SUN SHADOW CYCLES

Performance Standard 12F/11B.C

Students will apply the processes of technological design to document the natural cycles and patterns in the solar system accordingly:

- *Knowledge*: Identify the patterns of Earth's daily rotation on its axis and annual revolution around the sun,
- *Application*: Model the daily rotation and demonstrate the "shadowing" pattern from the sun over time and seasons through technological design investigations.
- *Communication*: Explain the patterns of the Earth's rotation and revolution.

Procedures

1. ***In order to know and apply concepts that explain the composition and structure of the universe and Earth's place in it (12F) and know and apply the concepts, principle and processes of technological design (11B),*** students should experience sufficient learning opportunities to develop the following:
   - Propose ideas for how to model the Earth's rotation on its axis and revolution around the sun through the processes of technological design.
   - Select, "construct", test, and critique their design for Earth days and nights.
   - Explain the changing position (orientation) of the Earth and the sun in the Earth's revolution throughout a full day.
   - Propose ideas for how to observe the shadowing pattern through a day and season.
   - Select, construct, test and critique a technological design for observing shadows through a day and season.
   - Explain changes in shadows during the days of different seasons.
   - Communicate the natural patterns of the solar "shadowing" cycles.

   Note to teacher: These activities relate to knowledge associated with standard 12F, while addressing the performance descriptors for stage C within standard 11B. Applying scientific habits of mind noted in standard 13A are foundational to these activities. Using various technologies to estimate, measure and record data address some performance descriptors in 13B. This activity and assessment have strong components that incorporate data collection strategies.
2. Have students review and discuss the assessment task and how the rubric will be used to evaluate their work.
3. Introduce this "Earth in Space" technological design investigation by asking students to describe the observed "cause and effect" of the Earth's rotation on its axis and revolution around the sun, by asking questions such as: "What makes day and night?" "What creates the light of daylight?" "Why doesn't day last all the time?" "Why are days and nights shorter and longer sometimes?" "What makes shadows?" "Are they the same always?" "What does the tilt of the Earth have to do with long days in the summer and short days in the winter?" etc. Record their answers and questions. Using a "think aloud" approach, try to enlist students help to pose ideas or "prototypes" for how you can model the day-night rotation of the Earth. You may choose to model Earth as a ball in a light source's "path". Look for the dark part of the ball. Relate the dark part to night. Build an understanding that the shadowed part of the solar system object is night time and that all day/night shadows are caused by sunlight. Offer necessary information about the established "tilt" of the earth so that their models can incorporate this "stipulation". Allow the students sufficient time to test their "prototype" ideas and then share their test results. (One suggestion is to use tennis balls glued to a golf tee to hold the angle of rotation constant, and a thumbtack to represent the location of Illinois.) Encourage students to propose ideas for how to improve their design so that it models how the earth moves around the sun, and as an extension, test for the dilemmas of longer or shorter days.
4. The assessment for understanding this concept rests on the explanations offered for how night and day occur on the Earth according to their models (or modified models after improvements from first design "prototype") and from data they collect. A generalized strategy for assessment requires a globe (or any kind of sphere, initially) and a light source. First, place a piece of tape or sticker on the globe representing the location of Illinois. Have each student shine the light on the globe showing Illinois in the daylight. Then have them show what happens to the Earth to cause nighttime in Illinois.
5. Broaden the investigation to include the concepts associated with changing shadows during the day. Ask students to observe their own shadows in the classroom. Ask if there is a difference in the shadow of the same person at different locations. Encourage the students to diagram the setting which includes the light source, the

person, the angle of the shadow and the lengths. They should propose explanations for why their shadows change with their "constant" light source. Continue the shadow observation process outside at specific times during one day (morning, noon, and afternoon) at the same location (probably on the playground in an area with an unobstructed view of the sun). By working in pairs, students will be able to collect data about themselves at the three specific times. Be sure to include their actual heights, shadow lengths, times and sun location and record the date. Periodically, repeat this activity throughout the week, month, season and year. Different pairs of students may be assigned to specific dates for data collection when it is not feasible for all students to collect data in the investigation. The technological design component of this activity needs to focus on the development of criteria to take consistent measurements for shadow-making, whether in the classroom or outdoors. The source of light and its angle are of primary consideration. Students should consider what happens to a shadow as the sun's position changes during the day. The basic question or dilemma to investigate is how to measure and record the shadow lengths corresponding to the angle of the source of light. By designing a strategy to measure consistently for classroom data tables, students will begin to note the changing position of the sun in the summer, fall, winter and spring sky. During the winter, the sun follows a lower path in the sky; during the summer, a higher path. The simplest strategy may be to require the student to face north or south (use compasses, if necessary) and record how high the sun is in the sky by raising their arms to point to the sun (possibly recording that their right or left arms are at the 10:00, 12:00 or 2:00 clock positions and drawing stick figures to represent the sun's location. They will need to practice this so that they can record the "angles" accurately. They could start with both arms held directly overhead to mark "high noon" and move only one arm to mark the location of the light source—the sun.) They need to create data tables that will record all of the necessary information they can collect about the shadow-making process. Students will be assessed on their understanding periodically about the changes in the shadow data through explanations of the patterns from the classroom's data tables.

6. Bring closure to both activities by consolidating the information about the day-night rotation, tilt of the Earth and the annual revolution around the sun and the changes in shadow-making. Synthesize their findings about shadow-making during a day and how this shadow-making changes through the seasons because of the way that the Earth tilts in its revolution around the sun.
7. As a final assessment for the long-term activity, ask students to diagram the relative path of the sun in the sky. From their data and diagrams, they should be asked to:
   - Predict the shadow lines that would be made at sunrise, noon, and afternoon.
   - Explain whether shadow lines would be longer in summer or winter and why.
   - Ask them to show both rotation and revolution of the Earth in its orbit.
8. Evaluate each student's work using the Science Rubric as follows and add the scores to determine the performance level:
   - *Knowledge*: Day/night activity: Understanding of the rotation of the Earth for day-night patterns is complete and accurate. Shadow-making activity: Understanding of the Earth revolution of the sun patterns is complete and accurate.
   - *Application*: Demonstrations of how night and day occur on Earth and of how shadows relate to the Earth's rotation and revolution around the sun were thorough and accurate.
   - *Communication*: The explanations of the Earth's day-night patterns and the path the sun appears to take in the sky in different seasons and the relationship to shadows were logical and well-detailed.

Examples of Student Work not available

Time Requirements

- 15 to 20 minutes for introductory day/night activity; 15-20 minutes for prototype development; approximately 30-40 minutes for individual or group demonstrations of day/night modeling
- 15-20 minutes for introductory shadow-making activity in the classroom; 15-20 minutes for initial outdoor shadow-making activity; 10 minutes for each periodic shadow-making activity three times a day, multiple times within a month and season.
- Shadow-making investigation task sheet for class assessment
- Five minutes per individual assessments for each technological design investigation

Resources

- Spheres of various sizes, including a globe
- Flashlight or desk light, bare light bulb without a shade, sunshine
- Compasses, if available
- Science Rubric