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The Story of Astronomy

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It was dark. The night sky hung clear over the tiny city in the valley; the stars awesome in their brilliance.

A small group of men stood on the top of the hill, looking across the city and the valley to another hill on the other side, some fifteen kilometers away. There, a similar group had assembled, their lights flickering in the distance. "We're ready," said the leader of the first group, a bearded man with intense eyes. "Check your lantern."

What was happening? Was this a covert military operation? A band of thieves and robbers plotting plunder? Actually, it was a scientific experiment. The leader was the great Galileo himself, who would later be denounced for claiming that the Earth revolves around the Sun.

The experiment was simplicity itself: a lantern would be uncovered on one hill. Fifteen kilometers away, a second lantern would be uncovered, shining back to the first. Light would have thus traveled thirty kilometers, twice across the valley where the Italian city of Florence nestled. By timing how long it took the light to travel this distance, Galileo could calculate the speed of light.

He was going to catch the ghost of the universe!

Oral traditions have since time immemorial satisfied generations of children and adults with stories of wonder, fantasy, truth, and mystery. Stories are irreplaceable stimulants for the imagination and an often endless source of entertainment. One of the most intriguing aspects of the story has to do with its explanatory powers. That is, for centuries stories were created and told to explain phenomena that were otherwise inexplicable.

The story of astronomy and astronomy's evolution as a science includes countless tales originally crafted to explain the visible celestial bodies, their motions (regular and irregular), the mysteries behind their existence, and the powers they exert over us on Earth. The names of the planets--Mars, Venus, and Pluto, as examples--all originate from stories. The constellations--including Orion the hunter, followed by his faithful dogs, chasing forever the seven sisters of the Pleiades--stories all. Even the great astronomers--Galileo, Newton, and Tycho Brahe of the silver nose (having lost his in a duel), among them--have fascinating stories. Because of this incredibly rich story history that permeates the science of astronomy, it seems only logical that learning about the fundamental principles and people involved in it, be accomplished through the telling and retelling of stories.

Learning Astronomy Through Storytelling
Storytelling Activities - Moon Story
Storytelling Activities - Star Story

Why Teach Astronomy?

There are four reasons for making astronomy a regular feature in an elementary science program. Besides the fact that it's intrinsically interesting to children (and just about everyone else, for that matter), it has a rich set of connections to the rest of science. And because it is a product of different kinds of people from the world over, astronomy provides opportunities for cross-cultural connections among members of any community. Finally, it addresses some of the curricular mandates at the elementary level.

Every star is part of a story. Published in 1661, *Harmonia macrocosmica* by Andreas Cellarius captured the constellations and activity of the heavens in the form of two, large celestial maps. Illustration courtesy of Linda Hall Library, Kansas City, Missouri.

Interest. Students repeatedly cite dinosaurs and space (including astronomy) as the two topics in science that are most interesting to them. This is particularly important considering that many teachers are focused on the means through which they can "hook" students into self-motivated learning. With their learning interests and motivational challenges addressed, students are encouraged to actively pursue and construct scientific knowledge. This lessens the teachers' exhaustive burden of trying to make science fun and interesting and leaves them to do what they do best--teach!

Science connections. Many of the preliminary concepts that students learn in an elementary astronomy unit build the conceptual foundations for acquiring knowledge that pertains to other areas of science. For example, a discussion of technological advancement may lead to a unit on simple machines-a recommended unit at the elementary level in many jurisdictions. Discussing rock formations on Earth, the Moon, and other planets relates to geology. Pondering life on other planets or elsewhere in the universe compels students to enter the realm of the biological sciences.

Multiculture. Astronomy is central to much of the lore and many of the traditions and ceremonies of numerous cultures. As examples, the Chinese New Year, the Islamic holy month of Ramadan, and many First Nations' traditions and ceremonies depend on accurate observations of the lunar cycle. Furthermore, Jewish festivals and religious holy days are still determined by an ancient, ten-month, lunar calendar.

Curricular mandates. The Earth and space component of many mandated science curricula is satisfied by bringing astronomy into the elementary-school classroom. Since children are already motivated to learn this science, it seems reasonable to fulfill the mandates in this natural way.

The Story of Astronomy

How Do Children Learn?

To know a story is to have knowledge-or so the story goes. However, just how children learn and how instruction should be designed to help them develop the conceptual structures that will permit them to grasp complex ideas, have been standard problems in educational psychology and, more recently, in cognitive science. There have been many theoretical solutions to these problems. Consider a relatively outdated interpretation of student learning called the transmission model, which presumes that children's minds are empty vessels waiting to be filled with knowledge that adults already possess.

Those who promote a constructivist approach to learning are heavily influenced by Piagetian accounts of intellectual development, and claim that children come to "know" by doing. That is, by engaging in specific activities, children build or construct the conceptual understandings that are relevant to their acquisition of knowledge.

Finally, the influence of Vygotsky has engendered the social constructivists' claim that children build their conceptual understandings and acquire knowledge by interacting with adults or more advanced peers.

Storytelling as a Pedagogical Tool

Here we propose an innovative approach to children's learning, one that integrates the transmission, constructivism, and social constructivism models by having teachers present some of the fundamental concepts involved in astronomy education at the elementary level. On the surface the approach looks like this:

transmission - teacher...

i. tells a story with astronomy content

constructivism - students...

i. listen
ii. ask questions
iii. make meaning of the story
iv. conceptualize the astronomical content
v. construct an understanding of the implications of the astronomy to the story
vi. learn the story

social constructivism - students...

i. retell the story

Upon closer examination of this cyclical sequence, one can see that students become engaged in various cognitive processes. For a constructivist example, children integrate a story's plot with the implications of the astronomical events and with the presence of similar phenomena in their own world. They elaborate on the science in the story and on the story itself. And finally they differentiate the plot from the science.

When a student is ready to tell the story, she must have not only learned the story but also all of its component parts-the characters, setting, plot, and the principles of astronomy that are integral to it. In educational circles, it is widely believed that the best way to test if someone really knows something is to have her teach it. The retelling of a story and preserving its internal structures is such a test.

Impediments to Elementary Astronomy Programs

Before presenting sample stories and curricular ideas, we must discuss some of the impediments, pedagogical and professional, to teaching and learning astronomy at the elementary level. The first and most prevalent of these involves the level of content mastery among elementary-level teachers. Astronomy is complicated. It sometimes seemingly flies against intuition and common sense. It's clear the Sun goes around the Earth, everyone can see that! The numbers are so vast, who can really understand them? Does anyone really know how far a lightyear is? And astronomy, being science, has a quality of intimidation that subjects in the arts do not have. The following story from an elementary school principal exemplifies this:

I remember when there was an almost total eclipse of the Sun in Toronto, back in the late 70s or early 80s, and I wondered whether to ignore the whole thing so that no child would inadvertently get blinded by looking at the Sun, or to make a fuss about it.

Making a fuss about it won out. After all, it was a significant astronomical event, and one of the few that occur in daytime when the students are in school. I kicked it off with a noon-hour staff meeting where I taught the staff all about the Sun, the Moon, and eclipses using light, cameras, smoke and mirrors, the whole thing. I had charts and diagrams, flashlights shining on spheres in darkened rooms, and pin-hole cameras. We talked about waxing and waning, gibbous and whole, the light of the Moon and the dark of the Moon. We probably even included tides.

I thought I'd taught a fantastic lesson, and afterwards, one of my very best teachers came up to me and spoke so admiringly that my head started to swell: "That was wonderful!" she said. "I could have listened to you all day. I was hoping it would never end."

As I was fumbling for the appropriately modest and gracious reply, she continued, "But I didn't understand one word you were talking about!"

Pedagogically there are obstacles to teaching astronomy through storytelling. To begin with, storytelling is an art and requires specific skills. Also, one must accumulate a repertoire of stories that contain sufficient content for the learning of the fundamentals of astronomy. Finally, astronomy is a nighttime science, and school is held in the daytime. Networking, the internet, and education consultants are useful resources for finding activities that will enable a teacher to cross these hurdles.

Teachers also need to shift their thinking about how to use stories in the curriculum. We urge teachers to veer away from simply introducing a unit of study via literature. For example, it would be expected that a teacher would read a story such as Goodnight Moon (Moroney), and then begin a unit on the Moon. What we suggest is that the story itself become the pedagogical medium rather than an introductory vehicle for the forthcoming learning project.

The Story of Astronomy

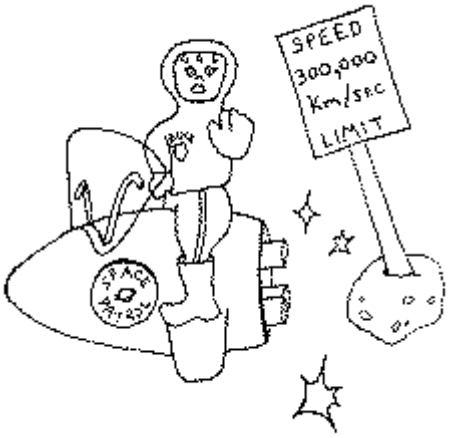
Learning Astronomy Through Storytelling

That children at different stages of development will derive different meanings from the same story is obvious but worth mentioning. This message is crucial to the planning of age-appropriate curricular content. Suppose, as an example, you choose to tell a story about the phases of the Moon such as Baloo the Moon (Moroney). If you teach K-2, the central message of the story that you want students to understand is simply that the Moon's shape, as they see it in the sky, varies. More advanced or keener children might work with a parent at home in the evening to draw the Moon once a week or so, or you might show slides of the Moon (see resource list) in its different phases and have children draw them as they see them.

For grades 3-5, the same story is used to introduce the same basic concept, but the idea should be extended to allow students to discover that there is a recurring pattern or order to those shapes, and that each segment of the pattern has a name. Expectations about students' learning of the names for the Moon's phases should vary.

Using the same story, middle school students in grades 6-8 should quickly learn the ideas introduced in the earlier grades if they do not already know them. Students can then begin to work on understanding why there are phases of the Moon. Further, students may be interested in how the Moon has been used historically for navigation or as a determinant for cultural/religious festivals that are based on its cyclical nature.

A similar pattern may be followed if you choose a constellation story such as How the Stars Came To Be, or The Seven Dancing Brothers (Moroney). Very young children may simply marvel at the idea that the stars make pictures. They will enjoy making those pictures themselves mentally and on paper. Children in middle childhood can begin to find some of the more salient constellations, and to learn about the different mythological and cultural origins of them. Older children will be able to learn more about the stars themselves, the theories behind their creation, demise, and positions in the sky. Such scientific knowledge can then be compared to the abundance of "star stories" that have sought to connect the positions of the stars in some fantastic way in order to fulfill a perennial need to understand celestial phenomena.



A final comment regarding the adaptation of the story to your students' stages of development. Children learn that a story has a plot, a setting, characters, a main problem, a crisis point, and a solution. The expected depth of understanding for younger children with respect to the characters, problem, and solution should be

differentiated from that of older students. For example, if you choose to use a Greek myth, the setting, characters, problem, and solution for young children will be only those that have been made explicit in the story. For older children, however, these may be explored on the explicit and implicit levels. That is, implicitly, behind the scenes of the story is a whole other cast of characters, problems, and solutions which motivated the derivation of the story. In Greek mythology, the setting is ancient Greece with ancient Greek astronomers and scientists as the characters. Their problem was how to explain what they saw in the day and night sky, the story of the sky's creation, and the apparent regularities and irregularities in the motions of some celestial bodies. The stories we hear over and over again today were used by ancient Greeks to explain what they saw.

In the activities section, we will guide you through specific stories and introduce you to active learning about astronomy through the magic of story. In addition, you will find professional tips for learning and telling stories about anything under the Sun. For, when it comes to the power of the story-the sky's the limit!

Oh yes. Did Galileo catch the elusive ghost of the universe that night five centuries ago? The men on top of the first hill uncovered the lantern; immediately, they spotted the light from the second lantern. Light had traveled so quickly that it appeared instantaneous, which is what everyone believed. Galileo still believed it traveled at a certain speed, but all he knew now was that, whatever speed it was, it was very fast! He had failed to catch the ghost of the universe.

It was a third of a century later that a Danish astronomer named Roemer was studying the moons of Jupiter (which Galileo had discovered using an early telescope). By observing changes in the times of their eclipses, Roemer calculated the speed of light with amazing accuracy. Today we know that, if light could travel in circles, it could go around the Earth seven and a half times in one second! Now that's fast.

And it was in this century that Einstein, the genius with the bad hairday and mismatched socks, stated that the speed of light was the limiting speed. Nothing in the universe can go faster than light.

The ghost of the universe has been caught.

as told by Lorne Brown

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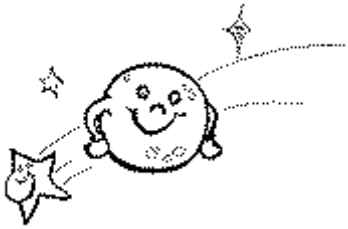
Storytelling Activities

To help you get started we are providing you with three short pieces to use with your students. As you begin to find your own niche as a storyteller and astronomer, you will gravitate toward the type of story with which you are most comfortable and eventually build your own repertoire of stories. We've also included a bibliography of resource material that will provide you with the background knowledge to the principles that you and your students will be investigating. Don't be afraid to learn and wonder along with them. Rather, embrace that opportunity!

Moon Story



Oh, glorious Moon!
As I gaze on your face
It comes to my mind
That never shall I gaze
On your glorious behind.
--Anonymous

The above ditty will make children giggle, and they'll learn to retell it in no time. There is a lesson in the poem, however: We on Earth always see the same side of the Moon because the Moon rotates exactly once and revolves exactly once in a month. Below is a plan for using this poem as a viable teaching tool with your students.

Grades K-2

Knowledge Objectives:	• the Moon is a sphere, and when we look upon a sphere we are only able to see a circle (or a "face") • from night to night the Moon might look different, but it is always the same Moon • we always see the same side of the "Moonball"
Story setting:	• the sky
Characters:	• the Moon
Problem:	• why do we only see one side of the "Moonball"?
Solution:	• see activity
Activities:	• have children make a styrofoam ball with a creative face of the Moon on one "side" and a behind on the other

	• have children hold the ball out in front of them and rotate around in a circle • to see that although they will always see only the face, the ball's behind does exist • have children retell the rhyme
Outcome:	• children learn that the Moon is a sphere, and we always see the same side

Grades 3-5

Knowledge Objectives:	• the spherical Moon rotates exactly once and revolves around the Earth exactly once per month as the Earth rotates on its own axis and revolves around the Sun
Problem:	• why do we only see one side of the Moon?
Solution:	• see *"Activities"*below
Activities:	• have groups of students build models of the Earth/Moon system (see references for classroom activities to find suitable activities of this sort) • using the model, have students simulate the coordinated movements (rotations and revolutions) of the Moon and Earth to discover the phenomenon of always seeing the same side of the Moon from Earth • have children retell the rhyme
Outcome:	• children learn that the same side of the Moon always faces us because of the Moon's monthly cycle of rotation and revolution

Grades 6-8

Knowledge Objectives:	• the light from the Sun is responsible for the amount of the Moon we actually see from night to night
Problem:	• why do we only see one side of the Moon? • why do we not see the whole face of the Moon every night?
Solution:	• see*"Activities"*below
Activities:	• have children build the model suggested for grades 3-5 and include a flashlight to simulate the Sun's light

	• have students use the model to coordinate the motions of the Earth and Moon with the Sun's light to discover not only why we see only one side of the Moon, but also why we see different Moon phases from Earth • tell a story about the phases of the Moon • challenge children to invent their own stories about the Moon's patterns of motion and how we are affected by them on Earth
Outcome:	• children learn that the Moon is always facing us because of its monthly cycle of rotation and revolution, and that the Sun affects how much of the Moon we see each night

Storytelling Activities

The next story is a Greek myth about the Big Dipper. The lore of the Big Dipper and other asterisms and larger constellations runs deep and diverse. Collections of folktales from around the world or myths from different ancient cultures that include such tales are abundant and available in every library and bookstore.

Star Story

Once upon a time there was a beautiful maiden named Callisto. She tied her hair with white ribbons and pinned her tunic with a brooch. She loved Artemis, the goddess of the hunt, and she joined her hunting party.

One afternoon, after Artemis and Callisto had been hunting, Callisto put down her bow and rested in a shady grove. Zeus, the king of the gods, looked down from his home on Parnassus, and saw Callisto. She was so beautiful he was smitten.

Zeus was often smitten by pretty maidens and beautiful goddesses. Since he had great powers, he could change his shape and appearance when he was courting some new and unsuspecting maiden. Knowing that Callisto had promised Artemis that she would never marry, Zeus cunningly took on the appearance of Artemis, and woke Callisto from her sleep.

Later, when Artemis found out that Callisto was pregnant, she was furious. She banished Callisto from her sight. She was not the only furious one. Zeus's wife was named Hera, and she was getting used to her husband's various love affairs. When Callisto gave birth to her son Arcturus, Hera turned her into a bear. Instead of the beautiful maiden Zeus had fallen in love with, she was a great bear, covered with fur, and growling. Once a hunter, she was now hunted.

One day, her son Arcturus came upon her. She recognized him, and advanced toward him in what she thought was a friendly, even motherly, fashion. But Arcturus saw only a great bear approaching. Not knowing it was his mother, he tried to spear it.

Zeus saw all this, and quickly intervened. He sent them both up into the sky, Callisto to become the constellation of Ursa Major, the Great Bear, which we call the big dipper. Arcturus became the Herdsman, forever guarding the bear, forever protecting his mother.

And there they are to this very day. Go outside tonight and look at the northern sky and you will see them.

as told by Lorne Brown

K-2

Knowledge Objectives:	• that the stars are in fixed formations in space called constellations • adults have grouped stars and given those groupings names
Story setting:	• a long time ago near a forest
Characters:(the names may be changed, of course, for younger children to remember)	• the pretty maiden Callisto, who is also the Bear • Artemis (the goddess of hunting) • Zeus (the king of the gods) • Hera (Zeus's wife) • Arcturus (son of Callisto and Zeus)
Plot:	• a young, beautiful maiden loved a hunter • that maiden was loved by Zeus, the all-powerful god of gods • Zeus changed himself into the hunter whom the young maiden loved and fooled her into loving him • the beautiful young maiden had a son with Zeus, and Zeus's wife was so furious that she turned the maiden into a furry, growling bear • the maiden's son came upon her as a growling bear • the son did not know it was his mother and tried to kill the bear • Zeus saw this and sent them both into the sky where they would be together and the maiden, now a bear, would be protected from other hunters
Problem:	• How will Zeus save Callisto, who is now a bear, from being hunted and killed by their son?
Solution:	• Zeus sent them both up into the sky where Callisto became the constellation Ursa Major (the Great Bear) and Arcturus became the Herdsman, who forever guards the bear and thus protects his mother
Activities:(It is may be difficult for young children to see the shapes and patterns in the sky, but...)	• have children make a personal map of the sky, and group stars to make a picture of (1) how Callisto and her son appear in the sky, and (2) how a creature or person of their choice (themselves, perhaps) would look as a constellation • have children retell the story to the best of their ability
Outcome:	• when children retell the story in their own words, they can better transmit the idea that the stars are mapped out in such a way that someone might think that a group of them looks like a bear

Grades 3-5

Knowledge Objectives:	• there are seven major stars that comprise the big dipper • those seven stars are configured in the pattern of a "dipper" • the big dipper is also called Ursa Major, meaning Great Bear • each constellation, including the big dipper, has been interpreted by different cultures as being a number of different things
Story setting:	• a long time ago near a forest (ancient Greece)
Explicit Characters:	• same as above
Implicit Characters:	• ancient Greek civilization
Plot:	• same as above
Explicit Problem:	• same as above
Implicit Problem:	• how to explain the fixed star formations in the night sky
Explicit Solution:	• same as above
Implicit Solution:	• create a story or myth to explain inexplicable scientific phenomena
Activities:	• have children make a personal map of the sky, and group stars to make a picture of (1) how Callisto and her son appeared in the sky, and (2) how a creature or person of their choice (themselves, perhaps) would look as a constellation • give students a map of the big dipper and have them determine the following: what the formation of stars represents to them personally; how the group of stars might represent a bear; and why the group of stars is also known as the big dipper • have children retell the story
Outcome:	• children come to know that the constellations are naturally occurring phenomena that have been grouped and labeled by people in attempts to explain their existence

Grades 6-8

Knowledge	• we see seven major stars that comprise the big dipper:

Objectives:	i. what is their configuration in the sky? ii. why can't we see all the stars in this constellation (effect of distance on visibility of stars)? • star patterns can be used as a "celestial compass"; for example, the last two stars in the bowl of the big dipper invariably point to the pole star Polaris • there is a pattern or cycle of change with respect to the positions of stars in the sky: the relative positions of the stars do not change, yet the celestial sphere as a whole appears to move, and consequently, constellations are not always seen in the same place in the sky-a phenomenon which is most apparent when charting constellations according to seasons
All story components are the same as for grades 3-5	
Activities:	• have students do the first activities from grades 3-5 • have children experiment with light to determine how a star's distance affects our ability to see it (see references for classroom activities of this sort) • assign research projects about how ancient mariners used stars for navigational purposes or how slaves escaping from pre-abolition southern states followed the "drinking gourd" toward Canada for freedom • have students work with monthly star charts to see the changing position of the big dipper in the sky and then to predict where the constellation (and others) will be at different times of the year (see references for publications that include star charts) • have students compare the constellations of the northern and southern hemispheres and decide: i. If ancient Greek civilization was in the southern hemisphere, would the story of Callisto change? If so, how? ii. Which of our constellations in the northern hemisphere are unique to us? Which are unique to the southern hemisphere? Are any seen in both hemispheres? Have students explain how this is possible. • have students write a biography on Callisto and Arcturus as sky figures explaining their seasonal travels and adventures • have students retell the story
Outcome:	• children come to know that constellations are naturally occurring phenomena that have been grouped and labeled by people • such organizations were made to explain the stable existence of groupings of stars and to create a systematic and organized way of finding our way through the labyrinth of stars which we know and those we have yet to know

Storytelling Activities

The models given in the previous pages of instruction may be used and adapted for any story you choose. Here is a second story about the big dipper, a Micmac myth, that may be used to investigate the principles and objectives outlined above.

> It was spring. A mother bear was slowly rousing herself from her long winter's hibernation and heading out to find something to eat.
>
> Little Chickadee saw Mother Bear. Little Chickadee was too small to hunt the bear alone, so he called six other hunters, and took with him his cooking pot. He put himself in the middle of two large hunters, Robin and Moose Bird, so they could protect the cooking pot.
>
> They set out after Mother Bear, but it was autumn before they finally caught up to her.
>
> Mother Bear saw them coming. She turned and faced them, rearing up. But Robin shot her with his arrow. He was so close to her that he found himself covered with Mother Bear's blood.
>
> Robin flew to the top of Maple Tree, and shook off the blood. He shook it all off except for the spot on his breast, which remains red to this day. The blood fell on Maple Tree, and ever since, every fall, maple trees turn red.
>
> Robin and Little Chickadee cooked the bear meat in Little Chickadee's pot. Moose Bird waited for them to do all the work, and then showed up in time to eat. Today, Micmac call lazy people "Moose Bird," or "He Who Comes In at the Last Minute."
>
> All winter, Mother Bear's skeleton lies on its back, but in the spring she ventures forth again to be pursued by the same bird hunters all summer until she is caught again in the fall. And so the cycle continues.
> *from Munroe (1987)*

Before choosing a topic of your own, it is worthwhile to reflect on why you and your students should spend time studying it. Considering constellations in general, for example, and the big dipper in particular, might excite you further or encourage you to choose a different one. In our own process for choosing constellations we reasoned the following: Constellations are apparent groupings of stars that we can see from Earth. There are not many scientific reasons for studying constellations since they are not scientifically determined groupings of stars. Rather, they are organized patterns that people use as guideposts for finding specific celestial bodies. Hence, if you are familiar with the sky, you can better deal with, and provide context for, astronomical information.