Approaches to Assisting Elementary Education Majors with Lunar Concepts

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Abstract

In order to prepare the next generation of elementary school teachers to teach astronomy concepts, specific activities are included in their science methods course that use modeling practices to address common misconceptions and alternative conceptions. Accessible materials and electronic simulations are used in sequence to build conceptual models of how the moon progresses through its phases and why lunar eclipses are not a monthly event. This poster documents my efforts toward this task.

Introduction

Ideas for teaching students about the phases of the moon are abundant. Some of them are even useful. Others are focused so much on teaching the names and order of the phases that they introduce as many misconceptions as they may have settled. The common Oreo moon phases for example illustrates the phase of the moon observed from Earth but fails to help students explain why the moon experiences phases.

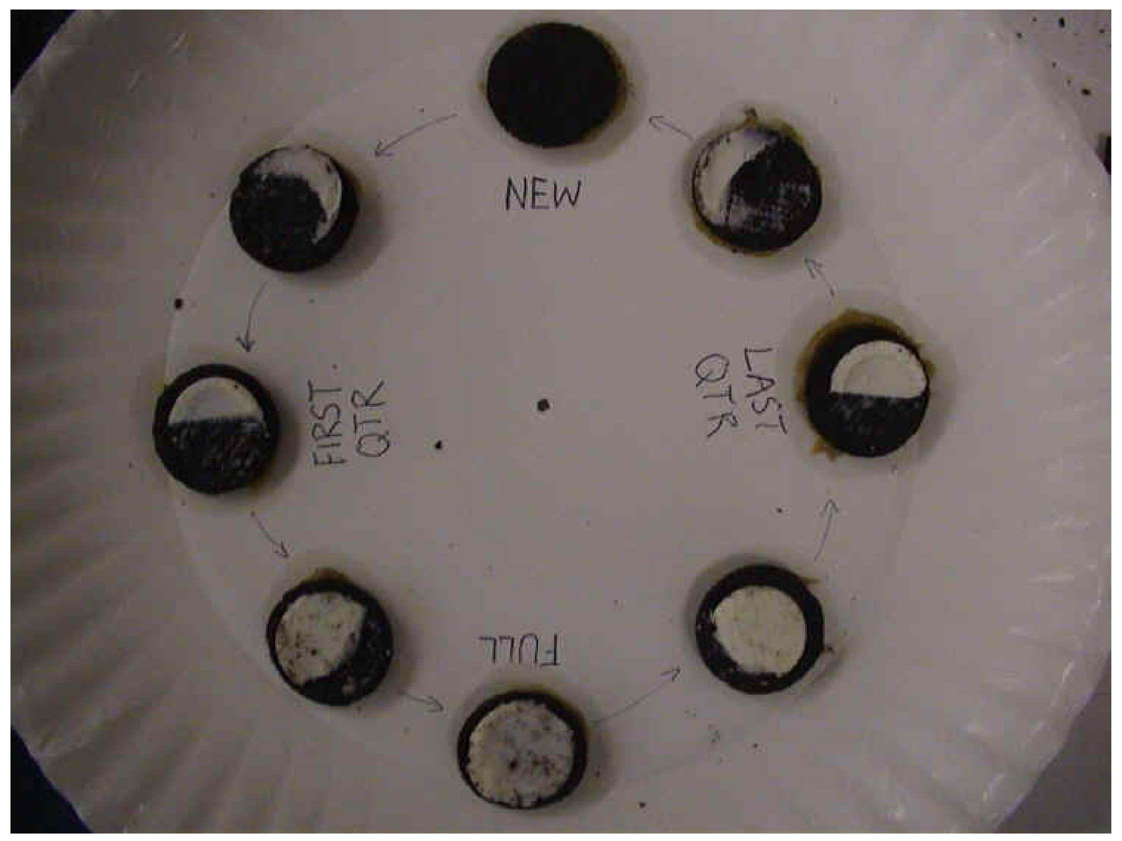


Figure: Oreos are placed in a circle around the circumference of a plate. If the Earth is imagined to be at the center, the icing of the cookie represents the illumination of the Earth. The model appears to indicate the moon moves in a circle but fails to be useful in explaining how these patterns appear in this order, or how the position of the Earth-Moon-Sun accounts for these patterns.

Fortunately the Next Generation Science Standards for K-5 elementary are centered on the determination of *patterns* from observation.

ESS1.A: The Universe and Its Stars
Patterns of the motion of the sun, *moon*, and stars in the sky can be observed, described, and predicted. (1-ESS1-1)

ESS1.B: Earth and the Solar System
The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, *moon*, and stars at different times of the day, month, and year. (5-ESS1-2)

Objectives (SWBAT)

1. describe the daily apparent motion of the moon across the sky and compare and contrast to that of the sun, as well as explain why the moon rises and sets later each day.
2. use the positions of the sun, earth, and moon to determine the phase of the moon.
3. use the contrasting phases of the moon and Venus to argue in support of the heliocentric model.
4. explain the difference between lunar sidereal and synodic months.

Approach #1: iPad Simulation

GoSkyWatch Planetarium

Any planetarium app that allows you to set the date and time AND set that clock into motion is useful for helping students investigate patterns in the motion of celestial objects. I always start by having students follow the motion of the sun across the sky from sunrise to sunset. As they observe this pattern they also note that the moon, planets, and stars also demonstrate *apparent motion*.

I ask the students to note the rise and set times for the moon, and then challenge them to make a daily table of these to determine any patterns in the moon's motion. Students determine the shift to be roughly *50 minutes later* each day.

"Why 50 minutes?" I ask. Then I have the students choose a fixed time and change the date, one day at a time, to see that the moon slips westward each day. In our discussion the students account for this motion by noting that the *moon is slowly moving* around the Earth.

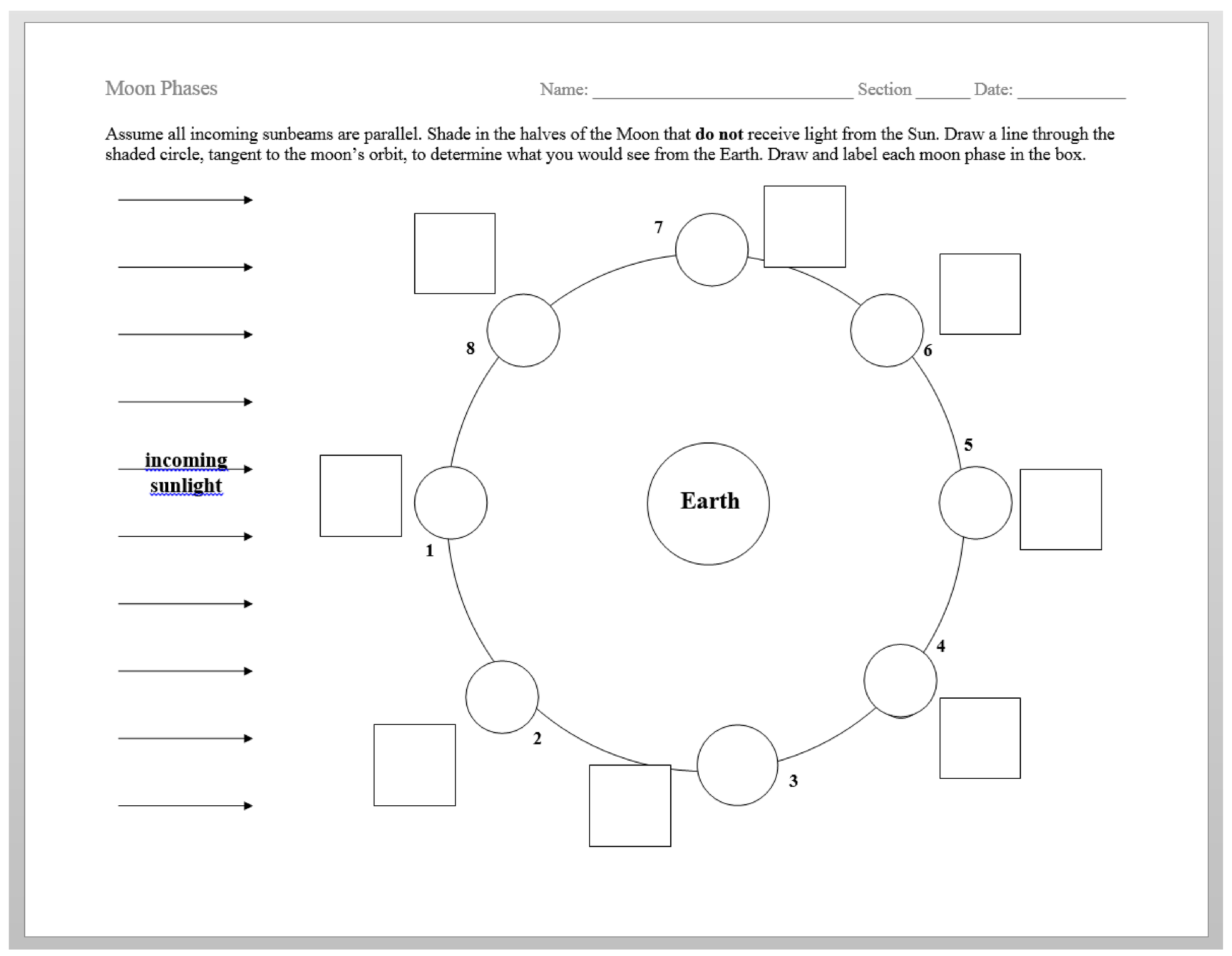
I challenge them to determine the rate of the slip by dividing the degrees in a circle (360°) by the period of moon phases (29.5 d) to get 12.2 degrees/day. If it takes Earth 24 hr to move 360 degrees, then it takes 0.81 hr to move 12.2 degrees. Multiply by 60 to get 48.8 minutes.

Other ideas and connections to focus on include: (a) the moon is visible during the day; (b) the moon demonstrates phases; (c) the moon is more full when it is in the opposite side of the sky from the sun.

Moon Phase + (Free)

Keeping a moon journal is a wonderful activity for faithful and dependable students and should be strongly encouraged in order to build students' observational skills. But the same patterns that can be gleaned from the data kept in a moon journal can be determined in a shorter period of time using this moon phase app. Moon Phase + provides a large picture of the moon phase as well as other data including rise and set times and visibility. Students can quickly observe the *terminator* moving from right to left. They can determine the period of the moon phase cycle (29.5 days)

Approach #2: 3D Modeling

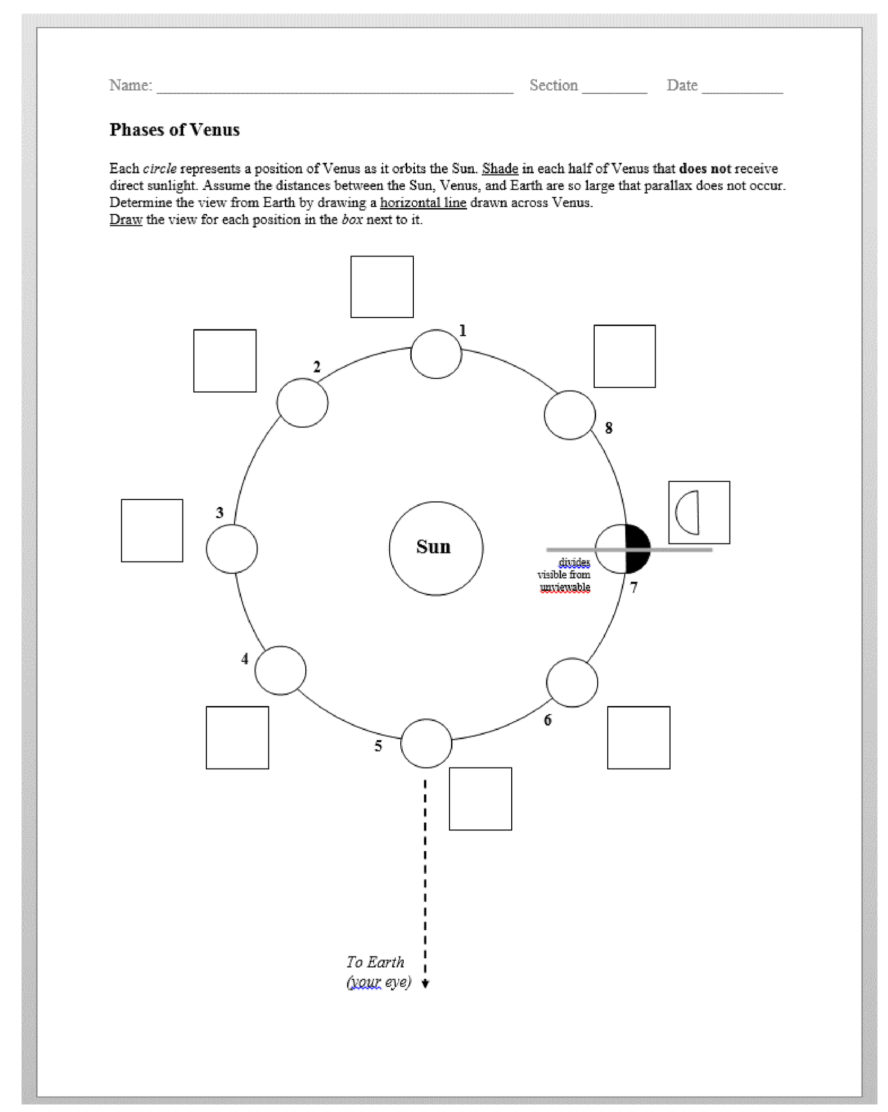


Moon Phases Name: ______________________ Section ______ Date: ___________

Assume all incoming sunbeams are parallel. Shade in the halves of the Moon that **do not** receive light from the Sun. Draw a line through the shaded circle, tangent to the moon's orbit, to determine what you would see from the Earth. Draw and label each moon phase in the box.

Phases of the Moon / Lunar Orbit
In my experience, too many teachers rely on a completed diagram to teach the phases of the moon. Earlier in my career I believed my students could simply use geometry and these templates to determine the phase of the moon.

One year I got the inspiration to use half-shaded ping pong balls and sticky tack to actually place the moon in position. The students place the ball in the circle so that the white side faced the sun and the shaded side faced away. Then I directed the student to look along the plane of the paper, positioning the eye so that it aligned with the Earth and moon, so that students could see the moon phase. Whatever they saw was to be drawn in the box next to the circle. This exercise yielded better understanding of moon phases than the "ball on a stick" method because there was no chance for a full moon eclipse.



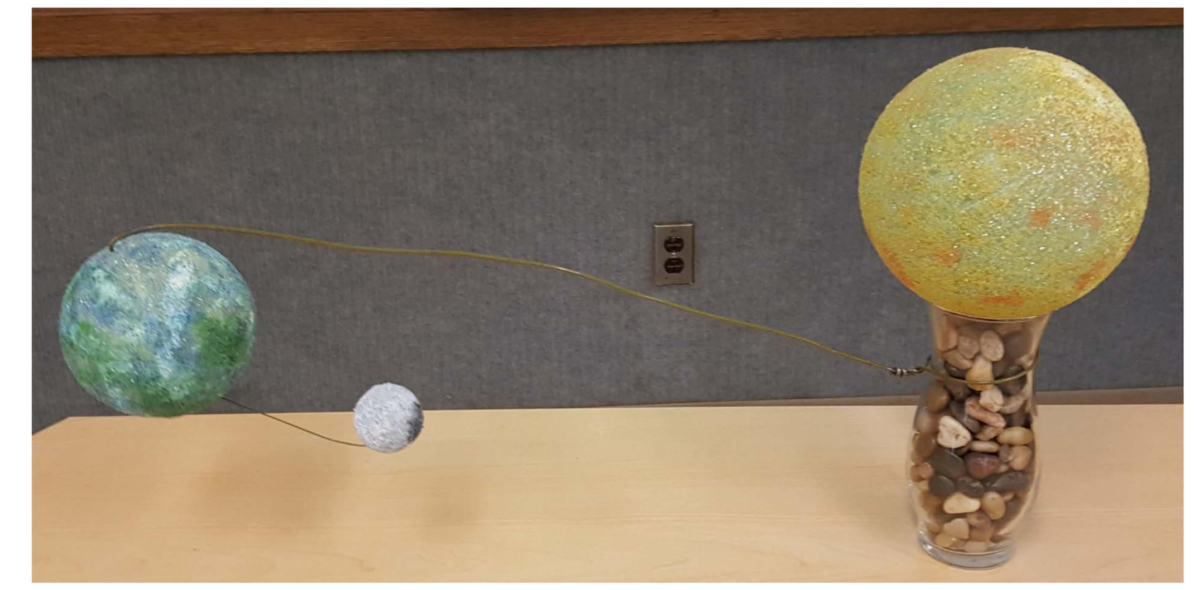
Name: ______________________ Section ________ Date __________

Phases of Venus

Each *circle* represents a position of Venus as it orbits the Sun. Shade in each half of Venus that **does not** receive direct sunlight. Assume the distances between the Sun, Venus, and Earth are so large that parallax does not occur. Determine the view from Earth by drawing a horizontal line drawn across Venus.
Draw the view for each position in the *box* next to it.

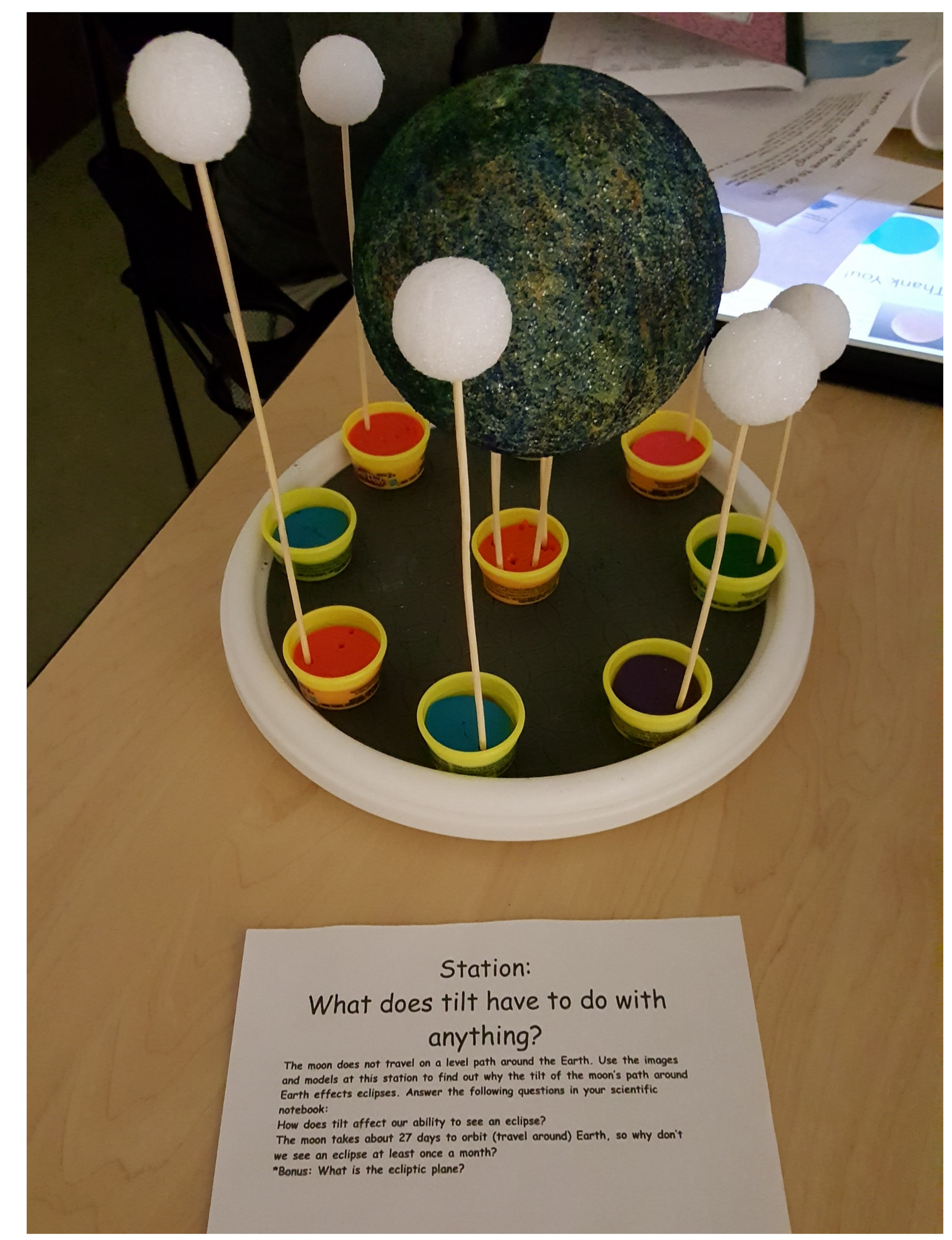
Phases of Venus
I like to contrast the phases of the moon with the *phases of Venus*. Students place the half-shaded ping pong ball on the diagram to represent Venus and draw in the phases. Through a series of questions I help them to realize the only explanation for the differences in Venus' phases is that it must be moving around the sun, serving as strong evidence for the heliocentric model.

Approach #3: Mechanical Models



Mechanical models provide an opportunity to physically manipulate an apparatus to test mental models. Two such models are shown above. The top one is useful for illustrating the many concepts, but I primarily use this to help students understand the difference between lunar sidereal (27.3 d) and synodic (29.5) periods. Dividing 360° by 12 months, we note the Sun moves 30 degrees/month. By the time the moon completes one full circle of motion, the Earth will have shifted by this amount, meaning the Sun-Earth-Moon will not yet be in line. Thus an additional 2.2 days of motion are required to realign and complete the cycle of phases.

The below model exaggerates the tilt but is useful for illustrating why Earth does not experience a eclipse every full moon. A student created this model and constructed questions for use in a teaching station.



References

Access the Next Generation Science Standards by Topic
http://ngss.nsta.org/AccessStandardsByTopic.aspx