THE SUN MAKES A CLOCK

Performance Standard 12F/11B/13 B.E

Students will apply the processes technological design to explain planetary and stellar cycles and investigate their interactions in society accordingly:

- *Knowledge*: Identify the basic principles of sundials and the societal reliance on time-keeping.
- *Application*: Design a usable sundial using appropriate scientific and mathematical concepts.
- *Communication*: Explain their observations from their sundials in terms of the relative motion of the earth and sun and the historical context of this technology.

Procedures

1. ***In order to know and apply concepts that explain the compositions and structure of the universe and the Earth's place in it (12F) and the processes, concepts and principles of technological design (11B), and the concepts that describe the interaction between science, technology and society (13B),*** students should experience sufficient learning opportunities to develop the following:
   - Brainstorm the technological design dilemma of applying the apparent motions in the Earth and Sun to use the sky as a clock.
   - Research historic designs for keeping daily time.
   - Examine models of the Earth's daily rotation on its axis and shadow formation.
   - Suggest appropriate materials, equipment and data-collection strategies, procedural sequence, success criteria and design options to safely test the technological design of a "timepiece".
   - Sketch design plan and select appropriate graphic display of data according to success criteria variables.
   - Complete assembly of innovation, following classroom rules for preparation, procedures and clean-up,
   - Collect and display mathematical/geometric data from investigation accurately and honestly.
   - Test prototype of design by conducting multiple trials and record observations.
   - Use scientific technologies to collect, store, retrieve, and communicate data, and incorporate appropriate safety precautions.
   - Recognize the necessity of controlled variables and compare carefully recorded observations and summaries.
   - Identify faulty procedural steps which could cause different results, errors, or distort how variables interact.
   - Communicate an evaluation report to explain the observations and explanations for differences in time-keeping accuracy for peer review.
   - Compare historic designs and technologies for keeping daily time.
   - Generate further questions for future investigations to measure time.

   Note to teacher: This activity relates to knowledge associated with the standard 12F, while addressing the performance descriptors for stage E within standard 11A. Applying scientific habits of mind noted in standards 13A are foundational to these activities. Exploring the historical designs and societal connections for time-keeping addresses performance descriptors in 13B.
2. Have students review and discuss the assessment task and how the rubric will be used to evaluate their work.
3. Begin contextual technological design investigation asking students what the shadow of a familiar object (the school's flagpole, etc.) would look like right now. Ask how this would change at various times of the day. Be sure students refer to both appearance of the shadow (length) and location (relative position to object). Brainstorm as to why shadows change as they do. Check student understanding of relative motion of both the Earth and the Sun and awareness that the 'movement' of the Sun is due to the position of the Earth in relation to it. Explain that humans have used this knowledge of the apparent movement of the Sun to create measure of the passage of time. The concepts of seconds, minutes and hours are simply measure of parts of a day, the time necessary for any planet to rotate one time on its central axis. Ask students if they have heard about or seen a device that allows you to tell the time based on the position of the Sun—sundials. Describe them and determine the common features.
   - The gnomon—the one who knows' will create the shadow.
   - The NOON line should be facing true north (astronomical), rather than magnetic north.
   - Sun time and Clock time only correspond at local noon of the solstices and equinoxes.

   Guide students toward stating their understanding using appropriate scientific vocabulary terms.

4. The premise of this investigation is to design a sundial which can mark daily time accurately. Students (or teacher) need to determine the success factors (what makes a good sundial?), the minimal allowable materials, dimensions and testing time, how to collect what data on which variables, etc. Allow time for design within the class period or beyond. The students need to sketch their plans, construct and test their design over several days and collect appropriate data about the increments of the apparent motion of the sun.
5. Students should research historic time-keeping methods and devices. Assign groupings to study and present time-keeping through history; this should incorporate daily, annual or seasonal devices from global history.
6. Tests for the timing technological designs should be made outside at a sunny, flat location after checking the local time. If Daylight Savings Time is in effect, subtract one hour. The student's dial should measure "sun time" rather than "clock time". Depending on mathematical understanding and curriculum, students may be asked to incorporate geometric factors about the hours and minutes; otherwise their design should at least show predictions for hourly (and perhaps quarter-hourly) divisions. Accuracy will need to be checked over time during the day.
7. Students should test and explain why they made their design decisions.
8. Encourage students to generate further questions which could follow from their initial research and presentations. Such questions could include how and why time zones were developed, how accuracy of time has improved, etc.
9. Evaluate each student's work using the Science Rubric as follows and add the scores to determine the performance level:
   - *Knowledge*: The basic principles of time-keeping and their historic significance were complete and correct,
   - *Application*: The sundial design was tested and proven to be accurate, and
   - *Communication*: The explanations for the experimental observations and historic designs were complete and accurate.

Examples of Student Work not available

Time Requirements

- Initial discussion and introduction to assignment: 25 to 30 minutes sessions, 2-4 days/class periods for research and prototype testing: 1-2 class periods for presentations and new question generation.

Resources

- Determined by student or teacher decisions for shadow makers and dial faces
- Science Rubric