanding educational component. High school students (Earthwatch Student Challenge Award program), teachers (NSF's Research Experience for High School Teachers), undergraduate students (NSF's REU program), and graduate students (on individual grants) receive training and hands-on research opportunities in a community of hard-working research associates and postdoctoral and principal investigators. UAF is currently developing plans for a summer arctic science field course, which will be open to undergraduate and graduate students from all institutions and taught by visiting faculty, including active Toolik Field Station principal investigators.

APPENDIX B: Principles for the Conduct of Research in the Arctic

Introduction

All researchers working in the North have an ethical responsibility toward the people of the North, their cultures, and the environment. The following principles have been formulated to provide guidance for researchers in the physical, biological, behavioral, health, economic, political, and social sciences and in the humanities. These principles are to be observed when carrying out or sponsoring research in the Arctic and northern regions or when applying the results of this research. This statement addresses the need to promote mutual respect and communication between scientists and northern residents. Cooperation is needed at all stages of research planning and implementation in projects that directly affect northern people. Cooperation will contribute to a better understanding of the potential benefits of Arctic research for northern residents and will contribute to the development of northern science through traditional knowledge and experience.

These *Principles for the Conduct of Research in the Arctic* were prepared by the Interagency Social Science Task Force in response to a recommendation by the Polar Research Board of the National Academy of Sciences and at the direction of the Interagency Arctic Research Policy Committee. This statement is not intended to replace other existing Federal, State, or professional guidelines, but rather to emphasize their relevance for the whole scientific community. Examples of similar guidelines used by professional organizations and agencies in the United States and in other countries are listed in the publications.

Implementation

All scientific investigations in the Arctic should be assessed in terms of potential human impact and interest. Social science research, particularly studies of human subjects, requires special consideration, as do studies of resources of economic and social value to Native people. In all instances, it is the responsibility of the principal investigator on each project to implement the following recommendations.

1. The researcher should inform appropriate community authorities of planned research on lands, waters, or territories used by or occupied by them. Research directly involving northern people should not proceed without their clear and informed consent. When informing the community and/or obtaining informed consent, the researchers should identify:
   a. all sponsors and sources of financial support;
   b. the person in charge and all investigators involved in the research, as well as any anticipated need for consultants, guides, or interpreters;
   c. the purposes, goals, and time-frame of the research;

d. data-gathering techniques (tape and video recordings, photographs, physiological measurements, etc.) and the uses to which they will be put;
e. foreseeable positive and negative implications and impacts of the research.

2. The duty of researchers to inform communities continues after informed consent has been obtained. Ongoing projects should be explained in terms understandable to the local community.
3. Researchers should consult with and, where applicable, include communities in project planning and implementation. Reasonable opportunities should be provided for the communities to express interests and to participate in the research.
4. Research results should be explained in non-technical terms and, where feasible, should be communicated by means of study materials that can be used by local teachers or in displays that can be shown at local community centers or museums.
5. Copies of research reports, data descriptions, and other relevant materials should be provided to the local community. Special efforts must be made to communicate results that are responsive to local concerns.
6. Subject to the requirements for anonymity, publications should always refer to the informed consent of participants and give credit to those contributing to the research project.
7. The researcher must respect local cultural traditions, languages, and values. The researcher should, where practicable, incorporate the following elements into the research design:
   a. use of local and traditional knowledge and experience;
   b. use of the languages of the local people;
   c. translation of research results, particularly those of local concern, into the languages of the people affected by the research;
8. When possible, research projects should anticipate and provide meaningful experience and training for young people.
9. In cases where individuals or groups provide information of a confidential nature, their anonymity must be guaranteed in both the original use of data and in its deposition for future use.
10. Research on humans should only be undertaken in a manner that respects their privacy and dignity:
    a. Research subjects must remain anonymous unless they have agreed to be identified. If anonymity cannot be guaranteed, the subjects must be informed of the possible consequences of becoming involved in the research.
    b. In cases where individuals or groups provide information of a confidential or personal nature, this confidentiality must be guaranteed in both the original use of data and its deposition for future use.
    c. The rights of children must be respected. All research involving children must be fully justified in terms of goals and objectives and never undertaken without the consent of the children and their parents or legal guardians.
    d. Participation of subjects, including the use of photography in research, should always be based on informed consent.
    e. The use and deposition of human tissue samples should always be based on the informed consent of the subjects or next of kin.
11. The researcher is accountable for all project decisions that affect the community, including decisions made by subordinates.
12. All relevant federal, state, and local regulations and policies pertaining to cultural, environmental, and health protection must be strictly observed.

13. Sacred sites, cultural materials, and cultural property cannot be disturbed or removed without community and/or individual consent and in accordance with federal and state laws and regulations.

In implementing these principles, researchers may find additional guidance in the publications listed below. In addition, a number of Alaska Native and municipal organizations can be contacted for general information, obtaining informed consent, and matters relating to research proposals and coordination with Native and local interests. A separate list is available from NSF's Office of Polar Programs.

Publications

Arctic Social Science: An Agenda for Action. National Academy of Sciences, Washington, D.C., 1989.

Draft Principles for an Arctic Policy. Inuit Circumpolar Conference, Kotzebue, 1986.

Ethics. Social Sciences and Humanities Research Council of Canada, Ottawa, 1977.

Nordic Statement of Principles and Priorities in Arctic Research. Center for Arctic Cultural Research, Umea, Sweden, 1989.

Policy on Research Ethics. Alaska Department of Fish and Game, Juneau, 1984.

Principles of Professional Responsibility. Council of the American Anthropological Association, Washington, D.C., 1971, rev. 1989.

The Ethical Principles for the Conduct of Research in the North. The Canadian Universities for Northern Studies, Ottawa, 1982.

The National Arctic Health Science Policy. American Public Health Association, Washington, D.C., 1984.

Protocol for Centers for Disease Control/Indian Health Service Serum Bank. Prepared by Arctic Investigations Program (CDC) and Alaska Area Native Health Service, 1990. (Available through Alaska Area Native Health Service, 255 Gambell Street, Anchorage, AK 99501.)

Indian Health Manual. Indian Health Service, U.S. Public Health Service, Rockville, Maryland, 1987.

Human Experimentation. Code of Ethics of the World Medical Association (Declaration of Helsinki). Published in *British Medical Journal,* 2:177, 1964.

Protection of Human Subjects. *Code of Federal Regulations* 45 CFR 46, 1974, rev. 1983.

Appendix C: Agenda

Purpose and Outcomes

Develop a set of recommendations to the National Science Foundation Office of Polar Programs for the implementation of effective arctic science and education programs.

Devise strategies, projects, or programs that:

1. Engage teachers, students, and residents of arctic communities in scientific research;
2. Build effective partnerships among academic, agency, arctic community, and education participants; and
3. Increase public awareness of arctic research and the importance of the arctic region.

Thursday, 30 March 2000

Solarium Room 501

8:15 am	Welcome
8:30 am	Opening remarks *Wendy Warnick, ARCUS Executive Director*
8:40 am	Comments from the working group chair *Peter Sommerville*
9:00 am	Self-introductions of working group members
10:30 am	BREAK

Conference Room 417

10:45 am	PRESENTATIONS (15–20 minutes each) Examples of field-based research experiences for teachers and students *Philip Martin, Michele Hauschulz, Pete Sommerville*
11:45 am	LUNCH

Conference Room 417

1:15 pm	PRESENTATIONS (15–20 minutes each) Examples of place-based education, community involvement, and cross-cultural education programs *Greg Smith, Kathy Swartz, Fran Mann, Steve Hastings*
2:35 pm	PRESENTATIONS (15–20 minutes each) Translating research experiences to classroom curricula *Rebecca Dahl, Steve Stevenoski*
3:15 pm	BREAK

Solarium Room 501

3:30 pm PLENARY SESSION BRAINSTORM
What are the challenges for arctic science education programs?
- field based
- classroom based
- community oriented
- cross cultural
- logistics

4:15 pm Break-out groups
Groups discuss and answer specific questions:
1. What do we mean by "the Arctic"?
2. What do we mean by science education?
3. How do we define cross-cultural in the context of arctic science education?

5:00 pm Regroup, report, and discuss

5:45 pm Summary remarks

6:00 pm Adjourn

6:30 pm DINNER

Friday, 31 March 2000

Solarium Room 501

8:15 am Welcome, coffee and snacks

8:30 am Opening remarks and summary of progress
Peter Sommerville

8:50 am Why the Arctic: NSF Office of Polar Programs investment in arctic science education
Fae Korsmo

9:10 am PLENARY SESSION BRAINSTORM on burning questions
What are the elements of successful science education programs?
What kinds of partnerships would be most useful?
What are the best ways to create and maintain good partnerships?
What do we want students to gain from arctic science education?
Are we excluding important opportunities by thinking in terms of "science education"?

9:45 am Break-out groups (three groups of ~5 individuals)
1. The three most important goals of arctic science education are …?
2. Who should be the target audience?
3. What kinds of activities should be supported to achieve these goals?
4. What outcomes would indicate success?

10:45 am BREAK

Solarium Room 501

11:00 am Regroup, report, and discuss

11:45 am Identify and summarize goals and benefits of various approaches to arctic science education programs

12:00 pm LUNCH

1:30 pm	Break-out groups (three groups of ~5 individuals) Design targeted program education programs within the following guidelines and keeping in mind the *Principles for Conduct of Research in the Arctic:* 1. Must include significant arctic research component; 2. Must include substantive involvement of arctic residents, including in planning and implementation; 3. Should benefit all partners to the greatest extent possible and do no harm to them; and 4. Think "pilot program" that can be easily replicated and modified.
3:30 pm	BREAK
3:45 pm	Synthesize building blocks of successful arctic science education programs
5:15 pm	Summary remarks
5:30 pm	Adjourn

Saturday, 1 April 2000

Solarium Room 501

8:45 am	BREAKFAST
10:00 am	Meet at IARC
10:05 am	Opening remarks—The Big Picture *Pete Sommerville*
10:15 am	Refine ideas for structure of program or constellation of programs
11:15 am	Develop recommendations to NSF/OPP
11:45 am	LUNCH
12:45 pm	Review recommendations
1:00 pm	Develop action items and timeline
1:15 pm	Concluding comments
1:30 pm	Adjourn

Appendix D: Working Group Participants and Report Reviewers

Working group participants are in bold text.

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