Galileo Was Right!
Proving a Sun-centered Solar System Using a Kinesthetic Model

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This activity is useful for a quick, low cost method of demonstrating one of Galileo's observations using his telescope: the phases of Venus (how much sunlight we see reflected from its disk) change with time, and Venus appears to change size as well. We will use orbital models of the Moon and Venus to demonstrate the following:

1. The moon's apparent diameter changes very little in the course of one complete orbit of the Earth.
2. If Venus orbited the Earth, we would likewise see very little change in its apparent diameter.
3. As Venus orbits the Sun, its apparent diameter changes greatly, and this change is consistent with a Sun-centered solar system.

Materials:
Ball about the size of a human head
A tennis ball or other ball of similar size for each student
Stick lamp or other central single light source
Small ruler
10 foot (4 meter) tape measure
Open space (at least 30 feet, or 8 meters, in diameter)

Terms to Know:
Apparent diameter
Geocentric (Earth-centered)
Heliocentric (Sun-centered)
Orbit
Model
Scale

Procedure:
- Arrange the stick lamp in the center of the room. Make sure that it is the brightest single source of light (draw window shades, or cover 'light leaks').
- Arrange your students at the edge of the room.
- Give each student a small ball. This ball represents the Moon. Students should hold the ball at arms length, and slowly turn counter clockwise (to their left).

- They should notice that the amount of light shining on the Moon appears to change from their viewpoint. These are the phases of the Moon, and you can use this as an opportunity to defeat the misconception that the Moon's phases are caused by shadows, or that the moon shines using its own light.
- Then have students measure the apparent diameter of the Moon at any 4 points in its orbit around their heads using the ruler held 10 cm (3 inches) from the tip of their nose. The students should observe a nearly constant diameter. Point out that any object in a regular orbit around Earth would show a similar pattern
- You will then move the students away from the edges of the room, and have them cluster together closer to the lamp (leave at least 3 meters between them and the lamp). Take the larger ball, and slowly walk around the students at a distance of 3 meters away. Ask the students to make observations of the ball. Try not to let your shadow fall on the ball (holding it above your head will work nicely).
- The students should notice that the ball is changing phase, and remaining roughly the same apparent diameter. Students then measure the apparent diameter of the larger ball at 4 points as you orbit around them, using the same ruler held at the same distance from their nose. Tell them that you have just demonstrated what Venus would look like to Galileo if it orbited Earth.
- Return the students to the edges of the room. Hold the large ball, and walk around (orbit) the lamp at a distance of 3 meters from it. Again, hold the ball aloft to keep your shadow from interfering, and ask the students to observe what is similar and different about the ball (point out that this is the same ball you were just holding a few minutes ago).
- They should observe that phases are similar, but the ball appears larger when it's close and smaller when it's far away. Then have them measure at 4 points in your orbit of the Sun with the ruler, using the same procedure as before. They should include measurements when you are closest to them, and again when you are furthest away from them. After they have completed the measurements, ask them to draw what Venus looked like when it was closest, and when it was furthest away. Then, show them Galileo's drawings of Venus.
- Ask them what motion Venus was doing when they drew it (orbiting the lamp) and what motion Venus actually makes in the sky (orbiting the Sun). Ask them if Galileo was right! Allow lots of time for discussion.

You should point out that this model is way out of scale! If the students' heads are the Earth, the Moon would be located about 25 feet (7 meters) away, instead of at arm's length, Venus would be located at least 180 feet away, and the Sun would be the size of the school building (about 55 meters wide) and located almost 600 feet away!