First Grade Space Explorers

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Introduction and Rationale

Twenty-six states across the country have collaborated to develop the Next Generation Science Standards (NGSS) to "ensure our students can think critically and address 21st-century global challenges in manufacturing, medicine, technology, the environment, and space exploration."[1] The remaining states have their own standards that have the same desired outcomes though they aim to achieve those outcomes with different strategies. This unit focuses on the NGSS as I teach in one of the states which has adopted NGSS. The informative material and activities explore Earth's place in the universe. They are appropriate for any first-grade teacher as they use the position and motion of the Moon and Sun as seen from our place on Earth to build a model of our solar system. The best practices are derived from the NGSS framework as well as numerous workshops that I have participated in over the course of my career.

No kit. That's my rationale for developing this curriculum unit. My team and I were recently informed that we must teach "Bright Days/Dark Nights," a NGSS curriculum "unit." Before NGSS, we were given a kit full of tools and resources with a teacher's manual and told to go teach a science unit. We did not need to be "experts" in the field as the information was in the teacher's manual and, if need be, there were scripted passages that we could use to inform our teaching. With NGSS however, we were given professional development via an online module which introduced the science standards for "Earth's Place in the Universe" and which also provided some activity ideas as to how to "teach" those standards. We are also required to take three workshops that teach us how to teach science the NGSS way. These three workshops are focused on the three disciplines of science: Physical Science, Earth Science, and Life Science. During each workshop we learn how to *facilitate* the students' learning through science investigations that *they* develop to address disciplinary core ideas, cross-cutting concepts, and science and engineering practices.[2]

School Demographics

In many schools across the country, science has been pushed aside to make room for more ELA and more math. This is evident in the state test scores given to our fifth graders each year. For the 2016-2017 year, my school's science test scores were barely above the state's, with only 48% of our fifth graders proficient in science.[3] According to NAEP, only 33% of our state's fourth graders are considered proficient which is below the national average.[4] We must find a way to integrate our science into the ELA and math curriculum. Investigations can be a crucial method to getting our students to reason quantitatively and make reasonable arguments thereby increasing their proficiency in speaking and listening. In my school this past year we had 782 students in grades K-5 (this year we have over 800). 33% of them were African American, 28% were white, and 26% were Asian. Nineteen percent of our population were English Language Learners, 22% were from low-income families, and 8% were receiving Special Education services. What better way to serve our minority students than to make them better English speakers? In fact, all students can benefit from the integration of interesting topics into our ELA and math instruction!

Course Objectives

The purpose of the activities in this unit are to help first graders develop investigations in which they use their senses of sight and touch to come to understand that Earth is one place in our universe, along with the Sun, Moon, and stars; that there are observable, predictable patterns of these objects that can aid them in managing their environment (wearing a coat when it's winter, needing a light source when there isn't one); and, that these patterns change over time and are cyclical.

The developers of NGSS like Fred D. Johnson, past president of National Science Teachers Association and I believe that first graders learn best (retain best what they learn) when disciplines are integrated.[5] This unit includes ELA, math, social studies, and science standards as outlined in the Appendix. To summarize, students are asked to analyze and evaluate text, compare and contrast the information, as well as use text and graphic features to understand what they are reading. Students make a graph to collect and interpret data, use and make models to understand phenomena, and they engage in argumentative reasoning.

The NGSS model is that students begin their scientific inquiry with some phenomenon, some question or observation that they observe about their world. Phenomenon is defined as a fact, occurrence, or circumstance observed or observable. The phenomena on which this unit focuses are: 1) the Sun appears to move across the sky in a predictable pattern (does the pattern repeat?) (why does my shadow change over time?), 2) the visible light on the Moon changes through the course of each month (does this repeat and how frequently?), and 3) the visible light on the Moon takes shape due to the way the sunlight hits the spherical Moon (could the Moon be any other shape or two-dimensional?).

NGSS require that the students develop their own investigations as part of the science and engineering practices. There are eight of these practices as follows: i) asking questions and defining problems, ii) developing and using models, iii) planning and carrying out investigations, iv) analyzing and interpreting data, v) using mathematics and computational thinking, vi) constructing explanations and designing solutions, vii) engaging in argument from evidence, and viii) obtaining, evaluating, and communicating information.[6]

Students develop ways of answering the questions or confirm their observations as reality. To that end, they need to have experiences that help them develop these questions. For example, the children play outside at recess, have they ever considered why they need a coat some days and not others. They can articulate that the Sun makes things warmer, then why is it that even when the Sun is out in January we still need to have on our coats? First graders begin to understand that the science and engineering practices they use are important to distinguishing facts from unproven information.

The disciplinary core ideas used in this unit are that patterns of the motion of the Sun, moon, and stars in the sky can be observed, described, and predicted. Seasonal patterns of sunrise and sunset can be observed, described, and predicted.

Crosscutting concepts that the children learn are that patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence. Events have causes that generate observable patterns, and simple tests can be designed to gather evidence or support or refute student ideas about causes (for example, where the Moon is in relation to the Sun and earth determine the shape of the light that is visible from the moon). Objects can be described in terms of their parts. Systems in the natural and designed world have parts that work together. The shape and stability of structures of natural and designed objects are related to their function(s). Some things will stay the same while others will change. Things may change slowly or rapidly. These crosscutting concepts help develop your students' understanding of how science works. We no longer give them tons of information specific to one area of science. The NGSS makes it very clear that educators need to help students develop a brain for inquiry that also helps them connect different areas of science together. [Common Core State Standards that are addressed in this curriculum can be found in Appendix 1.]

Content Knowledge

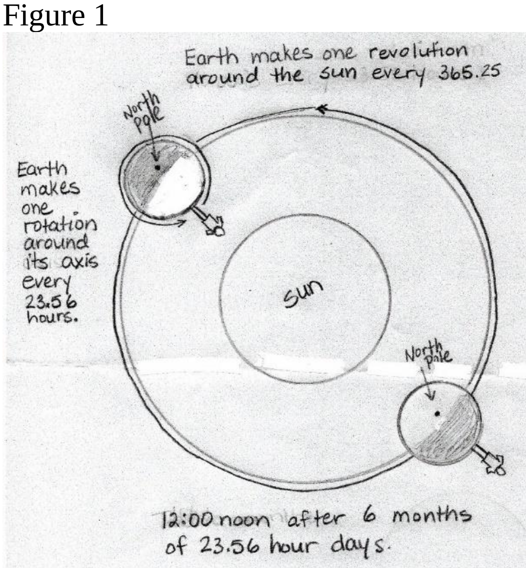
I must admit, astronomy is not something I know much about. I own a telescope that has become dusty with disuse. I can find the constellations of Orion and the Big Dipper, but I am frequently frustrated at certain times of the year when I can no longer locate them. I recently learned why lunar eclipses and the new moon phase are different; hint, a new moon has nothing to do with shadows. Additionally, I knew that you can see the Moon in the daytime sky, but I never questioned why I can only see it in the daytime sky sometimes. My primary reason for participating in this professional development opportunity is to become an "expert" in astronomy, at least to the point of gaining a basic understanding of the mechanics of the universe so as not to pass on the misconceptions that I may have had. This section is designed to give you some of the technical underpinnings of the patterns of the Sun and the Moon. Perhaps I can answer some of the questions about astronomy that you didn't know you had!

Our Sun

In order to teach young students about the Sun and Moon, we need to become somewhat familiar with the mechanics of those objects. Most of us are aware that the Sun is a star, that it is at the center of our solar system, and that our planet is positioned in the optimal distance from the Sun to enable life. When we were young, we were taught that the Sun rises in the East and sets in the West (which has not changed, although our language should be adjusted to help our little learners understand that the Sun is not doing the moving rather it's the Earth). Additionally, we might have learned that at 12 noon the Sun is directly overhead. Let's examine the Earth's rotation, which leads to our understanding of day and night.

We use a 24-hour period to determine one day here on Earth. The rotation, or spinning, of the Earth is measured from any given point on Earth's surface (think of where you stand). We begin the measurement at 12:00 noon and continue the measurement until the Earth makes a 360° return to the same point the next 12:00 noon. But there is a problem with this measurement. Because it assumes that we are returning to the exact same place in the universe. If we were to measure time this way, one Earth day would really be 23 hours and 56 minutes. We would only be considering the Earth, unrelated to the position of the Sun. This is called a sidereal (sigh-deer-ee-ul) day. Now consider that the Earth rotates on its axis, but also revolves around the Sun. This means we need to consider where the point on Earth (where you are standing at 12:00 noon) is in relation to the Sun. Consider the figure below:

Figure 1

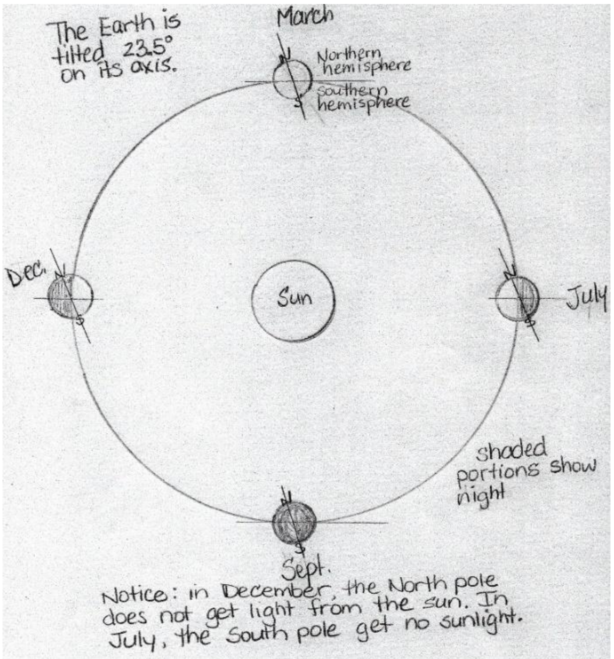


A few things to notice in the figure: obviously, it is not drawn to scale, both the rotation of the earth around its axis and Earth's orbit around the Sun are counter-clockwise and, this figure shows where you would be at 12:00 noon on Day 1 and six months after Day 1 assuming that each "day" corresponds to a 360° rotation of the Earth. Notice that you would be where we would expect midnight to happen after six months. This figure shows six months of days at 23:56 hours per day. It would be strange to be at work at 12:00 noon in full daylight one part of the year and in complete darkness another. This figure shows that a sidereal day does not account for the earth's revolution around the Sun. As each day passes, our position relative to the Sun changes because of our planet's orbit, and it takes four more minutes of Earth's rotation around its axis for us to be facing the Sun directly as we had the day before. This is called a solar day and it is the 24 hours we use to determine a day here on Earth.

There are other considerations we must make when understanding our days and nights. The rotational axis is an imaginary line through our poles. That line is "tilted" with respect to its orbit around the Sun. That is why, if you were able to stand at the North pole and look directly overhead for a 24-hour period during June, the Sun's path would make a large ellipse around the point where you stand (never moving below the horizon). You would experience this same phenomenon at the South pole in December. Each pole gets its season in the Sun because of the tilt of the Earth on its axis. Only one or the other pole can face the Sun for the length of the day at a time.

Additionally, if you were to stand at any point on the equator (another imaginary line), at any time throughout the year, and again, watch the sky for a 24 hour period, you would notice that the Sun begins its ascent in the eastern sky close to 6:00 am and disappears beneath the horizon in the west around 6:00 pm, every month of the year (the variation in this twelve hour period is about 10 minutes less during the winter and spring than in the summer and fall). The path of the Sun would be an arch. I was able to gather this information from a free online application called Stellarium. It is quite useful in supporting a person's visualization of the Earth's rotation and orbit around the Sun at any given date and time. We must rely on software like Stellarium to understand the phenomena of day and night and to understand that the Earth, Sun, and Moon must be spherical and not disc-like because we do not have the luxury of traveling to each of these places to see the path of the Sun for ourselves. But that is not to say that we cannot do our own data collection where we do stand on Earth. In one of the activities below, students collect shadows throughout the year to see how the Sun is in a different location each season. Consider the following figure:

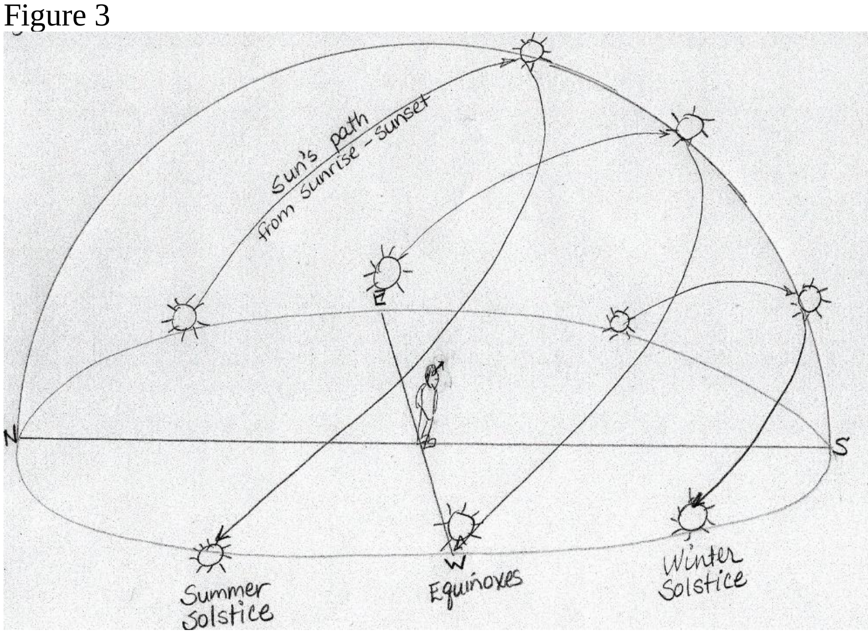
Figure 2



It is the varying strength of the sunlight that hits the Earth that causes the seasons. Because of the Earth's tilt the Sun's energy reaches different parts of the Earth with different levels of strength. This explains why the equatorial region always has the highest temperatures, and the poles the lowest[7]. The equatorial region receives the Sun's energy directly throughout the year, and as you move further away from the equator (in either direction) the energy received is more, or less, depending on the Earth's tilt. If your region is tilted toward the Sun, it gets more direct energy and the temperature increases. Conversely, if your region of the Earth is tilted away from the Sun, it gets less direct energy from the Sun, and therefore, cooler temps. Unfortunately, weather does not always help us to prove this concept as on the January day when the temps reach 60°! The atmosphere and a locale's proximity to water (oceans, specifically) also factor into the temperature and weather. Additionally, solar flares affect our atmosphere (magnetically) and can add to the variation in weather down on Earth's surface. So, in the big picture, using averages, it is the Sun's energy and how it reaches each place on Earth that ultimately determines the seasons of that place.

It is also interesting to note that due to the Earth's tilt on its axis, the Sun does not reach its highest point in the sky directly above our heads as we may have learned when we were in first grade! Only at the equator in June is the Sun at a 90° angle above our head. As we move further from the equator the Sun takes an east to west path, but the apex of the Sun is more likely a 70° angle above our heads.[8] Another way of visualizing this is to stand facing south (if you are reading this from the northern hemisphere) while the Sun makes its way across the sky. You would note that the Sun makes an arch-shaped path beginning in the east at the horizon, reaching its highest point in the sky at noon, and returning to the horizon in the west later in the day. Now if you were to do this once a week for six months, you would notice that the arched path of the Sun would become deeper or shallower depending on the time of the year. For example, if you were to begin this task in February and complete it in August, the arch would become increasingly "deeper" meaning the Sun's apex would be closer to the 90° angle above your head. If you were to take this data from August to February, the arch would become increasingly shallower over time, meaning that the apex (at noon) would appear to be closer to the horizon. Another way to observe this phenomenon would be to watch the sunlight patterns through the same window of your home, at the same time every day, throughout the year. You should notice that the sunlight "moves" from one side of the window to the other and back as the year progresses. The figure below gives you three points in the year to consider: the summer solstice (the day of the year with the most amount of sunlight), the vernal and autumnal equinoxes (the days where night and day have equal amounts of sunlight and night), and the winter solstice (the day with the least amount of daylight). Take note that the Sun's path through the summer sky takes a longer route in comparison to the path through the winter sky. This becomes evident if you record the length of the day on the 21st of each month.

Figure 3



The changing of the Sun's path throughout the year has been recorded by many people but it is a difficult and complex task. If you look at a globe, you may notice a figure eight placed somewhere on the Pacific Ocean. This is called an analemma and it shows the placement of the Sun at the same time of day, from the same point on Earth every ten days or so. Look carefully and you can see the dates recorded on the figure eight. Notice that the smaller loop is from the summer months, while the larger loop is from the one equinox to the other through the winter months. This path that the Sun's light takes through our sky is due to the tilt of the Earth and the elliptical orbit around the Sun. For any given place on Earth, this figure eight shape would appear in different "rotations" of the figure. For example, the more north this data is collected, the smaller loop will move toward the left while the larger loop moves toward the right. This is because of where the Sun is in the sky from any given point on the Earth.

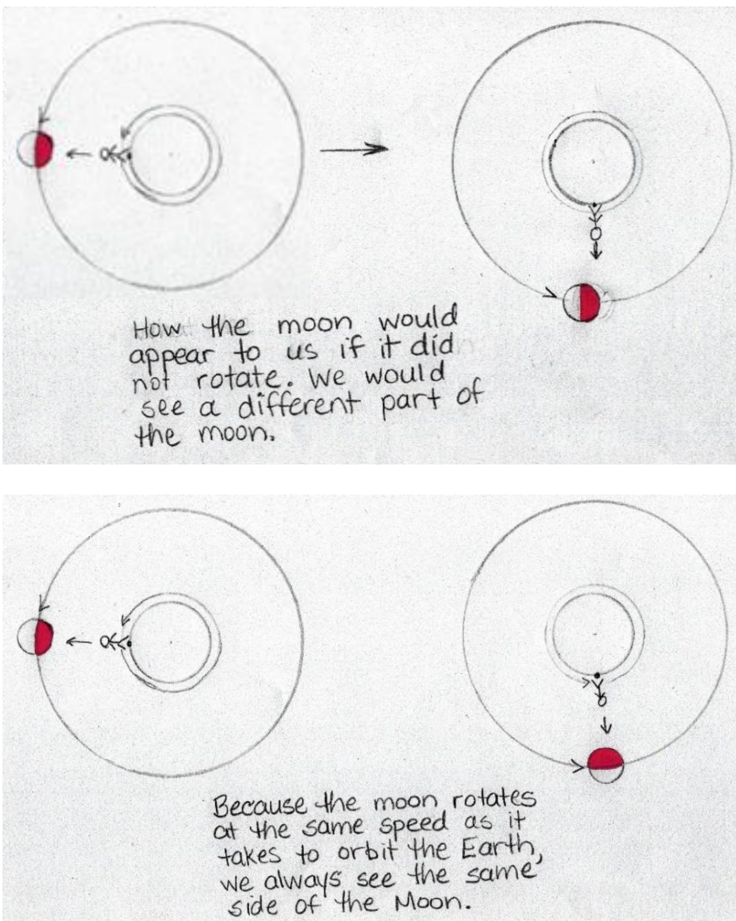
One misconception about the Sun is that it burns, meaning there is a fuel source that is on fire. While this may be the easier way to explain the Sun's radiance to young children, it is not really what is taking place. To be fair, the reality is impossible to explain to children, in fact, unless you understand nuclear fusion, it is hard for anyone to understand. To make this as simple as possible, consider that two hydrogen atoms race toward each other and collide. When this happens the nuclei of each join creating a new nucleus. This is fusion. As a result, there is a lot of energy released. Clap your hands together hard, then think of how your hands feel afterward. There should be a tingling and maybe even some heat. Now the tingling is more about nerves, but the heat is the energy that was created by the collision of your hands. This is as simple an explanation as you can make for our little people. Now, explain that this happens billions of times, over and over in the Sun. What is happening in the Sun is that electrons are trading places and creating energy because of the pressure of gravity. This process is what causes the Sun (and other stars) to shine. What we witness here on Earth through photos and film of the Sun is what looks like flames and burning but be sure your students understand that the Sun is not "on fire."

Our Moon

The moon, our closest neighbor, is made of the stuff of legend, folklore, and fiction, or you could take the view of it not being all that interesting. I mean after all, it's just there. It doesn't do anything, it has no life to observe, it's just rock and dust, and we have plenty of that here on Earth. So why should we care about the patterns we can observe about the moon? Our ocean tides are a result of the play of gravity between the Moon and Earth. Without the Moon there would still be tides, because the Sun's gravity also contributes to our tides, but the tides would be less substantial.[9] These tides also contribute to the slowing of Earth's rotation. Without the Moon we would have shorter days. Ask yourself, how would that affect our climate? Another important job of our Moon is to keep our planet's rotation stable, or less wobbly. Imagine a top spinning, and when it first begins it is upright and spinning in a very controlled manner. As the speed of the top slows, the top begins to spin in a more erratic manner, wobbling dangerously close to falling over on its side. With the moon, we don't generally notice the rotation of our Earth except when we observe the movements of the Sun and moon. I think I like that the Moon keeps us from wobbling around! The tilt of our Earth, of which you read above, would be much more dramatic, but this would only mean that our poles would be in different places on the Earth. And, anyone who has ever been in a classroom of six and seven-year-old children knows that, without the full moon, there would be nothing for teachers to explain the chaos that happens in the classroom during this moon phase!

Some information that I think is important for you to know and may be new to you as it was to me, is that the Moon has its own rotation. When I first heard this, it made no sense to me, because I was imagining that if the Moon rotated, we would see different sides of it (like the dark side). But I was thinking that the speed of the moon's rotation was like the Earth's rotation (a day). Consider the figures below:

Figure 4

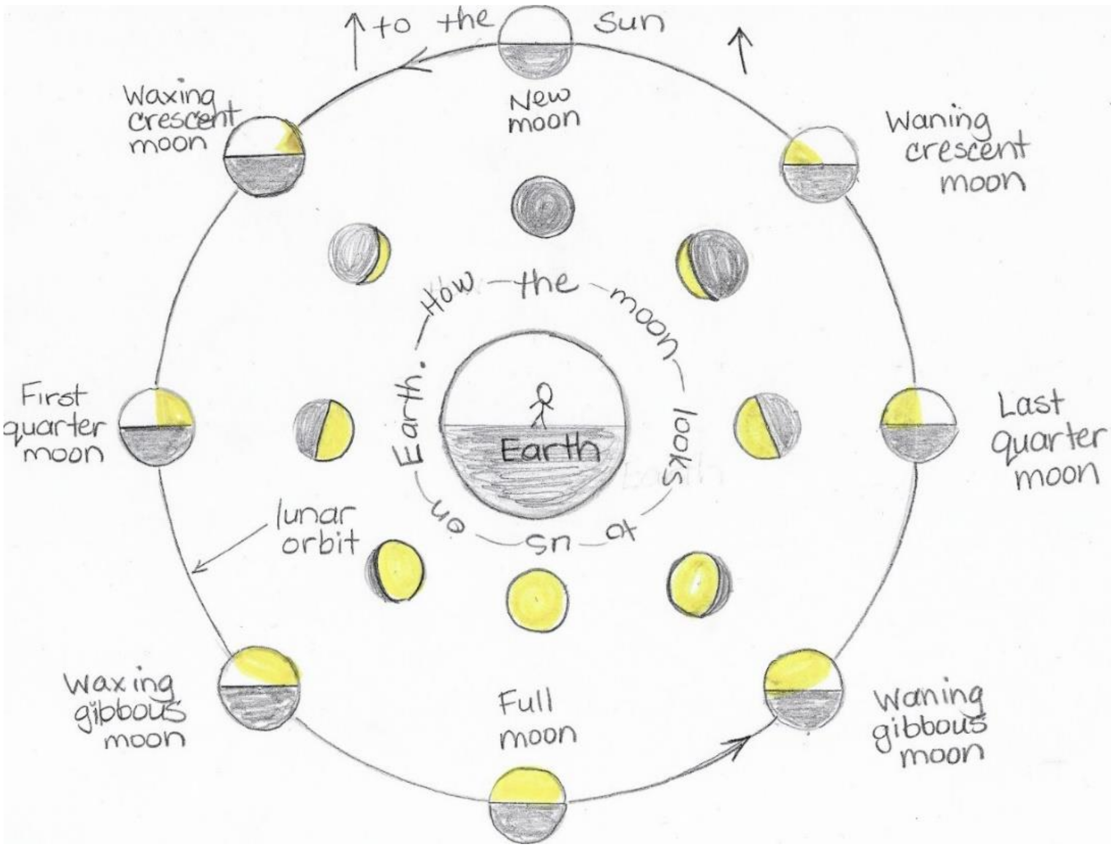


Notice that if the Moon did not rotate, as we make our way around our rotation, we would see a different side of the moon. The Moon rotates at the same speed as its revolution around our planet, so it is different than our rotation on our axis. Therefore, we call the "other side" of the Moon the dark side, because from our vantage point, that side does not see the Sun. But in fact, this is not true. This brings me to the moon phases.

There are a few concepts that I need to explain so that you can understand the mechanics of the moon phases. Let me begin with the fact that when we measure the Sun's and the Moon's distances from the Earth, their "angular size" is nearly identical.[10] That is because the diameter of the Sun is approximately 400 times the diameter of the Moon. Additionally, the Sun is approximately 400 times farther away from Earth than the Moon. This is what allows us to witness complete solar eclipses. You would think that this would happen at least once a month since our Moon finds itself between the Sun and the Earth during the new moon phase. But this does not occur as frequently as each month because the Moon's orbit around Earth does not sit on the "plane of the ecliptic." This is the imaginary plane made by the Earth's orbit around the Sun. The Moon orbit is tilted about 5 degrees above or below this plane. When the Moon comes between the Sun and the Earth, we are still able to see the Sun fully because of this angle and the tilt of our Earth. So how do eclipses occur than? It is only those times when the Moon's orbit hits that plane of the ecliptic in its orbit around Earth that solar eclipses can happen.[11]

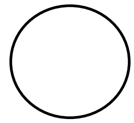
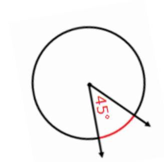
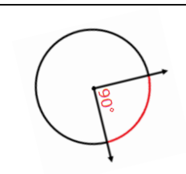
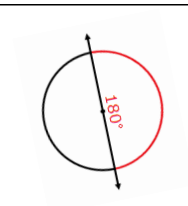
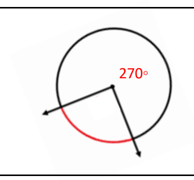
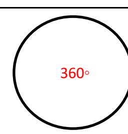
When the moon finds itself between the Sun and the Earth, the moon is not visible to people (even on the clearest of nights) except in the case of the rare solar eclipse. This is the new moon phase. [Please also recall that we briefly thought about the "dark side" of the moon. Since, people always see the same face of the moon, this would be the time when the Sun illuminates the "dark side" of the moon completely.] One thing I never paid much attention to is where I see the moon as it moves through its 27 day orbit around our Earth. But if we are to appropriately teach the pattern of the moon, this is something to consider. Because I am writing this from the northern hemisphere, the phases are from my perspective. A figure is necessary for me to make this clear:

Figure 5



Take note, the Moon moves between phases about every three to four days. The outer circle of moons shows the lunar orbit around the Earth and this is top down view as if we were hovering above Earth and the Moon. The inner circle of moons shows the illuminated part of the moons as we see them from the Earth. If you look carefully, you notice that the illuminated part of the moons on the outer circle are just the top half of the illuminated parts of the moons on the inner circle. Also, just as the Earth's daily rotation needs an extra four minutes because of its revolution around the Sun (sidereal versus solar day), the Moon's rotation around our Earth also needs some extra time, thereby making the total time between new moon phases 29.5 days.

It is important to know that each moon phase can be seen at different parts of the day in different parts of the sky. The easiest way to understand this is to think of the angle that would be made if we could draw a line from the sun, to ourselves, and to the Moon. The following table should help you visualize this. The sunrise and moonrise data were collected from the website timeanddate.com from my location. On this site, you can choose your location, date, and time for which you want data. The angle drawings assume we are looking south. Imagine standing at a fixed point every day for a month with your arms extended out toward the Sun and the Moon. The line pointing nearly south represents our view to the Sun and the other line represents our view to the Moon.

Moon Phase	Date	Sunrise	Angle	Moonrise
New moon	12/07/2018	7:09am SE		7:14am SE
Waxing crescent	12/11/2018	7:13am SE		10:31am ESE
First Quarter	12/15/2018	7:16am SE		12:38pm E
Waxing Gibbous	12/19/2018	7:18am SE		2:37pm ENE
Full moon	12/22/2018	7:20am SE		4:56pm NE
Waning Gibbous	12/25/2018	7:21am SE		8:19pm ENE
Third (Last) Quarter	12/29/2018	7:22am SE		1:05am E
Waning Crescent	01/01/2019	7:23am SE		3:03am ESE
New Moon	01/04/2019	7:23am SE		6:03am SE

If you look at the sunrise and moonrise times on the 7th of December, you note that they are not very far apart. If you were able to see the moon, you would see that it almost directly in line with the sun. There is very little angle between the two. For all intents and purposes, there is a zero-degree angle. As days pass, the moonrise follows the sunrise, first by a few hours and ultimately almost a day, at which point we say that the moon will rise before the sun as on January 4th. Because of the length of the difference between the sunrise and the moonrise, we get this effect where the distance between the moon and the sun in the sky create an angle from our vantage point. This helps in understanding where the moon will appear (or not be visible) in the sky and at what time of the day. For example, if we look at the First Quarter Moon data, the difference in the length of time from sunrise to moonrise creates a 90° angle if you were to extend your arms, one toward the sun and one toward the moon. We would be unable to extend our arms in this same way for a Third Quarter Moon, but we could use opposite arms and again create a 90° angle with our arms. The length of the difference between the Sun and Moon during a Full Moon would be almost a 180° as the Moon is rising when the Sun is setting. [Because this is December data, the difference is not exactly 12 hours because of the Earth's tilt away from the Sun. In March it would be more accurate to say 180°.] Another point to note is as the Moon makes its way around our planet the moon moves in relation to the cardinal directions. When I looked on Stellarium, I saw that the New Moon on December 7th was to the left of the Sun, but then the New Moon on January 4th was to the right of the Sun. At first, I was confused, but then realized I hadn't moved the full 29 ½ days through the Moon's cycle. When I checked out January 5th the Moon had moved back to the left of the Sun, thus completing the cycle.

One final point I wish to share briefly is that astronomers find it useful to use what is called a celestial sphere to work with many concepts related to our Sun, Moon, and stars (refer to Figure 3). This is another imaginary tool. Imagine a transparent sphere that surrounds our planet. On this sphere you can find the entire contents of the known universe. Just as cartographers use longitude and latitude lines to define areas on our planet, astronomers use a similar grid to define areas of the universe. What is neat about a celestial sphere is that it can be revolved around our planet so that we can see where objects in space would be relative to our position on Earth at any given date and time. These concepts are important to understand before we can share them with our students.

Strategies

Student engagement is key to their retention of content knowledge. We can offer students all the information they need to be knowledgeable in any area, but if they are not engaged, the information is not be retained or accessible throughout their lives. Learning Focused and Kagan Structures are two frameworks that provide strategies for helping students to be engaged and responsible for their learning. Many of the strategies require collaboration which in the world of science is very necessary. The most important discoveries and advancements were not made by individuals in isolation. They were the products of many discussions, interactions, and arguments. When students are given the opportunity to interact with others in their learning, that learning sticks.

Here, I recommend many strategies that you may use when working with this unit. As I outline the activities later in this unit, I provide suggestions for using these strategies, but these strategies can be used with other content areas as well.

Assessing Prior Knowledge and Recording Learning

Keeping charts like a KWL, vocabulary lists, or anchor charts are visual supports that allow students access to learning. I like to use a two-column chart with the headings "What You Think You Know" and "What We Have Learned." This gives the students an opportunity to update any prior knowledge. We use our vocabulary charts as a challenge and keep tallies for how many times a word has been used throughout our discussions. Another game we play is called "Stand the Line." Students show their understanding by getting closer to or further from a line. I use this strategy as an informal assessment to gauge understanding.

Instructional Strategies

A "parking lot" is a method of keeping track of questions or misconceptions that come up throughout the unit. Graphing and recording data in written or picture form help students keep track of new information. Collaborative groups or working with a partner is useful to help students discuss with their peers what they are learning. Interactive read-alouds help students hear information about what they are learning and give them a starting point to begin discussions. Before and after reading about the Sun or the Moon students should be encouraged to discuss what they have heard by either Turn & Talk or Think, Pair, Share. Turn and Talk is a quick moment where two students turn to one another to discuss their thinking and can be used before learning, as in to make predictions, or after learning to restate and confirm what they have learned. Think, Pair, Share is a bit more involved as the two (or three) students may have a more in-depth discussion before sharing their consensus on a topic. Frayer models can be used to learn and retain new vocabulary. Alphaboxes can also be used to record key vocabulary related to the topic. This may be easier for first graders as there is less to write, but the Frayer model can be used for more in-depth vocabulary that you want them to retain. You can find models of both strategies in the Supplemental Resources section of this unit.

Summarizing/Synthesizing Strategies

Once learning has happened, there are many summarizing strategies that can help all students synthesize what they have learned. Quiz, Quiz, Trade (a Kagan strategy) and Inside/Outside Circles are activities in which students confirm their understanding with their peers. 3-2-1 is a written (or can be labeled pictures) response to learning. Students fold a paper into three sections. In the first they record three things they have learned. In the second section they record two things that surprised them about what they learned. In the last section they record one thing they still have a question about or something they wonder. Aha! & Huh? is similar in that the students record two things they learned or "aha" moments and one thing about which they are still not sure (Huh?). It's always fun to have a Snowball Fight with our learning. Students can either write something they learned or a question they still have on a piece of paper, ball it into a snowball, and throw it across a circle of students. These "snowballs" are then picked up and read aloud to generate discussion. All these strategies are purposeful in helping all students stay engaged in their learning, but for them to be effective strategies, they must be explicitly taught before students are expected to use them.

Collaborative Discussion

Additionally, for discussions or paired activities to be purposeful, first graders must be taught how to have productive discussions. "The Inquiry Project" a TERC initiative provides professional development for teachers that helps them create an environment for more productive science discussion.[12] The project is geared toward third-fifth grade, but many of the questions can be used by first grade teachers. Initially, we should teach individual students how to share, expand or clarify their thinking. We ask questions like "Can you say more about that?" or "Can you give an example?" Then we need to teach students to listen carefully to one another. Having them rephrase what another says helps with this. When the student shares, they share what their partner said. Asking for evidence or reasoning is important. "Why do you think that?" is a purposeful question to help students to think about what they really know. Are they just rehashing something they heard or read, or do they have a real understanding of what they heard or read? Another way to address this is to ask, "Does it always work that way?" Helping students to collaboratively discuss science (or any content) helps them to solidify the content for themselves. When they think with others and ask questions like "Do you agree or disagree with that?" "Thumbs up or thumbs down" or "Who can add to what (another student) said?" they must take their knowledge and mesh it with what they are hearing from their peers. While this is higher level thinking, first graders are as capable as upper grade students if they are taught explicitly, interactively, and patiently. Interactive modeling is an effective method to getting students to learn expected behavior. If we want them to ask these questions regularly, we need to teach them when it is appropriate to ask these questions. This can be done as a whole class, small groups, or even individually. Teaching metacognition is a valuable use of your time as a teacher because it passes the ownership of learning on to the students. But, at the first-grade level it takes lots of time and practice before they become adept. Your students can use the five activities following to develop a beginning understanding of the motion of the Moon and the Sun.

Activities

Lesson #1 – Illuminated Shapes

Enduring Understanding

Before we can begin to look to the skies, our students should have a basic understanding of how light plays on different objects. They should also understand that our Moon reflects the Sun's light.

Essential Question
How does light appear on different two-dimensional and three-dimensional objects when the light source is stationary, and the objects are moved around the light source?

Objective

Students explore with different objects to observe the shapes that are made on the objects by the light from a lamp. While they are exploring, the teacher asks questions in order to generate discussion about the observations they are making.

Materials and Setup

A dark room, preferably a room with no windows. Many objects, specifically flat two-dimensional shapes made of a sturdy material that will not bend when held up by one hand (dark colored card stock). Also, three dimensional blocks, or objects made dark by painting or wrapping. I recommend a circle, square, rectangle, triangle, sphere, box, cylinder, and pyramid. A light source, I intend to use a table lamp with no shade.

Many students will suggest using a flashlight but help them to understand that a flashlight will provide a beam of light that is too small and too directed, that the Sun is such a gigantic light and its light is spread over great distances. Help them to see the difference between using a lamp and a flashlight. Also, remind them that like the Sun, they should not look directly at the lamp when the room is dark because it will make it difficult for them to see the light on the shapes.

Procedure

Bring the group to the place where they can carry out their investigations. Show them the provided shapes and the lamp. Tell them to use the light from the lamp to try to make lighted areas on the shapes while you take photos of the shapes they make with the light on the shapes. Have them discuss the photos with the rest of the class at another meeting. Remind them that the room is quite dark, and they are to stay in their own space while working. Turn the room lights out once the lamp is turned on. Give the students several minutes to explore with the various shapes. Partners near each other can trade once they have made their investigations. Listen to the discussion but do not correct any misconceptions yet. Do make sure they are using the correct labels for the different shapes. Take photos as the students work with the shapes.

Once all the students have had the chance to investigate illuminating shapes, share the photos (whether electronically or in printed form) that you took. Have them discuss with each other what they notice and if they can make any decisions/connections to what they see when they look at the moon. Have them record on the Illuminated Shapes worksheet (Supplemental Resources) the lighted part of each of the shapes they have seen.

Lesson #2 – Moon Watchers

Enduring Understanding

By making observations and collecting data, students come to understand that they can infer patterns, in this unit, specifically patterns related to the Sun and the Moon.

Essential Question

What can I do to find if the shape of light made on the Moon by the Sun follows a pattern throughout a month?

Objective

Students collectively create a journal (Our Moon Book) to participate in collecting data about the Moon to decide if there is a pattern to the moon phases.

Materials and Setup

Prepare the book by cutting 23 pieces of 9X12 black construction paper in half. On one page write Our Moon Book in white crayon. On each of the rest of the pages trace a four-inch circle in pen ink (I used blue). The children need to be able to see the outline, so they can color within it. Bind the pages together (I used a spiral binding machine). Record the first night yourself to share expectations. Prepare directions for parents to read (found in Supplemental Resources). Place this note, the bound book, and two white crayons in a clear, zippered baggie (gallon sized works).

Procedures

Tell students that each of them will have a chance to participate in making a book about the way the Moon looks each night throughout the next 45 days. Remind them that they have an important role as a scientist working on a group project to remember to record what they see as accurately as they can. Model what is accurate and what is not accurate on an example page. Tell the students that once we have collected a couple of weeks' worth of data, we will discuss what the data are showing us. In the parent note it states that there will be times that your students may be unable to see the moon. These include the days when the moon rises very late (after their bedtime) or in the morning (once they are in school). Additionally, they will not be able to see the new moon and possibly the day before and after the new moon. Cloudy days will also hinder data collection. The parent letter states that they can use an online tool to see what how the moon appears for those days.

Revisit the data set about every two weeks throughout the 45-day period. During discussions, remember your role as facilitator. Do not tell students what to see, rather ask leading questions and have the class generate the questions. You should hear students talking about where the light is shining on the Moon, how the shape grows or shrinks throughout the month, if the shape of light is on the top, side, or bottom of the Moon, if there are any unexpected shapes. If a student incorrectly records the shape (simply coloring in the whole moon or a shape that does not fit the pattern), help the class discuss how sometimes scientists get false information from data due to human bias, gathering data in different ways (for example, the time of day), or recording misinformation. Help the students determine if there is a pattern to be seen. You may need to remind them that a pattern is found when a pattern unit is repeated.

When all the data have been collected, you could take photos of each page and prepare a Power Point presentation with all the photos in order. There are also webpages that show the images of moon for the entire month (farmer's almanac and giant moon are two such sites).

Now that you have collected the data and had several discussions about their findings, students should be able to articulate that the moon does go through phases that repeat in a cyclical pattern. Additionally, you could mention to the students and their families that they can keep their own moon journal to see if this pattern changes throughout the year.

Lesson #3 – Model the Moon Phases

Enduring Understanding

Making a model of a phenomenon can help us better understand that phenomenon, specific to this unit, the moon phases.

Essential Question

How can I use a model to represent my understanding of how the Moon moves around the Earth in a month?

Objective

Students use “Moonie Pops” (a term coined by my professor) to model how the Moon revolves around the Earth through a moon cycle. They are be able to see the shape made by the Sun’s light at each phase

Materials and Setup

Styrofoam balls (with about a 3- or 4-inch diameter), wooden coffee stirrer sticks, a dark room, and a light source like a lamp without a shade. If possible, it might be prudent to set the space up by marking the eight spots where the named moon phases would happen around the lamp.

Prepare the moons on a stick (Moonie Pops) prior to the activity with students by mounting a ball on the stirrer stick. Draw an X or + on one side of each ball, this way the students know which side of the moon to look at. You need eight, but you could have more to see the shapes made by the light on the moon in between the eight named phases.

Procedures

Before the activity, add to the What We Think We Know/What We Learned chart that you would have created prior to starting the activities. Students should talk about the pattern of the moon phase cycle that they found and that they are convinced that the moon is spherical. Ask students if they can figure out why the moon takes the different shapes that they recorded in Our Moon Book. Record responses on the chart on the What We Think We Know side. Ask if they have any ideas as to how they could find out for sure. If necessary, remind them that the Moon could be found in different parts of the sky at different times during the month and that sometimes the Moon was not visible to us. If the idea is not presented, suggest that the students could make a model to test what they think happens. Ask what they would need to represent in the model (the Moon, the Sun, and Earth). They will more than likely suggest using the globe but tell them that their head and eyes would make a better Earth. See what ideas they come up with. Then introduce the activity. Show the Moonie Pops and remind them of the lamp activity.

Depending on the size of your class, you may need to divide your class in half and students work with a partner, taking turns at each of the eight phases. This activity may take a bit longer than the first activity, because the students need to be precise with their models. Once in the dark room, before turning out the lights, show the students how they should hold their moon at arm’s length away from their body, at face level. Remind them that their face is the Earth. Tell them they want to think of where the Sun’s light falls on their face, as well as their moon. If might refer to Figure 6 above that shows the illuminated part of the moon through its cycle, you may be able to visualize this activity better.

Begin with the students standing at the New Moon phase. They should face the sun with their arms stretched out in front of them, but not blocking the sun. This is important because we do not want to create an eclipse, but the students need to see that they are facing the sun (at the 12:00 noon position) and they can see no light on their moon. This is the time when the “dark side” of the moon gets full sun, it’s just on the opposite side of the moon that we see. Have them talk aloud as to what they see on the moon face, so that all the students can hear what is happening. Tell the students that as they move from phase to phase, this is what they should look for. Have the students directly across from the New Moon folks share what they see. They should be facing directly away from the lamp, so their back is to the light. That makes it 12:00 midnight on their nose. They may have to hold their moon a bit higher, so their head does not make a shadow on their moon. Again, we are not looking to make an eclipse. They should be able to see their moon fully lit. Continue through the rest of the phases, helping the students to understand where the sun is in relation to our heads and what we can see on the face of the moon. Once you have worked through all eight phases, have the students rotate and try each phase for themselves.

Once your whole class has participated in this activity, bring the conversation back to them. What did they observe? How did a model help them to understand what happens? What information do they want to add to the chart? This is more an activity for the students to understand modeling, more than for them to understand moon phases. They are not expected at first grade to know the moon phases and where the Sun and Moon are, but this is purposeful for them to have exposure and practice in modeling.

Lesson #4 – Where’s the Sun?

Important: please have a conversation about the importance of never looking directly at the Sun before beginning these activities.

Enduring Understanding

The Sun also has a pattern in our sky, that is different than the Moon. The Sun begins our day in the East and moves through a high point and sets in the West.

Essential Question

How does the sun move across the sky?

Objective

Students use their sense of touch to feel where the Sun is on their face, three times a day, four times a year. They record their findings with a partner to discuss after the last data collection. They will learn that the Sun always rises on the left side of their face (when facing south), will be on the top of their face/head at midday, and be on the right side of their face at the end of their school day.

Materials and Setup

You need a method for having one partner of two blindfolded. Choose a spot outside your school where the students can face south prior to the activity. Additionally, remove any obstacles to reaching this place from your classroom. Each student needs a "Recording the Sun on Your Face" worksheet with their name, their partner's name, the date, and the time for each time you go outside (see Supplemental Resources). When they return to the classroom, they use a yellow or orange crayon to show where they felt the Sun's heat on their face and where they saw the Sun in relation to their head. Partners take turns being the one blindfolded. I recommend the same student be blindfolded for the day (rather than alternating in one day).

Procedures

Before beginning talk with students about what they think they know about the Sun. They may say that the Sun seems to follow them when driving in a car. After recording their responses on the chart, ask them if they have an idea of how to figure out if the Sun has a pattern to its movement across the daytime sky. A few students might say that it rises in the east and sets in the west. Ask them if they know where the east is (sitting in the classroom). They may look to a window to figure this out. Ask if east stays in one place or moves, because we have learned that the earth moves. Ask if they have any ideas to decide if it moves. Suggest that they could use the Sun to help answer this question. Outline the activity. Partners work together, one is blindfolded before we go outside. The sighted partner leads the blindfolded one. Show them how to assist by having the blindfolded person place their forearm over the sighted partner's forearm. The sighted partner needs to know that they need to have their partner face south, and that when you get outside you will point for them to know where it is. Tell them that the blindfolded partner uses their sense of touch to feel where the Sun is. Tell the sighted partner that they cannot "help" them know where it is, but that they should listen to their blindfolded partner and help them remember which side of their face/head they felt the Sun's heat. Once the activity is established with the students, have the blindfolded students place the blindfolds over their faces (help adjust tightness as needed). Then proceed to the place to do the investigation. This will not take too long. Blindfolded friends can remove the blindfold once they confirm with their partner their findings. Return to the classroom to record the data.

Depending on the hours of your school day, I recommend as close to 8:00am, between 11:00 and 12:00, and 2:30 to 3:30. I also recommend mid-September, mid-December, mid-March, and the first week in June (if possible, otherwise, late May). It will depend on the time of year where the students feel the Sun, and it may be difficult to feel a difference in the winter because the Sun is so low in the sky. Try to make this a flexible lesson where you choose the clearest day possible for maximum sunlight. Do not share this information until all investigations for the year are completed. Let the students see their data and discuss it first.

Lesson #5 – Shadow Catchers A & B

Enduring Understanding

The amount of daylight depends on the day of the year because the Sun takes a different path through the sky each season.

Essential Question

Why is it that some days during the school year I have to wake up in the night to come to school, and other days I have to go to bed when the Sun is still up?

Objective

Students should learn through collecting data (by one or two methods) that the Sun takes a longer path through the sky during the warmer months, thereby creating a longer day.

Materials and Setup A

A flagpole, knowledge of where South is, three copies for each student of the “Recording the Sun’s Position in the Sky” worksheet, clipboards (or something to lean on when writing).

Procedures

Before beginning this activity, play Stand the Line (see above in Strategies) with questions about what students know about how the Sun moves. “The Sun moves from east to west.” “The Sun moves around the Earth.” “The Sun rises the same time every day.” Students bring their recording sheet, pencil, and clipboard outside to gather at the flagpole. They are to record where they see the sun in relation to the flagpole while facing south. Again, you do this activity three times a day, four times a year. See my recommendations for timing in Activity 4 Procedures. I recommend do all the morning on one page, all the midday on another, and the late afternoon on a third page. This way, the students compare the different times of year, but also the different times in the day.

Keep these until the end of the year to discuss their findings. Share the analemma at this time to connect what they recorded on their worksheets.

Materials and Setup B

Each student needs a tower of six Unifix cubes, the Recording Shadows worksheet, a pencil, and a clipboard. Locate an appropriate place on the school grounds where the students can face south and they each can have a specific place to return to each time they do this activity. This is important, so they can compare the length of the shadows made throughout the year.

Procedures

Students color in the shadow made by the tower of cubes placed vertically in the center of their paper. They do this activity three times a day, once a month (if possible). To see the pattern more clearly, more data points would be helpful. The shadows should be longer in the winter months and get shorter as the year progresses. Keep these papers for the year to return to and discuss their findings.

Hopefully, you find these activities purposeful while fun and engaging for your students. They should generate thoughtful discussion. Assessment should focus more on the discussions and participation more than accurate recording of data. We are introducing science to our young learners and we want them to be excited about doing science. They should be able to articulate the patterns that they have observed throughout the year.

Resources for Classroom Activities

Several articles on readworks.org which is an online source for non-fiction articles.

https://stellarium.org/ this site provides an online app that helps you find your place in relation to the stars, the Moon and the Sun.

https://www.youtube.com/watch?v=OZIB_leg75Q. Synchronous Rotation of the Moon video which is an excellent representation of the moon's rotation!

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