

An Astronomy Outreach Program

A fascinating science, astronomy is also a means to reach across cultural borders.

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One thing that most if not all astronomers and educators agree on is that a good science education is important for everyone. Science is too much a part of our lives today for society to afford an ignorant citizenry. Science educators and organizations like the Astronomical Society of the Pacific have been working hard to give children an understanding of science, but in recent years scientists have come to realize that they, too, can play a useful part in the K-12 classroom. Astronomers have an advantage in this regard because the night sky elicits a natural interest in astronomy for most kids and adults.

One group that is striving to improve the education of their children is Native Americans, and they have a hard road ahead. According to a 1990 *Time* magazine article, Native Americans in general—they specify Navajo in particular—have one of the nation's highest rates of illiteracy and high school delinquency; approximately one-quarter of Navajo teenagers are not in school. In addition, Native Americans have been nearly absent from the physical sciences. In the field of professional astronomy, for example, 0.1% are Native Americans (1990 survey by the American Astronomical Society). Furthermore, among the Navajo and Hopi schools in northern Arizona and New Mexico, very few science teachers are themselves Native Americans, resulting in a lack of science role models for students. When asked to describe an astronomer before ever seeing one, most eighth-grade Navajo students' descriptions were of middle-aged, white males with foreign accents. This picture is not conducive to having the students think of astronomy or science as a career for themselves.

Located in northern Arizona adjacent to the Navajo and Hopi nations, Lowell Observatory is optimally situated to share the excitement of astronomy with several Native American peoples and to contribute to enhancing science education in their schools. Although nearby,

the distances involved are still quite large. The Navajo and Hopi nations cover vast areas, with very low population densities. The Navajo nation occupies almost the entire northeastern corner of Arizona, plus parts of Utah and New Mexico—a little over 63,000 square kilometers, or the size of West Virginia. The smaller Hopi nation is embedded within the Navajo nation, occupying approximately 10,000 square kilometers, or an area slightly larger than Delaware. Driving time from Lowell Observatory to Shiprock, New Mexico, is about five hours one-way, and this on well-maintained roads. Travel to more remote areas can require more travel time. The towns that are close to

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larger cities can more easily interact with the non-reservation community, but there aren't many of these towns. Those towns that are more remote generally have less interaction with the larger community.

In the summer of 1996, we initiated an astronomy outreach program, which is now in its third year. The goal of the program is to help teachers get Navajo and Hopi students excited about astronomy in particular and science and education in general. Our program began with larger communities (mainly to make it easier for us to get started), but our aim is to also work with those remote places that normally do not receive many visitors.

The Outreach Program

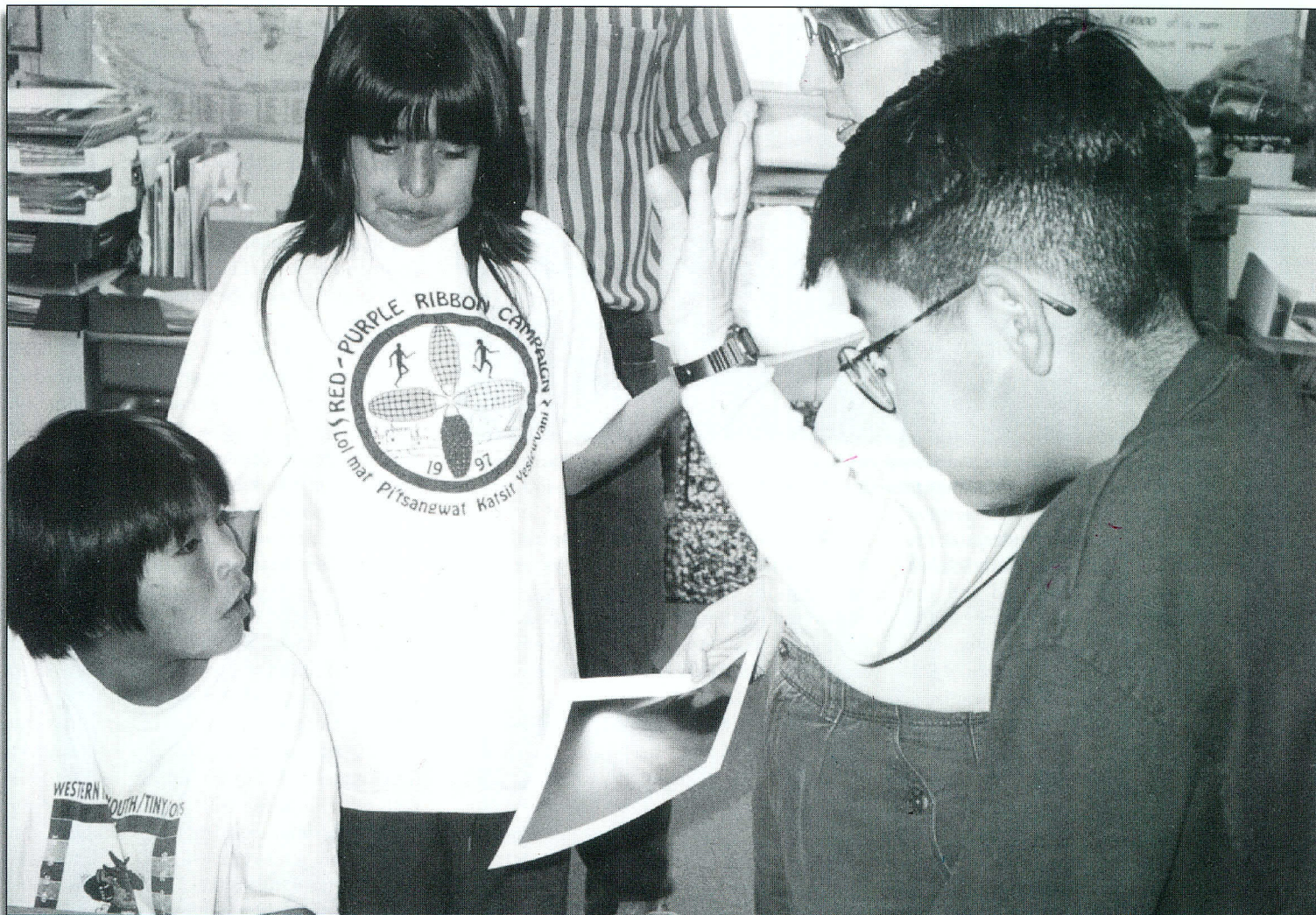
Our program is modeled after the ASP's ASTRO program, pairing astronomers and teachers (see “Matches Made in the Heavens,” Sept/Oct 1994, p. 24). Each of us works with one teacher at a different school, a different teacher at a different school each year. Throughout the year we make numerous visits to our chosen classes and perform hands-on

astronomy activities with the class. At least once per year we hold a nighttime star party, inviting parents, family, and community members. The participation of parents in the education process of their children is important to the success of that process, and star parties are an excellent way to foster this involvement.

We attempt to address the problem of limited reach (we usually interact directly with only twenty to thirty students per year) by incorporating a “teacher-training” aspect to our program. Because they are full partners in the classroom activities, teachers learn about the activities so that they can do the exercises with their other classes. We supply the materials for the activities and discussion, including color pictures, notes, gas discharge tubes, etc., and we leave the supplies with the teacher at the end of the day. In this way, the experiment or demonstration can be repeated with other classes during other years. We also offer to meet with the other teachers in the school who are interested and show them the activities as well. The specific teacher that we are working with acts as a resource person for the other teachers. By working with the teachers, we expand the impact of our program beyond the classrooms with which we meet directly.

For the classroom activities we often draw on the wealth of ideas compiled by other people, with modifications based on our own experiences. In particular, we heavily use the “Universe at Your Fingertips,” a large compendium of activities put together by the ASP's ASTRO project. In addition, there are useful astronomy activities offered by, for example, “GEMS: Great Explorations in Math & Science” (California, Berkeley), the Optical Society of America, “Project SPICA: A Teacher Resource to Enhance Astronomy Education,” and “Ranger Rick's NatureScope Astronomy Adventures” (National Wildlife Federation). As schools and classrooms gain access to the Internet (as many expect to do within one to two years), we will be able to draw directly on science materials available on-line, such as the wonderful NASA pictures. In addition, we try to pull material from our own research and that of our colleagues at Lowell Observatory into the activities. For example, when we do

for Navajo and Hopi Schools



Hunter shows a picture of comet Hale-Bopp to students in Linda Doering's fifth grade class at Second Mesa Day School (Hopi Nation) in January 1998. The comet image was taken by David Schleicher, astronomer at Lowell Observatory. Photo courtesy of Linda Doering.

activities on comets, we show pictures of Hyakutake and Hale-Bopp obtained for research purposes by Lowell staff. The connection with an active research observatory adds an air of excitement—the pictures we show may have been obtained just a few nights before and the students may be among the first to view them.

In the second year we added a new component to the program: bringing the classes to Lowell Observatory to spend the night at two of our research telescopes. The Perkins 1.8 meter and the Hall 1.1 meter telescopes sit side by side on Anderson Mesa, a dark site southeast of Flagstaff. We reserved nights on both of these telescopes with a near-infrared camera

on the 1.8 meter and an optical CCD camera on the 1.1 meter. We also set up two small portable telescopes in the compound and had

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another person showing constellations. The students rotated from one station to another, in small groups. At the two large telescopes

they observed galaxies, studying their morphology, and each group observed the same galaxies in the near-infrared and in the optical.

This program is focused on fifth through eighth grade classes. We chose to work with a narrow grade range for two reasons. First, we wish to work with students at a single rough conceptual development level. According to an article by J. Bishop (see “Astronomy Learning and Student Thinking,” Mar/Apr 1996, p. 16), a teacher’s effectiveness is enhanced by tailoring instruction to what the children of that age are able to comprehend. By working with students in approximately the same stage of thinking, we can more easily learn how to present ideas and how to work with the students on activi-



Stansberry makes a comet out of dry ice for students in Linda Doering's fifth grade class at Second Mesa Day School (Hopi Nation) in January 1998. Photo courtesy of Linda Doering.

ties. Second, we want to reach students at the transition period between the young child's inherent curiosity about the world and the fixed negative attitude towards science often seen in high school students. S. Shuler, in a 1996 article in the *Association of Women in Science Magazine*, made a plea for more emphasis on middle school science education. She explains that during this stage science performance for girls and minorities changes drastically, and it is at this stage that one can have the most impact on their career options and attitudes toward science.

We are astronomers, not educators, and none of us has any formal educational training. So, we are learning as we go along what we need to know to make the program as effective as possible. In the summer of 1996 when we were shaping the plan for this program, we spoke with educators and administrators to get their suggestions. In the first two years we worked with teachers who have more astronomy background than may be typical, so we could concentrate more on learning from them how best to participate in the classroom. These teachers have been very helpful in shaping the program. The teachers with whom we are working joined us to attend the 1997 and 1998 ASTRO workshops in Tucson, which helped us prepare for the school year.

Of course, we are also learning from the students themselves. Hunter and her teacher last year, Linda Doering, did an activity with Hopi fifth graders based on making the Earth

and Moon system out of modeling clay. This requires that each group roll fifty equal-sized balls from the clay, an activity that took much longer than expected. Hunter was roaming from group to group, as she thought appropriate, when one student said, "Why aren't you helping us?" Hunter looked around and realized that Doering was helping each group in turn by rolling balls herself. It just hadn't occurred to Hunter to participate in that way.

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Being Aware of Cultural Differences

Going to a reservation to do an outreach program is different in many ways from going to your child's school, or even a school in your own neighborhood. We are entering a culture that is unfamiliar to us, and therefore we take the same care as when we visit a foreign country.

One of our initial concerns was whether or not the tribes would welcome this program. Both the Navajo and Hopi nations are keenly interested in improving their education in general and science education in particular. However, imposed educational techniques

have not always been so positive for Native Americans in the past. A century ago Navajo and Hopi children were forcibly taken from their families, held in boarding schools many kilometers from home, and forbidden to speak their language or practice their own culture. Because we wanted our program to be something that the tribes saw as a positive and desirable contribution to their schools, we solicited the opinions and help of tribal members early on rather than developing the program ourselves without this benefit. Therefore, when we were in the planning stages of the program, we wrote to the tribal education departments explaining our ideas for this program and seeking their input. This led in turn to discussions with the Hopi Education Director and a Navajo cultural education faculty member at the Navajo Community College. During these meetings, we presented our ideas and received from them suggestions on improvements, along with a great deal of encouraging enthusiasm.

Differences in culture can lead to a tremendous learning experience for everyone involved, but such interactions must be approached with sensitivity and an open mind. We recognized from the beginning that for our program to be most effective we would need to deal with cultural and background differences between the students and ourselves. We talked with numerous helpful people who opened our eyes to new ways of looking at things and of thinking, and through them we developed a list of issues and concerns to address. We found that input from the tribe, learning styles, language barriers, cultural connections, and taboos were issues that we had to be aware of and plan for. Usually they did not turn out to be major issues, but a little thought and sensitivity ahead of time can keep them from turning into such. Another complication comes from the fact that there are significant cultural and language differences not only between the Navajo and Hopi but also within each tribe. The Hopi at Second Mesa, for example, have somewhat different traditions and dialect from those at First Mesa, about thirty kilometers away. Thus, what we learn for one group is not necessarily applicable to another.

In 1995 the American Indian Science and Engineering Society, with funding from the National Science Foundation, produced a report whose conclusion was that science educators need to use techniques appropriate to Native Americans' learning styles. Differences in learning styles arise because of cultural differences and the way in which children are taught at home. Not all Native American cul-

tures are alike, of course, and what works well for one may not work well for another group or individual. Furthermore, many of the principles of good teaching work with most any cultural group, an example being the desirability of hands-on activities over book-learning

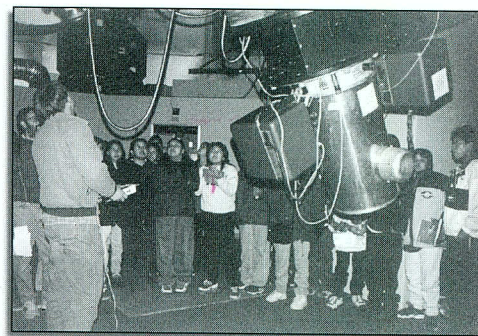
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alone. But the educator H. Gilliland in a 1995 book on teaching Native American students emphasizes that Native American children tend to be more visual learners. In fact, the English translation of the Navajo word *bínabinéltáá'*

implies both showing (demonstrating) and teaching through showing. Thus, in our classroom activities we try to emphasize visual aspects such as drawing and describing what students see.

Gilliland also suggests that many Native American students learn best when they work in cooperative groups rather than through individual competition, and we have found that our teachers organize their classrooms this way by arranging desks in small groups rather than the traditional rows that emphasize the individual. This sense of cooperation does not mean that one student won't sabotage another group's experiment by filling their pan of flour with a handful of little rocks, as we discovered during one activity. But it does mean that overall this is a more receptive environment in which to carry out our classroom activities.

For some of our students English is a second language. According to Linda Doering, in her fifth grade class roughly one-third can speak the Hopi language, one-third can understand it, and one-third do not know it at all. At this point we have not encountered a class where language is itself a barrier, but Gilliland points out that Native American students for whom

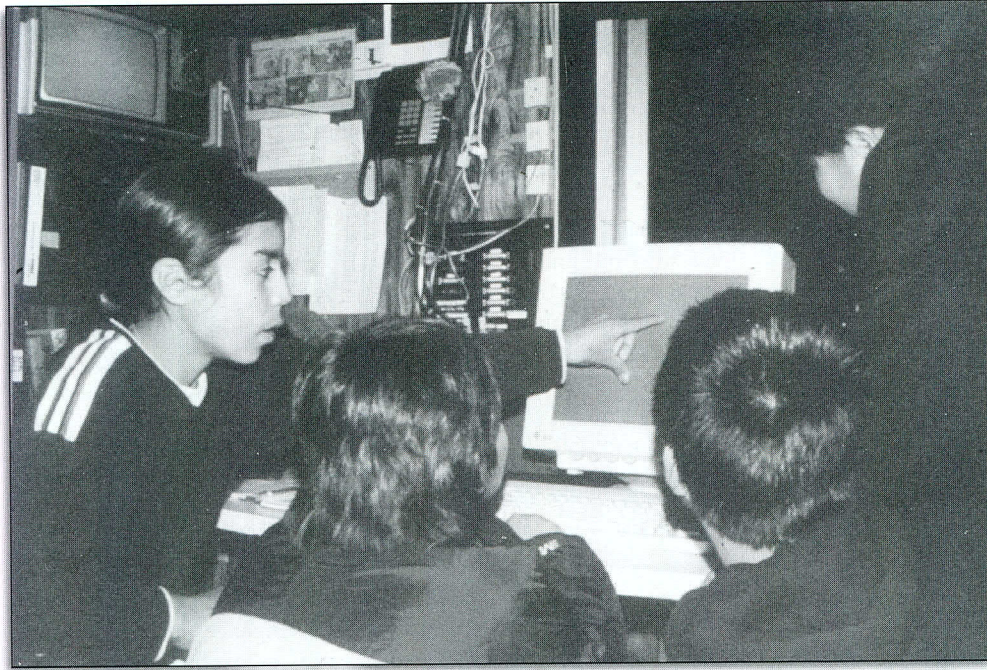


Stansberry introduces students from David Schindelman's seventh grade class at Chinle Middle School (Navajo Nation) to the Perkins 1.8 meter telescope at Anderson Mesa in April 1998. The instrument is a near-infrared camera built by OSU that the students used to study the morphology of galaxies. Photo courtesy of Lowell Observatory.

English is a second language may not know the nuances of the language such as multiple meanings of words, even if they appear to speak English well. Thus, we are exploring involving a translator in our classroom visits, and this may become more necessary when we work with more remote schools. The issue of language differences also means being more aware than



Students in Linda Doering's fifth grade class at Second Mesa Day School (Hopi Nation) pose with their model of a comet that is very close to the Sun (long tail, large coma). The nucleus—a peanut at the center—is buried in the coma—cotton balls. Photo courtesy of Linda Doering.



Seventh graders from David Schindelman's class at Chinle Middle School (Navajo Nation) look at galaxy images they have just taken with the Perkins 1.8 meter telescope at Anderson Mesa in April 1998. Photo courtesy of Lowell Observatory.

usual of our non-verbal communication and what our gestures, tone of voice, and pattern of eye contact are conveying to the students.

To help us deal with the language issue, we visited a Flagstaff classroom with a large proportion of English-as-a-Second-Language (ESL) students. The teacher suggested emphasizing visual techniques, writing short notes on the board as one speaks, and avoiding terminology. With the latter advice in mind, Hunter

decided to stick to the basic Moon phases (new, full, first quarter, last quarter) in one classroom activity. As she and the students were moving their styrofoam balls around their heads to simulate Moon phases, she didn't quite move far enough before asking the students what the phase was. One student promptly exclaimed, "A waning gibbous Moon." Lesson? Just because there are potential language issues, don't underestimate your students.

Another suggestion for ESL students was to not call on students because they might not be able to articulate the answer. But, again, our experience so far is different. Although eighth graders are more reticent, as eighth graders generally are, in the fifth-grade classes just

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about everyone volunteers all the time to answer regardless of whether or not they know the answer. The only problem came after an activity when students were asked to sum up what they had learned—then there was dead silence. However, that may have had nothing to do with languages.

Numerous educators have expressed the need to make cultural connections in order to make the learning activity more potent to the student. After all, the Native Americans have been studying the skies for millennia, and they have a rich heritage of knowledge and stories. We ourselves do not know most of this traditional knowledge, but even if we did, it is not our place to teach it. What we can do is make collaborations with those who can. For example, at one star party in Shiprock, we arranged for two people to attend who could instruct the

Stars in Navajo and Hopi Traditional Knowledge

The Hopi and Navajo have a long and rich history of astronomical observations. Hopi tradition emphasizes the Sun (*daawa*), which is crucial to life, as well as the Moon (*muuyaw*). The daily, monthly, and yearly cycles of the Sun and Moon serve as a calendar to remind people when to carry out the various activities that punctuate the day and year, and the new year begins at the winter solstice (*daawa gii awgbidu*). In addition to the Sun, each star (*soohu*) in the sky has a special duty to perform. The Milky Way (*soongwuga*) is the gathering place of the stars, and a shooting star or meteor (*soohubosdoga*) is seen as a star that has fulfilled its purpose and fades away. One fallen star or meteorite (*soobosvu*) created Meteor Crater (*Yuvugbu*) in Arizona.

Navajo tradition emphasizes the nighttime sky and the rules to live by that one can find there. The many named constellations and stars, as well as the Milky Way (*Yikaisdahi*), are said to have been carefully placed in the sky by Black God, while the countless

unnamed stars are the result of Coyote (*Ma'ii*), the trickster, grabbing Black God's bag of stars and blowing the contents across the sky. The carefully placed stars create patterns to guide humans, while the stars scattered by Coyote represent the less orderly and unpredictable aspects of life. Two major constellations are Revolving Male (*Náhookos biká'ii*) and Revolving Female (*Náhookos ba'áadii*), which are composed of the Big Dipper and part of Cassiopeia and which revolve around the North Star. These constellations represent a married couple that circle the fire in the center of their hogan, a traditional home built with the doorway facing east.

We wish to thank Radford Quamahongnewa for sharing materials from the Native Science Connections Project with us. Additional material was taken from *Book of the Hopi* by Frank Waters and *Living the Sky: The Cosmos of the American Indian* by Ray A. Williamson.

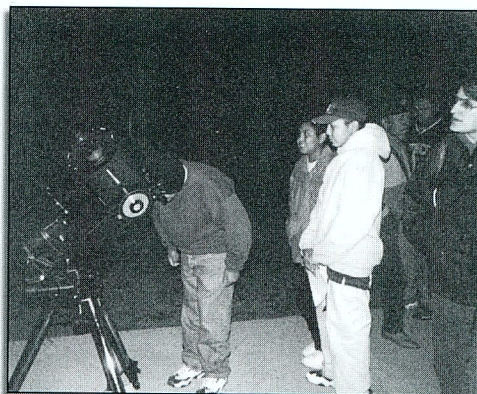


Eighth graders from David Schindelman's class at Chinle Middle School (Navajo Nation) look at an optical image of a galaxy that they have just taken with the Hall I.1 meter telescope at Lowell Observatory in May 1998. Photo courtesy of Lowell Observatory.

students about the Navajo constellations while we showed them objects through our portable telescope. When rain drove us inside to the library, our guests gave us a lecture on the Navajo constellations and their associated stories. In another situation, the teacher played a taped story about a frog and the Moon while we rolled balls out of clay. Now we invite the students to teach us about traditional knowledge by having them talk with their parents and/or grandparents to learn sky stories, then teach them to us in class. In this way they will make the cultural connections themselves.

Another area of concern is taboos. For example, there are Navajo and Hopi taboos against looking at the Moon and other astronomical objects, potentially making star parties rather difficult. A star party is okay with advance warning that allows for certain rituals before-hand if desired, or by eliminating the Moon as an object to observe. We have learned, too, that there are restrictions on when we can hold star parties.

For the Hopi, December is a time to be indoors to listen to the traditional stories, and so it is a bad month to hold a star party. For the Navajo, traditional stories can't be told after the first thunder in the spring, but a modern star party is acceptable. Not surprisingly, in the desert southwest it is bad manners to speak ill of clouds which could potentially bring much-needed rain. We must, therefore, check our natural astronomer's inclination to lament



Eighth graders from David Schindelman's class at Chinle Middle School (Navajo Nation) visually examine objects through our portable 8 inch Meade telescope during their visit to Anderson Mesa telescopes in May 1998. Photo courtesy of Lowell Observatory.

clouds on nights when star parties are scheduled. We learned this one the hard way—after making several remarks about how we hoped the clouds would go away so we could hold our star party that night, the teacher told us to stop because the traditional stories say that the ancestors ascend to the clouds after death. In effect, we were telling their ancestors to leave. Not a very polite thing for a guest to do.

The Future of the Program

Our outreach program is modest and one of several operating in Navajo and Hopi schools

(others that we know of are run through Northern Arizona University and NASA's Jet Propulsion Laboratory). However, the response of the students and teachers to our visits convinces us that our efforts are worthwhile. After one classroom visit about the formation of impact craters, one Navajo eighth grader wrote, "...who would of thought of how to explain craters to a bunch of kids out on the reservation that may of not herd [sic] of different star names and never herd [sic] of different moon names." Another eighth grader wrote, "I really enjoyed having Dr. Hunter and Dr. Bosh come to our class and teach us a lot about astronomy and how much fun it looks like to be an astronomer." Many students referred to the activities as "cool."

We are grateful to Lowell Observatory and to NASA's IDEAS grant program for the funding that enabled us to get this program going. We have funding from AlliedSignal enabling the program to continue through the 1998-1999 school year and partial funding for the 1999-2000 school year, and we hope that the program can be sustained indefinitely. We know that we have a lot yet to learn and that the more we learn, the more effective the program will become. The important point is for us to recognize that science education is not separate from other aspects of the students' lives and to be aware of the consequences of cultural differences. We have to remember that this program is really an information exchange. We tell them about astronomy and science; they teach us about their culture. An enriching experience for all involved, hopefully. Certainly it is for us. **mt**

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