# The Indigenous Worldview of Yupiaq Culture: Its Scientific Nature and Relevance to the Practice and Teaching of Science

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## Abstract

Is science an invention of European thought, or have legitimate scientific bodies of knowledge and scientific ways of thinking emerged separately in other cultures? Can indigenous knowledge systems contribute to contemporary science teaching? Here we describe evidence from the Yupiaq culture in southwestern Alaska which demonstrates a body of scientific knowledge and epistemology that differs from that of Western science. We contend that drawing from Yupiaq culture, knowledge, and epistemology can provide not only a more culturally relevant frame of reference for teaching science concepts to Yupiaq students, but also a potentially valuable context for more effectively addressing many of the recommendations of U.S. science education reform initiatives. © 1998 John Wiley & Sons, Inc. J Res Sci Teach 35: 133-144, 1998.

> The science accounted for in this book are largely part of a tradition of thought that happened to develop in Europe during the past 500 years – a tradition to which people from all cultures contribute today. (Rutherford & Ahlgren, 1990, p. 136)

As this quote from Science for all Americans implies, Western science has become the prototype for what counts as science today, and other ways of thinking and doing science have been largely discounted by the Euro-American scientific and educational communities. With its emphasis on controlled experimentation, replicability, and alleged objectivity, science as practiced in laboratories and as traditionally taught in U.S. schools does differ from the practice and thinking found in many indigenous cultures, but does that mean that what occurs in other cultures is believe that such indigenous groups practice science in ways that has similarities to – and important and useful differences from – Western science, and that the worldview underpinning this indigenous vision of science has valuable implications for science instruction.

Scientific hypotheses and knowledge acquisition generally have their roots in observations and insights about the natural world. Nevertheless, scientists and educators today often present textbook/laboratory science as the true science. Such a narrow view of science not only diminishes the legitimacy of knowledge derived through generations of naturalistic observation and insight, it simultaneously devalues those cultures which traditionally rely heavily on naturalistic observation and insight. In addition, contemporary science classes commonly portray science as a discrete body of knowledge distinctly separated from most other subject areas and as a body of knowledge discovered by European and Euro-American scientists. This characterization makes science an activity foreign to the way of thinking of cultures in which science is interwoven within most aspects of daily life.

Philosophers of science generally acknowledge the elusiveness of a definition of the nature of science, and in particular tend to disagree with common characterizations of the nature of science depicted in recent science education literature (Alters, 1997). Nevertheless, in our conversations with science educators and scientists in the United States, we have been confronted with the assumption that the nature of science is clearly defined. Lee (1997) pointed out that statements in Science for all Americans (Rutherford & Ahlgren, 1990) and National Science Education Standards (National Research Council, 1996) demonstrate that these important reform documents both promote a Western scientific cultural tradition. We agree with Lee that the tendency to define science strictly from the viewpoint of Western culture has serious and detrimental ramifications for students from non-Western cultures and languages, and we add that a Eurocentric view of science places unnecessary limitations on the development of scientific literacy for all students.

We contend that no single origin for science exists: that science has a plurality of origins and a plurality of practices. In this position statement, we support that belief with examples of scientific knowledge and ways of thinking about the world from one indigenous culture, that of the Yupiaq people of southwestern Alaska. As with many other indigenous groups, the worldview of the Yupiaq people has enabled them to survive for thousands of years. We contend that knowledge embedded in that worldview is scientific in nature, and that it remains relevant to today's world.

Throughout this article, we will refer to the term worldview as a means of conceptualizing the principles and beliefs – including the epistemological and ontological underpinnings of those beliefs – which people have acquired to make sense of the world around them. Our usage is intended to be consistent with Webster's new world dictionary of American English (Neufeld & Guralnik, 1991), which defines worldview as "a comprehensive, especially personal, philosophy or conception of the world and of human life." As perceived by the authors of this article, the concept of worldview is also closely related to the definitions of culture and cognitive map (Berger, Berger, & Kellner, 1974).

## Alaska Native Culture and Education

The majority of residents in rural Alaska are Alaska Natives who live in villages with small populations (25-1000 people/village). With some 20 Alaska Native languages spoken in the state, many school students speak an indigenous language as a first language. Many families in rural Alaska maintain a lifestyle that is largely dependent on subsistence hunting and fishing. Wild foods (salmon, caribou, moose, and numerous wild berries and herbs) from a major portion of their food supply, and many rural residents rely on commercial fishing in the summer months as their main financial support.

The Yupiaq (also known as Yup'ik) culture is one of several Alaska Native cultures known to Westerners as Eskimo (a term which has too often been used pejoratively). Members of the Yupiaq culture reside in southwestern Alaska on an area of land larger than many individual states in the contiguous 48 states. There are no roads connecting these villages, which are isolated by hundreds of miles from access to the highway systems that connect cities such as Anchorage to the contiguous states. Despite their isolation from the rest of the nation, rural villages have been affected greatly by modern Western culture. Televisions and telephones have become common. While dog sleds still are used recreationally, snow machines have become the more common mode of transportation in winter, and four-wheelers and power boats have become common in the summer.

Teachers and administrators in rural Alaska schools are mostly Euro-American and short-term, many staying in a village only 1 or 2 years (with a few staying for less than a week). While the villages themselves strongly reflect their particular Alaska Native culture, Euro-American culture dominates the school and the curriculum. In the recent past, Alaska Native students were forbidden to speak their native language in the schools. Indeed, eradication of Alaska Native culture was an early goal of Alaskan educational systems (Alaska Natives Commission, 1993). The activism of Alaska Natives and of groups such as the Alaska Federation of Natives has gradually brought change.

The Alaska Natives Commission (1993) produced a report addressing the educational problems and needs of Alaska Natives. Twenty-one percent of Alaska's K-12 students are Alaska Natives. However, "twenty-two of Alaska's 54 school districts have student populations of 75% or more Alaska Natives. . . .In some school districts up to 30% of Native children in elementary school are below grade level" (p. 14). In 20 school districts (19 of which had 60% to 98% Alaska Native students), students scored "on average below the 22nd percentile in either reading, mathematics, or language arts at the 4th, 6th, or 8th grade" (p. 15), and "only about 67% of Alaska Native students complete high school" (p. 17). Alaska Natives who do complete high school score dramatically lower (about 40% lower) than Caucasian Alaskans on the American College Test (ACT). Among the various factors contributing to student failure, the report cites poverty and the cultural and linguistic differences between students and school personnel.

As a result of Alaska Native activism, many rural school districts today offer instruction in the local language and culture (Alaska Natives Commission, 1993). For example, in Manokotak, Alaska, children are taught in Yup'ik from kindergarten to third grade. In Chefornak, Alaska, Alaska Native teacher aides conduct weekly classes on local traditional music and dance. Nonetheless, less than 4% of Alaskan teachers are Alaska Natives. Small rural schools must rely on Alaska Native volunteers and Alaska Native teacher aides for specialized instruction in local language and culture. Thus, most of the instruction is from the viewpoint of the Euro-American teacher, and there remains a wide gap between the culture of the child at home and the culture of the child in school.

## Alaska Native Contributions to Science and Technology

Alaska Native scientific knowledge has largely been ignored by Euro-American scientists. However, in recent years knowledge from indigenous Alaskan cultures has contributed to several scientific studies. For example, the knowledge of local villages was used in an environmental impact study conducted in the Alaskan tundra. Indigenous elders' knowledge of bowhead whale behavior was used to correct an inaccurate count of bowhead whale population in the North Slope region (Bingham, 1997). In southwest Alaska, a group of scientists participating in a public hearing provided data demonstrating that Beluga whales did not feed on salmon. A group of local Alaska Natives (mainly Yupiaqs) persuaded the scientists to visit a nearby beach where they opened the stomach of a recently harvested Beluga. When several large salmon spilled out, one of the elders was reported to have said, “How’d those get in there then?” (R.S. Nelson, personal communication, 1996).

In the past few years, several educational studies of the traditional knowledge and practices of Yupiaq people have been conducted in southwestern Alaska. The Cuiulistet group, an organization of Yupiaq teachers, has conducted ongoing studies of Yupiaq mathematics and science in an effort to bring that knowledge directly into classrooms in Bristol Bay villages (Lipka, 1994a, 1994b). Two of the authors (A.O.K. and R.A.N.) have participated in a number of the research meetings held by the Ciulistet teachers/researchers.

Kawagley (1995) conducted an ethnographic study of Yupiaq knowledge and ways of knowing and doing science in Akiak, a small village of 385 people near Bethel, Alaska. Kawagley is the first Yupiaq to receive a Ph.D. He received permission of the Tribal Council of the Yupiit Nation and the Yupiit School District to conduct observations and interviews in Akiak. He visited classrooms, reviewed school curricula, and interviewed local teachers and villagers. Having grown up in the region, Kawagley views himself as a participant-observer.

Each of these studies relied heavily on interviews with village elders and on the lifelong experiences of the Yupiaq researchers. Interviews with elders, respected for their wisdom and knowledge, reveal a rich body of indigenous knowledge and well-defined ways of viewing the world. In the meetings of the Ciulistet teachers, the elders have often been invited to demonstrate their knowledge through stories and through physical demonstrations of skills. For example, elders have taught the younger teachers and school children how to make river fish traps and how to prepare and sew caribou skins for clothing items.

Much of Yupiaq scientific knowledge is manifested most clearly in their technology. One may argue that technology is not science. However, technology does not spring from a void. To invent technological devices, scientific observations and experimentation must be conducted. Yupiaq inventions, which include the kayak, river fish traps, and a wide range of hunting and fishing gear, represent technology that could not have been developed without extensive scientific study of the flow of currents in rivers, the ebb and flow of tides in bays, and the feeding, resting, and migratory habits of fish, mammals, and birds.

For example, each item of fishing gear is typically developed to capture a particular species of fish in a particular type of water (in a river, under ice, on the shore of the bay, or in the open ocean). To make the appropriate traps and nets, the fisherman has to have significant scientific knowledge of the behaviors of each species of fish, tidal patterns, and the patterns of flow of water in rivers. In remote villages, most food is still retrieved from the wild. Therefore, all young men must have extensive knowledge of migration patterns, mating habits, and feeding behaviors of a wildlife (including seals, walrus, several species of whales, moose, caribou, ptarmigan, and many species of waterfowl).

Yupiaq women gather wild foods and preserve and prepare foods from animals, which are harvested mostly by the men. The women know when and where to collect wild berries, which provide a crucial source of vitamins. They typically have extensive knowledge of local wild plants, including a wide variety of edible and medicinal ones. They know when and where to gather grasses for basketmaking. Many still know how to prepare clothing, including shoes, coats, and raingear, from skins of caribou, moose, seals, and even salmon skins. Most know how to prepare and preserve fish, moose, and caribou for long-term storage.

Tepa, or "stink heads," is a Yupiaq delicacy. King salmon heads are buried, wrapped in grasses. The fermented heads are eaten. To be safely prepared, the fish must be stored in the right type of soil at the right temperature. This was a relatively safe food to eat until the introduction of plastic bags. Fish stored underground in plastic bags are more likely to develop botulism than fish stored in grasses. It was soon discovered that the traditional method of preparing the "stink heads" was safer than the modern way.

Yupiaq people have extensive knowledge of navigation on open seas and rivers, and over snow-covered tundra. They have their own terminology for constellations and have an understanding of the seasonal positioning of the constellations. They have developed a large body of knowledge about climatic and seasonal changes – knowledge about temperature changes, the behavior of ice and snow, the meaning of different cloud formations, the significance of changes in wind direction and speed, and knowledge of air pressure. This knowledge has been crucial to survival and was essential for the development of the technological devices used in the past (many of which are still used today) for hunting and fishing.

In his book The demon-haunted world, Carl Sagan (1996) remarked on the discovery of quinine by premodern people in the Amazon.

> They must have tried every tree and every plant – roots, stems, bark, leaves – tried chewing on them, mashing them up, making an infusion. This constitutes a massive set of scientific experiments continuing over generations – experiments

> that moreover could not be duplicated today for reasons of medical ethics. Think of how many bark infusions from other trees must have been useless, or made the patient retch or even die. In such a case, the healer chalks these potential medicines off the list, and moves on to the next. (p. 251)

Likewise, Yupiaq traditional knowledge reflects an understanding of the natural world based on a "massive set of scientific experiments continuing over generations." Yupiaq scientific knowledge is based on thorough longitudinal studies and observations of the natural surroundings. Traditionally, knowledge was passed down from the elders to the youth through storytelling. Until very recently, the Yupiaq language was not written down. Thus, all important knowledge was preserved by oral traditions which were crucial to survival. The preservation of the next generation depended on an efficient method of learning that which previous generations had already discovered (such as knowledge of seasonal and long-range weather patterns, salmon migration patterns, and knowledge and skills about river ice and sea ice formation and movement).

Besides through oral tradition, knowledge and skills are handed down in other ways as well. Fishing, hunting, and food gathering and preparation practices are passed on to children by working with, observing, and mimicking their parents, grandparents, and older siblings. Typically, the person teaching the skill will say very little. The learner is expected to observe closely and mimic what is being done. It is quite common for children to become quite skillful with a variety of tools, including sharp knives, at an early age. To translate Yupiaq teaching and learning into current educational jargon, one could state that teaching strongly emphasizes modeling and guided practice, and that cooperative learning, peer tutoring, and hands-on learning are essential strategies.

## Yupiaq Worldvew

In addition to a body of knowledge about the natural and physical world, Yupiaq ways of thinking about the world reflect a worldview distinct from the Western way of thinking. In Yupiaq culture, science is not separated from daily life. Their science is interspersed with art, storytelling, hunting, and craftsmanship.

In contrast to the idea that science is a body of knowledge discovered by scientists working in their laboratories, Kawagley (1995) found that Yupiaq villagers see themselves as the producers of knowledge. In their daily lives, these men and women are the observers of their environment. There are no special gatekeepers of knowledge. The elders of the community are the repositories of traditional knowledge and they see it as their responsibility to educate the younger members. However, Western culture has interfered with the traditional teaching and learning mode. Suppression of the Alaska Native language and culture has resulted in a generation of youth many of whom cannot communicate with the elders in their own communities (Alaska Natives Commission, 1993). School teachers have in amny cases replaced the elders as the transmitters of knowledge.

The Yupiaq people have difficulty with many Western concepts and the words to describe or define them. Western words come from worldview that is objectivistic and technomechanistic, as opposed to the Yupiaq worldview which is ecological and spiritual. Thus the concepts and word-thoughts (and metaphors) of the Yupiaq people are often ineffable because they are based on feelings of connectedness and relationships. Therein lies the Yupiaq problem with words such as science and mathematics and the various scientific and mathematical disciplines and their concomitant terms and concepts. These all are strange and foreign to the Yupiaq people. Kawagley (1995) asked a group of Yupiaq elders to define mathematics and science.

> The elders' discussion of the definition of mathematics focused on the Yupiaq word Cuqtaariyaraq, "the process of measuring." The other definitions that were considered reflect further abstractions of their thinking processes as applied to one who uses mathematics. These included "someone who is astute and perceptive"; "an expert evaluator"; "an expert assessor"; "someone who evaluates something, mentally assessing the feasibility and coming pretty close to the estimate"; "becoming good at calculating"; becoming good at visualizing." Finally, they agreed that the best Yupiaq definition of mathematics would be "the process of measuring and estimating in time and space." (p. 57)

No Yupiaq word exists for science. When asked to define science, the elders defined it as:

> "Trying to know"; "trying to understand"; "trying to grasp the origin"; "trying to find the source"; "the process of understanding"; "way to try and understand through process of elimination"; "a process that is the science of life"; and "a process of seeing and predicting the future." (pp. 57-58)

Western scientific knowledge has become so specialized that it is often difficult to take the whole organism of the whole system into account. Western culture segregates science from other realms of knowledge and even subdivides science into various categories, so that a scientist specializing in one field may well lack a basic understanding of other scientific and nonscientific fields. For Yupiaqs, scientific knowledge is not segregated from other aspects of daily life and it is not subdivided into different fields of science. To design a fish trap, for example, one must know how the river behaves, how the salmon behave, and how the split-willow of which the trap is made behaves (i.e., one must have an understanding of physics, biology, and engineering).

While the Yupiaq people we have interviewed value observation highly, they do not consider direct observation as the only way of attaining knowledge about the universe. Spiritual understanding is another way of obtaining knowledge – observing one's inner spirit, as well as one's outer environment, contributes to the whole range of Yupiaq knowledge.

Kawagley (1995) noted that Yupiaq people view the world as being composed of five elements: earth, air, fire, water, and spirit. Aristotle spoke of the four elements: earth, air, fire, and water. However, spirit has been missing from Western science. The incorporation of spirit in the Yupiaq worldview resulted in an awareness of the interdependence of humanity with the environment, a reverence for and a sense of responsibility for protecting the environment.

The elders Kawagley interviewed commented that

> This is what our ancestors have said" they've said not to pollute the land. They've said that if we're not careful with out refuse, some animals, though they were plentiful once, will no longer be around. They were actually foreseeing their future when they told us that.
>
> That's the science of life. We have to take care of our tundra in order to have plenty and have abundant wildlife. (p. 58)

In the past, before the introduction of Western materials and ways of doing things, Yupiaq people practices what may be thought of as soft technology (Lovins, 1977). This low-impact technology involved the making of tools and preparation of shelters, clothing, and food with as little harm to the natural and supernatural worlds as possible. The shamans were the intermediaries between the spiritual and natural worlds. They informed the people of what was appropriate or not in their dealing with the earth. The use of natural materials made all objects ultimately recyclable. The people took extensive precautions to protect the lives of the animals and plants they depended upon for their existence.

Kawagley found that Yupiaq people are involved in the human effort to develop a worldview consonant with themselves, nature, and the spiritual world. Such reverence for nature has been largely missing from Western cultural interactions with the environment. Einstein (1956) stated, "The ancients knew something that we seem to have forgotten. All means prove but a blunt instrument, if they have not behind them a living spirit" (p. 24).

In Western culture today, science, philosophy, and metaphysics are treated as separate areas of study; yet, historically this division was not so apparent. Western scientific and philosophical thinking has often turned to questions about the nature of existence and of God. Even in modern physics, such great thinkers as Einstein and Hawking have not found it necessary to separate questions about God from questions about the behavior of the universe. Yet, many Western scientists and science educators today treat science and spirit as separate and unrelated entities.

In Western science, the closest to Yupiaq science can be seen in the study of ecology, which incorporates biological, chemical, and physical systems (earth, air, fire, and water). However, even many ecologists have ignored the fifth element, spirit. Lack of attention to the fifth element has resulted in a science that ignores the interaction and needs of societies and cultures within ecosystems. Only recently has ecological study begun to seriously consider and incorporate human social needs and concerns about changes in ecosystems.

## Conclusions

As depicted by science education professors in the United States and by documents such as Science for all Americans (Rutherford & Ahlgren, 1990) and National Science Education Standards (National Research Council, 1996), the nature of science is seen as clearly defined and based on a Western tradition. We believe that the nature of science is not clearly defined or clearly definable, but rather that it is largely dependent on the cultural tradition of the practitioner of science.

We believe that there is no one way to do or think about science. Science is not strictly European in origin. Modern scientific knowledge is a blend of the observations and insights of many different cultures. Besides the large body of scientific knowledge that came out of the Chinese, Greek, Egyptian, and Arabic cultures, a significant amount of modern scientific knowledge originated in the knowledge of indigenous cultures. For example, about 121 modern prescription drugs were derived from plants. Western researchers would not have known which plants to test for healing properties without the knowledge supplied by traditional healers (Abelson, 1990).

Yupiaq science is a science based on observation of the natural world coupled with direct experimentation in the natural setting. The science conducted in Western laboratories is largely a way of doing science that is Western in origin and is in some crucial ways distinct from the way that science is and has been done in indigenous cultures. Western science tends to be impersonal, formal, and elitist (only certain college-educated individuals are granted the status of scientist). Indigenous science is informal and nonelitist. Western science promotes a mechanistic view of the universe. Indigenous science incorporates spirit.

There is a large body of science that exists in Yupiaq culture – but it is a science that is rapidly disappearing as the language is disappearing. Recent publicity has altered us to concerns about the loss of knowledge of plant medicines in the Amazon rain forests as the Amazon tribes disappear (Jackson, 1989). However, we know very little about what we are losing as the cultures and languages of indigenous Alaskans disappear.

## Implications for Curriculum Development and Pedagogy

Not enough has been written that provides specific examples of methods for making science and mathematics education truly accessible to all students, even students in a remote Alaskan village of 300 people. The National Science Teachers Association now has several books that will be of value to teachers, such as Science for all cultures (Carey, 1993). The Northwest Regional Educational Laboratory has just produced a good attempt in its Science and Mathematics for all students (1997). However, even this booklet lumps all minorities into one category ("students of color") and unwittingly implies that this amorphous group of students all share the same challenges in mathematics and science achievement.

Rodriguez (1997) criticized the National Science Education Standards (National Research Council, 1996) for what he refers to as a "discourse of invisibility" with regard to women and minorities. He criticized the National Research council for not taking a strong stand in providing guidelines for how to promote the scientific literacy of all students. The science education community must take the lead in addressing the needs of those students for whom research has demonstrated that science and mathematics instruction as traditionally practiced in American schools has failed. Those students include a disproportionate number of females and a disproportionate number of Latin American, African-American, Native American and Alaska Native students.

What is the best way to teach science in Yupiaq classrooms? Many elders in Yupiaq villages want their young people to learn the traditional knowledge and skills that enabled their ancestors to survive in the past, not just because it is a part of their heritage but because that knowledge is still relevant to life in the villages today. They also want their young people to learn scientific knowledge and skills of the world outside the village – because the elders understand that that knowledge is also relevant to the lives of their children. The elders understand that the Yupiaq view of the world is different from the view of the world as seen through the eyes of the Euro-American teachers in their schools. They want their children to understand both worldviews – because they see both as crucial to the survival of their youth.

However, science instruction as it has been traditionally delivered has not been effective. Science curriculum as it has historically appeared in rural Alaska has been based on textbooks which, for example, have assumed that grasshoppers, turtles, cows, and sidewalks were a part of every child's daily life. Many rural Alaskan students have seen none of these. In contrast, most rural Alaskan students have many experiences with nature that urban and suburban students lack, experiences (such as hunting caribou and seals) which school textbooks and standardized tests never include in the examples.

Science historically has presented Yupiaq students with a bewildering, largely irrelevant body of information in a different science subject each year. Science has been taught through reading textbooks (as opposed to the oral method more familiar in local cultures) and listening to lectures that incorporate many unfamiliar terms. It has been graded competitively (in a culture that values cooperation). Students are required to memorize an enormous amount of unrelated abstract information with no clear use in real life, Because Western methods of teaching science often run counter to the students' own cultural experiences, Yupiaq students have been disenfranchised not only by what is taught but also by how it is taught.

We believe that one way, and possibly the most effective way, to improve learning in Yupiaq classrooms is to infuse indigenous knowledge and worldview in the curriculum. To effectively incorporate Yupiaq culture into classroom content and practice requires some fundamental changes in the way students, teachers, and schools function. Designing instructional materials and practices which acknowledge and respect Yupiaq society represents much more than just movement away from an outdated view of science and science teaching, however. It also represents significant progress toward the goals, outcomes, and recommendations of recent science education reform documents, documents such as National Science Educational Standards (National Research Council, 1996) and Science for all Americans (Rutherford & Ahlgren, 1990), as well as being congruent with emerging understandings of the teaching and learning process.

It is interesting to note that although these science reform documents pay little attention to the educational needs of specific minority groups and female students, the changes in curriculum and pedagogy recommended in these documents in many cases closely correspond to the changes necessary to incorporate Yupiaq knowledge, worldview, and culture into the classroom.

A Yupiaq worldview, like recent science reform documents, invokes a more holistic view of science, minimizing the artificial distinctions among concrete subjects in science while emphasizing the interconnectedness and interdependence of all dimensions of nature and human activity. The Yupiaq heritage can bring to the classroom a multidisciplinary, multidirectional, and multisensory learning style, with the total environment, natural and artificial, as the learning laboratory.

For example, one of the authors observed the following science lesson conducted by an Alaska Native student-teacher with a group of six students in Grades 3-7. The student-teacher asked the children to design an experiment. The children decided they wanted to know what type of substance would work best to remove hair from caribou hides. They came up with a variety of solutions to test, including laundry soap and caribou brains (one student remembered that she had seen someone use caribou brains in preparing hides). One student's father, who was watching the lesson, walked out to his shed and brought back the head of a caribou he had recently killed. He sawed it open so the children could extract the brain. The teacher and a village elder present assisted the children in gathering the materials they needed for the experiment but they did not give the children any suggestions about how to carry out the experiment. The children soaked the caribou hide in plain water, in water with laundry soap, and in water with caribou brains. They soaked the hides for 24 h. Then they tried to scrape the hair off the hides using a traditional knife. The teacher and the elder (a grandmother with much experience in preparing caribou hides) continued to watch without giving advise. The hair did not come off the hides. Finally, the children spontaneously asked the grandmother what they could do differently. The grandmother than explained that when she prepares caribou hides she soaks them in the river for many days. She also told them that the brain is used for tanning the hides, not removing fur.

In this lesson, the children combined knowledge from their own culture with experimental techniques they learned from the Western culture. They naturally pursued a hands-on discovery experience. The adults (including a variety of extended family members) provided a nonjudgmental facilitative learning environment that allowed the children the freedom to learn on their own by experimentation. The children pursued ideas from their peers until they have exhausted their options, at which point they sought the wisdom of the experience of their elders.

This is but one example of ways in which indigenous culture can be incorporated into a science class. Ecological themes can provide another natural way to combine the rich Yupiaq heritage with Western knowledge. Oral legends about the land or the animals, as told by the elders, can be included in the lessons. These legends often include morals about the importance of conservation, including respect for the land and for wildlife. Incorporating elders into the life of schools helps to restore in children respect for these rare, valuable human resources. Naturalistic observations, so much a part of the Yupiaq way of life, are also an important part of what ecological researchers do. Children can develop their observational skills with the modeling and assistance of local community members, while also learning the quantitative techniques so highly valued in Western scientific traditions.

The spiritual or mystical element of Yupiaq understanding can manifest itself throughout the curriculum not as religious instruction, but as such things as reverence for the natural world, acknowledgement of humanity's dependence on and responsibility to our ecosystem, and appreciation of the mysteries of the universe. Learning to respect the spirit of the river that flows by the village is infinitely more relevant to the life of the child in rural Alaska than drawing a picture of an atom that appears in the textbook. It may also be a more precise metaphor. The fine arts can be incorporated into the science lesson in a variety of ways: for example, through the use of traditional dance (such as dances related to certain hunting or fishing traditions) and through artwork (such as carvings that depict wildlife or dance masks that represent spirits of animals).

What emerges from incorporating indigenous worldview, knowledge, and culture into Alaskan schools is a curriculum which can integrate the natural sciences with social sciences, language arts, fine arts, and mathematics in a way which the learner can recognize as having legitimate meaning in daily life.

A classroom reflecting Yupiaq culture looks and feels much like the village outside the classroom door. Groups of individuals of various ages, from young children to the elders of the community, are engaged in hands-on activities, working together to complete meaningful tasks or to solve concrete, multifaceted problems relevant o their daily lives. The natural environmental setting is a common tool for learning. Both Yupiaq and English are spoken, as each has its own contribution to the learning; and as Kawagley (1995) stated, "We should make use of the Yupiaq language because it is a tool of the spirit and therefore the voice of the culture" (p. 116). Everyone has an opportunity to express opinions if they wish, and decisions are arrived at by consensus.

In the Yup'ik village and in the classroom that might reflect it, assessments are authentic. In the village, one's skill as a hunter is based on factors such as the number of caribou harvested in a day, not the accuracy with which one shoots at paper bull's eyes; assessing a student's understanding of basic hydrodynamics might be based on the student's examination of the river to predict the best channel for a loaded skiff, not the student's responses on a multiple choice test. Evaluations are prescriptive and ongoing; rather than, "You received a C- on your hydrodynamics project." a teacher might say, "You nicked your propeller a little when you tried that channel. Look at the way the river comes off that cut-bank and try to figure out where the least amount of gravel got deposited." If a student does not yet grasp a particular skill, the student might be given further modeling of the skill and then be given another opportunity to attempt it on his or her own. The student continues practicing and further modeling is provided until the skill is mastered.

Where feasible, the elders are actively involved in telling the stories and demonstrating the crafts and practices of the Yupiaq heritage. Teachers and community members work together to assist students in strengthening their identification with their own culture while simultaneously learning to use the tools and knowledge of Western science as a force that can help them maintain self-reliance and self-sufficiency.

Pedagogy that thus draws from indigenous knowledge, worldview, and culture can provide students with not only a locally relevant science education, but also in many ways with the kind of learning environment and experiences recommended for students everywhere.

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