



Galaxy NGC 4013 (Image: NASA)



Orion Nebula (Image: NASA)



ENGAGE

Ask your students the following questions based upon the picture of Piplup (TEACHER RESOURCE).

- In the Pokémon world, what might cause Piplup's shadow?
- How might this shadow change?
- In our world, what can you infer, or guess, about the time of day by looking at shadows?
- How might Piplup's shadow "tell time?"



Piplup

EXPLORE

A. Piplup's Shadow

Students should work with a partner to explore the Sun-Earth relationship through experiments with a shadow stick. A shadow stick, or gnomon, is a simple form of a sundial. The time of day can be inferred by the length and position of the stick's shadow.

1. For each team, you'll need:
 - A ruler or meter stick
 - A wooden skewer
 - A picture of Piplup
 - A ball of clay
2. Instruct the students to cut out Piplup's image (STUDENT HANDOUT) and tape the image to the dull end of a wooden skewer.
3. On a sunny day, choose a spot that is flat and out of the shadow of buildings and trees.
4. Ask the students to flatten the ball of clay into a circle and stick the skewer in the middle of the clay. They've created a gnomon that will cast shadows.
5. Be sure that the skewer is perpendicular to the ground.
6. Using a chart similar to this chart, ask the students to record the time and to measure and record the height of the skewer, from the ground to the top of Piplup's image.
7. Students should mark the end of the shadow with a small rock or similar object. Ask them to measure and record the length of the shadow.
8. Ask students to take digital images of their gnomon's shadows. If they need help, guide them to Nortel LearnIT video tutorials at: <http://nortellearnit.org/technology/Imaging/>.
9. Allow your students to return to this spot every 30-45 minutes for additional measurements and photos. Repeat the readings as often as you can.
10. Lead your students in a discussion about the changes they've observed in the shadows.

Data Chart

Time	Length of the gnomon	Length of the shadow

B. More Sundials -- If time permits, students could create paper sundials following directions found at these websites:

- http://www.nasa.gov/audience/forchildren/activities/A_Make_a_Sundial prt.htm
<http://www-spof.gsfc.nasa.gov/stargaze/Sundial.htm>



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EXPLAIN

- A. Lead a discussion using these questions:
- What changes in the Sun's shadows did you observe throughout the day?
 - Are there patterns to these changes?
 - How could you use the length of the shadows to tell time?
 - Describe the Sun-Earth movements that cause these shadows.
- B. Guide students to these Internet resources for more information about Sun-Earth relationships, shadows and timekeeping:
1. NASA's Sun-Earth Day Multimedia: SunWatchers Through Time
<http://sunearthday.nasa.gov/2005/multimedia/timeline.htm>
 2. NASA Sun-Earth Day Website:
http://sunearthday.nasa.gov/2005/educators/lp_k5.htm
 3. What Makes Shadows?
http://eyeonthesky.org/lessonplans/04sun_shadows.html
 4. Making Sundials:
http://eyeonthesky.org/lessonplans/14sun_sundials.html
 5. What Makes Day and Night?
http://eyeonthesky.org/lessonplans/05sun_daynight.html
 6. NASA KSNM video: *Night and Day*
http://ksnn.larc.nasa.gov/k2/s_nightDay_v.html
 7. Sundial animation:
<http://liftoff.msfc.nasa.gov/Academy/Earth/Sundial/Sundial-how.html>

ELABORATE

Challenge your students to create a short PowerPoint slideshow using a digital camera to capture pictures of shadows. To complete this project, you'll need digital cameras and digital imaging software. Before you begin, you may want your students to review the Nortel LearnIT Digital Imaging videos at: <http://www.nortellearnit.org/technology/Imaging/>

- A. Timekeeping Powerpoint Story
1. On a sunny day, working in teams of two, ask your students to hunt for several scenes that show objects and their shadows created by the Sun. Using digital imagery, capture pictures of these scenes at different times of the day so that the shadows vary.
 2. Just as legends are told about Dialga's dominion over time, so have legends been told about Earth's cycles of night and day. Ask students to add a legendary story to their PowerPoint presentation that helps explain Earth's timekeeping cycles. Some night/day legends are found at the Sky Tellers Website: http://www.lpi.usra.edu/education/skytellers/day_night/
 3. Help your students create a PowerPoint slideshow using these images and stories. The slideshow should "challenge" other students to make inferences about the time based upon the shadows and creatively explain the changes through storytelling.
 4. A PowerPoint storyboard will help students creatively organize their slides. A storyboard can be found at: <http://www.nortellearnit.org/resources/Handouts/>
If needed, students can learn more about PowerPoint by reviewing these Nortel LearnIT PowerPoint videos at: http://nortellearnit.org/technology/PowerPoint_Presentations/



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EVALUATE

Through discussion and student drawings, determine if your students have an accurate understanding of Earth's movement around the Sun. Check to see if students understand the relationship between the length of an object's shadow and the position of the Sun in the sky.

To evaluate the PowerPoint slides, use a rubric found at the Nortel LearnIT site:

<http://nortellearnit.org/resources/Handouts/>

EXTEND

These activities may be used to extend or continue your students' exploration.

A. EXPERT INTERVIEWS – WHAT DO YOU WONDER NOW?

What are your students wondering now that they've learned more about the Sun-Earth connection and timekeeping? Generate a list of questions that your students might ask "the experts" from NASA, the National Institute of Aerospace, and research universities. Submit this list following the link on this website. Several questions from all submitted will be used in video interviews with "experts" and posted to this site.

B. Over the years, people have created many interesting ways to measure "time." They've used sand clocks, water clocks, candle clocks, and now atomic clocks. Find out more about these timekeepers by visiting this website:

http://hea-www.harvard.edu/ECT/the_book/Chap3/Chapter3.html

An animation of several historical sundials can be found at this website:

<http://www.britannica.com/eb/art-60367/Before-precision-machine-parts-could-be-made-for-clocks-people>

Once your students have learned more about timekeeping devices, challenge them to create their own timekeeping devices.

C. Make a "horizontal sundial" by following the directions found at this website:

<http://www.lmsal.com/YPOP/Classroom/Lessons/Sundials/novice.html>

D. The Sun isn't the only natural object that can be used to tell time. People can also tell time by looking at patterns and changes in the stars. This online edition of *Sky & Telescope* helps you make a star clock.

http://www.skyandtelescope.com/letsgo/familyfun/Make_a_Star_Clock.html

E. Moon phases show changes in time, too. Explore this website to learn more about Moon phases and how the Moon's cycle helps tell time.

<http://www.astro.umd.edu/educationalresources/astro/moon/phases.html>



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