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Using Multicultural Dimensions to Teach Astronomy

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What is Multicultural Astronomy?

We define multicultural astronomy as the variety of ways in which cultures of the past and present have observed, recorded, interpreted and made use of astronomy to structure their lives and or satisfy their curiosity about the universe. Based on different motivations, values, traditions and geographical locations (including latitude), students can come to understand that different cultures will interpret and use the same phenomenon in different ways. Multicultural astronomy may be manifested in written documents, oral traditions, and physical artifacts such as aligned buildings, stones or other markings. The study of such physical artifacts with astronomical connections is called "archeoastronomy". The examples covered in this newsletter will focus on observations that your students can duplicate either in the real sky or with planetarium software to help them understand how and why the sky looks different from different places on Earth. Then they will explore how these same observations have been incorporated by different people into their cultures.

> See Newsletter #31 for a discussion of the use of archeoastronomy in the curriculum. Examples of oral traditions and suggestions for how to incorporate them in your astronomy curriculum can be found in Newsletter #42, (1998) entitled: The Story of Astronomy.

Why Include Multicultural Astronomy in Your Curriculum?

To introduce students to the differences and similarities between diverse cultures' interpretations of astronomical phenomena.

Using multicultural dimensions to teach astronomy can go beyond just showcasing the differences among various cultures' interpretations and representations of the universe, its objects and events. While such differences are often based on religion, they are not trivial or primitive, but have been central to the organization of many cultures' economic and religious activities. The cyclical nature of our universe has produced observable celestial events, such as Moon phases, eclipses, day/night cycles, and seasons, which are observed by people all over the world. Over the years, people of all cultures have observed astronomical events, recorded them, analyzed and classified them as predictable and unpredictable, and they have passed this knowledge on to their successors. An approach to multicultural astronomy education should not only focus on differences between cultures, but should include a discussion of similarities. These ideas can give students insight into the important historical role astronomy has played in helping people to organize their lives and in supporting our understanding of the environment. This insight will also help students to recognize and reflect on the relevance that astronomy has had in their own lives. Moreover, students of various cultural backgrounds will be able to contribute to discussions in astronomy by sharing and reflecting on how the development of their own cultural traditions in setting their calendars, for instance, was influenced by their ancestors' observations of the sky.

To demonstrate the activities involved in the science of astronomy and provide models of people engaging in the practice of astronomy

No matter what reasons different people may have had for carrying out their observations of the universe, their actions have given rise to the science of astronomy. It is a science quite different from the experimental science that students usually encounter in our schools which is associated with the traditional scientific method. The science of astronomy focuses on observation and it may appeal to those students who have become disinterested in some aspects of experimental school science. Multicultural astronomy provides students with examples of how people of the past and present practiced the science of astronomy by: making observations; keeping detailed records of observations; interpreting observations; transmitting these observations to others and using them for practical purposes. Such examples can serve as models for students to carry out their own astronomy investigations.

To have students visualize the appearance of astronomical phenomena from different perspectives.

Since the appearance of the sky is dependent on the observer's position on Earth, many of the differences between various cultures' representations of the sky can be attributed to these differing perspectives. The study of these various perspectives can provide a context for students to engage in abstract visualizations that can help support their understanding of some basic astronomy concepts such as: the cause of seasons and Moon phases; the position and motion of constellations and the changing position of the Sun during the day and year. Moreover, this multi-perspective approach to studying astronomy concepts provides an alternative way for dealing with those conceptually difficult topics as students will be required to apply their understanding across a variety of different contexts. Research in the study of conceptual change in science education suggests that having students apply new knowledge across a variety of contexts contributes to conceptual change process and can be a useful way of remediating misconceptions. Getting students to visualize the sky from different frames of reference as they are learning astronomy concepts is particularly challenging because it requires some agility with spatial thinking and a deep understanding of the concept. A multicultural approach supports this type of learning.

To engage students to think critically about how our understanding of astronomy has evolved over the years.

By providing students with examples of people engaging in the science of astronomy, all over the world, and at different times in history, provides a context for learning. Instead of just transmitting facts about how the universe works, stories and artifacts that provide evidence of how others have studied the universe can help to ground this knowledge and promote a critical approach to learning astronomy. A critical approach may involve investigating the evolution of astronomical thinking. How have observations of the same phenomenon been interpreted by different people, in different places over time? How has our understanding of astronomy evolved as a result of technology? These are only a few broad questions that multicultural astronomy can address.

Using the Rising and Setting of Constellations to Determine Seasons

Students need to understand that based on their different values, traditions, needs and positions on Earth (latitude), different cultures will have different ways of interpreting and using the same astronomical phenomena. For example, since the Earth revolves around the Sun, different constellations are visible in the night sky during the year. The conspicuous appearance of the Pleiades at certain times of the year, has led to its associations with seasonal change. Many cultures organized agricultural activities around the appearance of this star cluster. For the Onondaga Indians of upstate New York, the Pleiades signal when it is safe to grow food. The Pleiades reach their highest point in the early evening sky by mid February. This is the prime of winter and food is scarce for these people. They watch this group of stars carefully and wait for them to signal when it is time to plant seeds again. This time is signaled by the gradual disappearance of the star cluster in the evenings as it sets in the west in the months following February.

The Pleiades are the basis of the calendar for the Barsana Indians of Colombia. Instead of bringing cold dry weather, the appearance of the Pleiades signals the beginning of their rainy season. However, like the Onondaga Indians, this is also a time of scarcity of food. At this latitude, the Pleiades highest point, observed in the early evening, also occurs during January and February; this signals the beginning of the planting season and summer. By April, the Pleiades move west and gradually become less apparent in the evenings. This time marks the rainy season where food supplies become depleted.

At far northern latitudes, the Pleiades never set, so it cannot be used for calendar-keeping in the same way it can be in the temperate and tropical climate zones. It may be interesting to see if students can predict and explain which months or seasons are associated with the Pleiades, across different countries around the world. Here are several concepts that a discussion of the Pleiades might cover: the appearance of stars in different parts of the sky throughout the year; the apparent path of the Sun throughout the year, which in turn could form the basis for discussing the seasons); and the reversal of the seasonal cycle of between the northern and southern hemispheres.

The elaborate structure of the early Egyptian society was based on the ability to predict when the annual rising or flooding of the Nile would occur since this event left much of their land in the valley covered with water. This was followed by periods of planting, growth and harvesting. Records dating from the 3rd millennium BC have shown that the Egyptian calendar was divided into three seasons that reflected the structure of their society- flooding, planting, and the harvest. While each of these seasons were roughly four lunar months in length, with each lunar month being approximately twenty-nine and a half days, this posed a problem for predicting precisely when the Nile would flood. This year of twelve lunar months would fall short of the average rising of the river from one year to the next and fell eleven days short of a solar year (the time it takes for the Earth to make one complete revolution around the Sun). To solve this problem, the Egyptians used the helical rising of the star Sirius to help in the prediction of the river flooding. A helical rising is the period of time when the star is briefly seen in the eastern sky before dawn and is no longer hidden from the glare of the Sun. The Egyptians gradually realized that, in this 12 lunar-month year, the rising of Sirius varied from year to year by 11 days. Whenever it rose late in the 12th month an extra month was added to ensure that it would rise again in the twelfth month in the following year. This rather arbitrary system of calendar keeping did not suit the needs of this highly organized society! Eventually this problem gave rise to the 365 day calendar.

Just as the appearance of the Pleiades and Sirius at a certain time of night has been correlated with the seasons, the orientation of a constellation such as the Big or Little Dipper at certain times of the night, has also been correlated with seasonal change.

Students can verify some of these observations using star charts, planispheres, celestial globes, planetarium software, or by visiting a real planetarium. Planetarium programs which allow students to observe pictures of the night sky from any place on Earth, can be particularly useful in facilitating the visualization and investigation of these patterns while studying multicultural astronomy.

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Activity 1: 'Different' Skies at Different Latitudes

Purpose: To introduce student to the idea that the sky appears different to observers at different latitudes.

Materials:

- charts of stars in the sky, at the same date and time, but at different latitudes; these can be obtained from planetarium software
- Celestial globe (optional)

Procedure:

1. Compare pictures of the sky at the same times but at different latitudes, and record:

- the latitude on Earth from which the sky was observed
- the time of observation
- the direction in which the observation was made
- observations in the form of diagrams or notes

(All of these should be specified by the planetarium software)

2. Have students make a chart to list similarities and differences between the observations.

3. Mark the positions from which these pictures would have been taken on the celestial globe and give students the opportunity to account for differences or similarities observed.

Note: A trip to a real planetarium could be useful in helping students to compare their own observations of objects in the sky to those represented in the celestial globe or simulations.

Observing the Changing Position of the Sun To Establish Cardinal Directions

There is evidence to suggest that early people made careful observations of the rising and setting of the Sun and were able to recognize that the Sun didn't just rise and set anywhere. Observations of the Sun's apparent movement across the sky and its pattern of rising and setting in the east and west horizon helped to establish the cardinal directions.

For the Hopi of Arizona, the cardinal directions were not like our north/south/east/west, but related the directions to the points on the skyline where the Sun rises and sets at the solstices. These positions are roughly north-east, south-east, north-west, and south-west. The beginning of the Hopi winter was determined by the Sun Chief and the Soyal Chief (soyal means the solstice ceremony). Anthropological records of the Hopi Horizon calendar show the Sun priest's observations for the purpose of timing the midwinter ceremonies. In these diagrams, changing position of the Sun is drawn with respect to its position between two peaks in the San Francisco mountains. For instance, the Sun setting in the notch between two particular San Francisco mountain peaks, near Flagstaff Arizona, was the signal to begin, in four days, the nine day celebration of the winter solstice.

Activity 2: Observing the Sun

Purpose: To give students the opportunity to observe the changing position of the Sun and understand how observations of these patterns helped to establish cardinal directions.

Materials

- newspapers or almanacs as guides for Sunrise or Sunset times
- observation area
- chart for recording observations of Sunrise and Sunset time
- a series of landscape drawings (one set of the eastern landscape and one of the western landscape)

Procedure

1. Review safety procedures for observing the Sun- **DO NOT LOOK DIRECTLY AT THE SUN OR OBSERVE ALONE IN AN ISOLATED OR OTHERWISE UNSAFE LOCATION!**
2. Go over observation tips:

- observe a landmark in the distance to avoid the effects of parallax
- keep the same position for observations
- use the same landmark for observations
- have them define what "Sunset" will be and what "Sunrise" will be (e.g., Sunrise is the time that the centre of the Sun's disk is on the horizon and Sunset is when the centre of the Sun's disk first touches down on the horizon)
- Note: Many students will have access to observing less than perfect horizons, find the best you can.

3. Have students make several pairs of landscape diagrams that indicate their landmarks (one eastern and one western)
4. Label north and south on landscape diagrams
5. Allow students to observe the rising and setting of the Sun over several weeks or months, if possible.
6. Answer the following questions:
    - Did the position of the Sunrise or Sunset change? How?
    - Did the time of the Sunset change? How?

Note: If observations occur in the early fall expect earlier Sunsets, and later Sunrises, and southward shifts. If observing past December, expect later Sunsets and earlier Sunrises and northward shifts. "Solstice" means "standing still" and students should expect very little change in the weeks prior to and after the solstices (Dec. 21 and June 21). Around Equinoxes (Sept. 22 and March 22) Sunset time and position changes are dramatic.

Observing the Changing Position of the Sun To Establish a Seasonal Calendar

Among those groups of people on Earth, whose means of survival is solely dependent on hunting and fishing are the Inuit. For them, the Sun does not rise for some period of time. The cycle of the Sun and the Moon are of great importance in determining the festivities and subsistence of this culture. At the far northern latitude of Igloolik which is 69 í 22'N, the Sun falls below the horizon on the 29th of November and is not seen again until the 14th of January. It is constantly above the horizon for the sixty-six days between the 19th of May and the 24th of July. It was important for the Igloolik, which is one of the Inuit cultures, to track the altitude of the Sun to determine how long it was before the dark days of winter were upon them. For instance, even though the Sun would be above the horizon every day for 24 hours, it's highest position in the sky would become progressively lower and lower as winter approached. The time of the Sun's return after the dark days of winter signaled a renewal of food and festivities for the Igloolik. The Igloolik had very interesting means of observing the Sun's return and measuring the Sun's altitude and they identified three different stages, each signifying something of importance to the Igloolik culture. The first stage of the Sun's return was observed when a harpoon shaft held horizontally at arms length at noon would fit between the horizon and the lower rim of the Sun's disk. This indicated that the Sun was barely back on its return. The second stage was observed when you extended your arm and the thumb of your mitted hand would fill the gap between the Sun and the horizon. This stage signaled the start of seal hunting. The final stage of the Sun's return was marked by the observation that the Sun had reached its highest altitude when the full width of your mitted hand could fill the gap between the Sun and the horizon. This observation marked the end of the winter and the time when the chances for catching marine animals would be better (MacDonald, 1998)

This description of how a simple means for measuring the Sun's altitude was used by the Igloolik to determine their seasonal changes and hunting periods, could help to illustrate to students that the they do not necessarily need complex or high-tech instruments to make simple informative observations of the sky or to track the changing position of celestial objects. The method illustrated below has been known to be quite "handy" for estimating the angle of sky object above the horizon.

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Activity 3: Measuring the Position of the Sun in the Sky

Purpose: To give students the opportunity to measure the position of the Sun in the sky using simple tools and methods.

Note: For safety reasons you may choose to use this exercise to have students measure the position of the Moon in the sky.

Materials: a hand (preferably, your own)

Procedure:

a) Read the Inuit example above to students.

b) Define horizon as the line along which the sky and land appear to meet.

c) Choose one part of the horizon to observe. Try to choose one with landmarks, to give students a common reference point.

d) Have them stretch out their arm and make a vertical fist (with the thumb on top), while looking directly at the horizon. (Their outstretched arm should be perpendicular to the horizon, and the imaginary lines, one running along their arm and one running from their neck to the top of their head, should make a 90 degree angle).

e) This discussion provides a good opportunity to review geometry terminology, since the bottom of the fist on the horizon to the top of the fist makes an angle of ten degrees.

f) Have students count how many fists they can fit between the horizon and the bottom of the Sun's disk.

When deciding when to make further observations, you should discuss the importance of keeping variables constant. For instance, the time of the day and the place from which they measure the angle and position of the Sun should be the same.

Alternatively, you may have students devise their own methods of relative measurement and apply them to measuring the position of the Sun in the sky.

Observing the Changing Position of the Sun To Establish a Seasonal Calendar in the Southern Hemisphere

The following example illustrates the reversal of the seasons in the southern hemisphere compared to the northern hemisphere. Considering that children have deep misconceptions about the Sun's motion in the sky, this story requires some discussion about how the Earth's rotation is the cause of the apparent motion of the Sun.

The New Zealand Maori display their understanding and observations of the connection between the solstices, the seasons and the position of the Sun in the sky in the following story. They say that "during the year the

Sun roams from Rangi's head to his toes and back again. Rangi is the sky, and when the Sun is near Rangi's head it is summer in New Zealand. The Maori also say that the Sun is spending time with the Hine-raumati, the Summer Maid. He leaves her in December, around the time of the Summer solstice to go and live with Hine-takurua who is the Winter Maid. The Sun enjoys the company of Hine-takura until the June solstice, when it's time for him to head back to the land. There the Summer Maid is cultivating crops and preparing the game of the forest for the summer hunt. There are two things that should be highlighted for students in this story. First, the position of the Sun changes from high to low in the summer and winter respectively. Second, children should note that the months of summer and winter in New Zealand are opposite to those of the Northern Hemisphere. In the northern hemisphere the summer months are in June to August in the southern hemisphere the summer months are December to February.

Activity 4: The Sun and the Seasons at Different Latitudes

Purpose: To understand the difference between seasons and the position of the Sun in the northern and southern hemispheres.

Procedure:

1. Read the Maori story to students.
2. If time is available, have students observe the position of the Sun in the sky over the course of the seasons. If time is limited, they may observe the changing position of the Sun on planetarium software. This would also allow them to compare position differences in different hemispheres as well.
3. Have students rewrite the Maori story to apply to the observation of the Sun and the seasons in the Northern Hemisphere.

Navigation

Halfway between the celestial poles is the celestial equator, this is a projection of the Earth's equator onto the sky. The stars on the celestial equator will rise due east and set due west. The stars that form the "belt" of Orion are an example of stars that travel this path. Early navigators learned to use the rising and setting of these stars to find their way. They were particularly important to the Pacific Islanders when they were surrounded by water, and land could not serve as a reference point. Over time, the observations and records of these star patterns provided a method for navigation that would be communicated to others.

In the northern hemisphere, the star Polaris is quite close to the direction of the North Celestial Pole - the point in the sky directly above the North Pole. Polaris is circumpolar, which means that it never rises or sets; it makes a very small circle around the North Celestial Pole. Other stars, like the Big Dipper also circle around this "pole star" but they do so in much larger circles. From more northerly latitudes, they also never set. Those stars in the sky that are circumpolar depend on one's latitude. For example, if you were standing on the North Pole, all the stars that were visible would be circumpolar and would just move horizontally, circling around the celestial pole overhead. If you are between the North Pole and the equator, the direction of the North Celestial Pole is tilted away from the point directly above you. In fact, the angle of Polaris above the horizon is approximately equal to your latitude. Having students learn to identify Polaris in the sky, hence the direction north can be a short but useful lesson in celestial navigation for them to learn.

Polaris became a symbol of freedom to slaves as well as a guide star for those who would flee north. Children were taught to identify Polaris by finding the Big Dipper. Slaves passed the travel instructions from plantation to plantation by singing the song "Follow the Drinking Gourd". In the song, The Big Dipper was the drinking gourd, which was a spoon shaped utensil with a curved handle, which the slaves would use to drink water.

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Activity 5: Decoding the Celestial Navigation Clues in the Song, Follow the Drinking Gourd.

Purpose: Discover practical uses of the sky as a historical navigational aid.

Materials:

The words to the song and a description of their meanings can be found at the following web site: http://quest.arc.nasa.gov/ltc/special/mlk/gourd2.html. Print out just the song lyrics for your students.

Optional: book or audio tape of Follow the Drinking Gourd. Several versions are in print, the one by Jeanette Winter is best for younger children (7-10 years old). The version with the same title by Bernardine Connelly and Yvonne Buchanan is better for older children (9-12 years old).

Procedure:

1. Give your students the lyrics to this folk song.
2. Have them highlight the celestial and seasonal references.
3. Have your students decode the references.
4. Read the book or use the web reference to compare their results.

Calendars

The cycling of Sun and Moon, have helped to determine the time of year for many cultures. These cycles are problematic because the length of a year is actually more than twelve lunar months and fewer than thirteen. A year that begins at the time of new Moon and a new revolution of the Earth around the Sun can never end in the same manner. This problem has plagued calendar developers for millennia. It is not surprising that different cultures have found different ways to solve this problem and have developed different calendars based on their different priorities and traditions.

Activity 6: Comparing Calendars of Different Cultures

Purpose: To introduce students to various ways in which different cultures have used the cycles of the Sun and or the Moon to establish their calendar.

Materials:

- General reference books and almanacs have calendar information from different cultures that would be useful here
- Information about a variety of different calendars for different cultures (e.g., Christian, Jewish, Muslim, Chinese, Hindu etc.)
- Or, one calendar that marks the holidays and significant days for different cultures and one that indicates dates of Moon phases, equinoxes and solstices

Procedure: Have students compare calendars for different cultures and look for similarities and differences regarding days of significance and the appearance of the Moon and the position of the Sun with respect to the time of the year.

Observing the Sky through Different Eyes and for Different Purposes

The familiar constellation patterns and names are quite arbitrary. The Big Dipper goes by other names in other countries. Other cultures adopted different star patterns. For instance, the Chinese used smaller, more detailed star patterns. As a result, their records provide more precise positional information about certain celestial events. In addition, the Chinese had two different ways of interpreting and observing celestial events. One way the Chinese used astronomy was known as lifa; it was a discipline that aimed to understand the regularities and the predictable events in the celestial system through careful, observations, measurements and records. The other approach to astronomy was known as tianwen and in this discipline the Chinese observed the sky and kept watch for unpredictable events and tried to relate the significance of such events, to the happenings in their world. What is most impressive is that the activities of the tianwen specialists can be traced back to the late second millennium BC. Their records of the observations of phenomena such as meteor showers, comets, solar eclipses, Sunspots and exploding stars, called novae and supernovae are so detailed and accurate that they are useful for modern astronomers interested in these phenomena.

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Activity 7: Observing the Sky for Different Purposes

Purpose: To investigate how different cultures have engaged in astronomical observations for both practical and interpretive purposes.

Materials

Resource materials that provide descriptions of astronomy as practiced in various cultures such as the: Chinese, Mayans, Muslims, East Indians, Pacific Islanders, Maori, Aboriginal Australians, Natives of North America, including the Inuit.

Procedure

1. Have students research astronomy as it is and was practiced by one of the groups in the list provided.
2. Have students study how astronomical observations served the people of the group they are investigating.
3. As an extension, students may investigate the people who are observing the sky in our society today and outline the purposes they have for observing the sky? How are the observations being made today similar to those made in other cultures, how are they different?

Some works to refer to when using multicultural astronomy in your classroom:

Hoskin, M. (1997). *The Cambridge Illustrated History of Astronomy.* Melbourne: Cambridge University Press.

Krupp, E. C. (1991). *Beyond the Blue Horizon. Myths and Legends of the Sun, Moon, Stars and Planets.* New York: Oxford University Press

Krupp, E. C. (1987). E*choes of the Ancient Skies. The Astronomy of Lost Civilizations.* New York: Oxford University Press.

MacDonald, J. (1998). *The Arctic Sky. Inuit Astronomy, Star Lore and Legend.* Toronto: Royal Ontario Museum

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ASP Multicultural Astronomy Resources

Here are some products from the ASP to help you find your way around the night sky. To place an order go to our web site: www.astrosociety.org/cart.

AT 117 **Native American Star Tales** For all ages. Three audiocassettes, appx. 45 mins. each CANNOT be purchased individually. Titles: The Feather Moon, Tales of the Sun & Moon, and The Star Husband, Native American sky lore related by storyteller Lynn Moroney with music in background. Set of 3 for $32.95.

KT 101 **Cycles**, set of 10 booklets
Adults and older children will love this friendly pocket-sized guide! Restore a natural awareness of the cycles of our planet, lost today by modern man's dependence on clocks and calendars. Engaging illustrations graphically reveal the motion of the Sun and stars, phases of the Moon, and the reasons for the seasons. Remedy common scientific misconceptions with these delightful, enlightening cartoons. For ages 10 and up (1995, paper, 32 pgs.) $37.95