ABSTRACT

This lesson investigates light pollution in the night sky. Students conduct the investigation using local resources, the Internet, digital cameras, computer-based sensing probeware, and laptop computers. Analysis of the data and synthesis of their discoveries by student investigation teams lead to recommendations for modifications to lighting practices and uses. Student groups make presentations to a panel of city planners and community members. *At Issue: Light Pollution* is designed for seventh and eighth graders, but could be modified for younger or older students.

TIES TO CURRICULUM

At Issue: Light Pollution fulfills many objectives of the *National Science Education Standards* and the mathematics standards set by the National Council for Teachers of Mathematics. Students conduct a scientific inquiry into light pollution and energy using appropriate tools and techniques to gather, analyze, and interpret data, as mandated by both sets of standards. The investigations require students to use scanners, digital cameras, multi-media presentation software, and computer-based remote sensors to collect data, so students also develop technology proficiency.

LEARNING OBJECTIVES

In this investigation students will

- investigate how light relates to other forms of energy;
- construct and use instruments to investigate the properties of light;
- explore the right triangle relations sine, cosine, and tangent and their applications in measurement;
- select and compute appropriate units to measure distance and angles;
- collect information, data, and observations;
- select and organize information needed to solve a problem; and
- propose action regarding the issue of light pollution in urban areas.

NUMBER OF LAPTOPS AND GROUP SIZE

This activity requires at least one laptop, but one laptop per group of four students is ideal.

TIME REQUIREMENT

At Issue: Light Pollution requires approximately seven hours for review, data collection, and discussion. If findings are significant, you may need additional time for presentations.

Task	Time	Location
Introduction	3 hours	Classroom
Data collection	1½ hours at night	Outside
Data analysis and recommendations	3 hours	Classroom/ homework

LESSON DESCRIPTION

MATERIALS

- Laptop computers
- Internet access
- PASCO Science Workshop
- Word processing, spreadsheet, image manipulation, and multimedia software
- Computer interface box and software, and necessary cables to connect to laptop (e.g., PASCO Interface 500)
- Light sensor probe
- Motion sensor probe
- Digital camera
- Trundle wheel or 100 m tape
- Clinometers (homemade or purchased)
- Paraffin wax
- Knife or razor
- Aluminum foil
- Rubber bands
- Flashlights
- Walkie-talkie units
- Presentation technology (e.g., LCD panel or digital projector)
- Resource material on stars, constellations, light, electricity, light fixtures, lamps

Students conduct investigations of the properties of light (light intensity, how light travels, how lights and lamps differ from each other, etc) in the classroom. Students will determine if we waste light at night outside our school and in our communities, and if there are options that could be phased in over time to reduce energy loss and light pollution. Both simple and sophisticated tools are used in the classroom to conduct these investigations. Ask teams to keep careful records with both tools, and to record results and conclusions in logs on the laptops.

Introduction

Introduce the concept of light pollution, the yellowish glow in the night sky which marks the sky above many urban areas. In designing city lights, little thought may have been given to energy efficiency and conservation, and many city lights throw as much light upward as they do downward to brighten streets, sidewalks, and parking lots. The resulting light pollution is visible from space, as students will see on the Earth and Moon Viewer or the Internal DarkSky Web sites (see Figure 1). Spend a few class periods and homework assignments investigating light pollution.

Figure 1: A night view of the United States from space

International DarkSky Association

Explain that after conducting preliminary research, students will create night views of their local area using the laptop and digital projector. Students can use a simple tool made out of paraffin to compare light intensities. To make this tool, cut a block of paraffin in half (see Figure 2).

Cut a piece of aluminum foil the same size as the original paraffin rectangle. Fold the foil in half, shiny side out, place between the two paraffin halves, and secure with rubber bands (see Figure 3). When light passes through the paraffin, the aluminum foil will reflect the light in such a way that the two sides of the paraffin block will appear to be gray or white. Hold the light sensor between two light sources so that the light strikes perpendicular to the face of the paraffin. When the tool is held at a point equidistant between two lights of equal intensity, the color of each face of the tool appears to be the same. If the color of each face is the same, but the distances are clearly not equal, then the light which is further away from the tool is the more intense, In this way, students can use the light sensor tool to determine the relative intensity of two light sources and the location of the mid-point of those light sources. The actual light intensity can be quantified using the laptop and probes.

Figure 2: Cutting the paraffin block

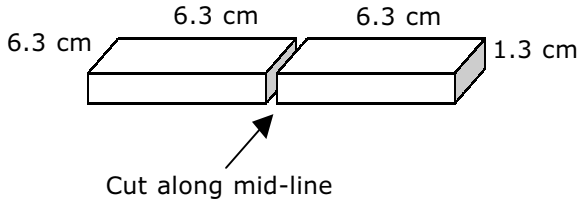


Figure 3: Creating the light sensor tool

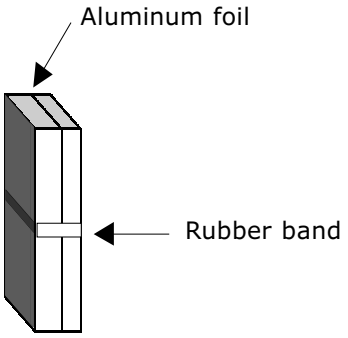
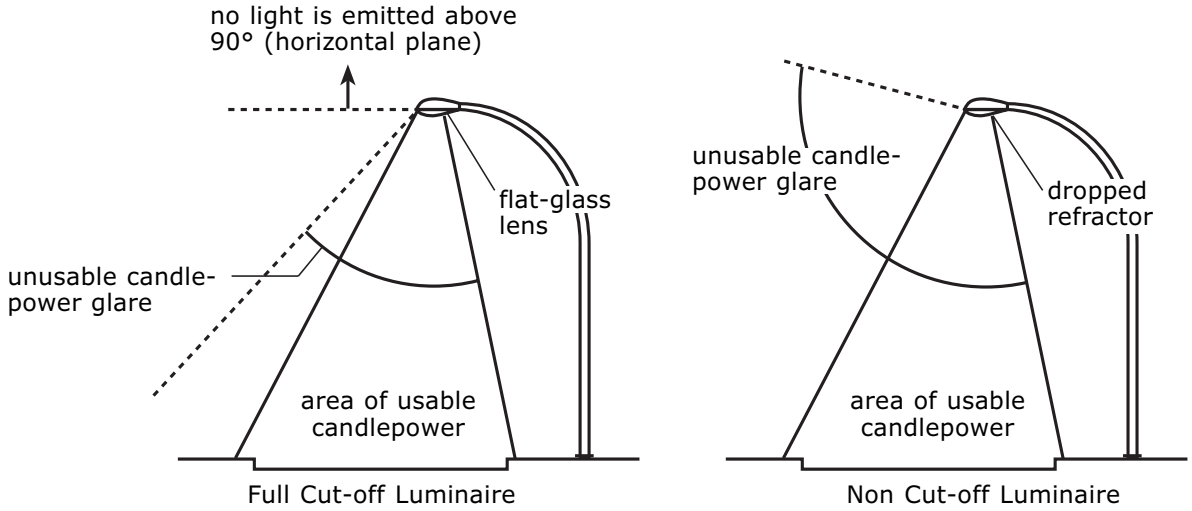


Figure 4: How street lights create light pollution



Adapted from the International DarkSky Association

Introduce PASCO Science Workshop to measure light intensity using laptop computers. The computer interface boxes use light and motion detector probes to measure light intensity as distance from the source increases.

As students continue their investigations, they may need additional information. You may wish to invite a city planner or contractor to the classroom to discuss the design and placement of street lights, outdoor building lights, or electricity use in the city. Students could also conduct a telephone interview or visit a city planner's office. The laptop computers will be especially handy for taking notes during these visits.

Field Activity

Divide the neighborhood around the school into zones, and assign each group of four students to a zone. Each group should also include a teacher, parent, or community member. Groups should carry walkie-talkies for safety.

Each group will identify specific light source locations in its zone. Using a laptop computer and light sensor, each team will collect light intensity data, and use digital cameras to photograph the shape of light from different sources. For instance, a street light mounted on a pole throws light a certain distance diagonally down and out (see Figure 4).

A student can measure the distance from the furthest illuminated spot to the base of the pole with the trundle wheel or tape measure. Another student can measure the angle to the top of the pole. With these measurements, students can use trigonometry to calculate the length of the hypotenuse and the height of the pole; calculations can be done in the field or in the mathematics classroom the next day. If students are unfamiliar with trigonometry, use the motion detector to determine the distances to the top and bottom of the pole. The light probe measures light intensity at a given location, so it is critical to know distance from that light source.

Finally, groups prepare recommendations on reducing light pollution. Teams use the data collected on the field trips, and evidence collected in their own investigations and research to determine which lights, if any, might be replaced or modified to save energy and reduce light pollution. Students can use the laptop computer for presentations to city planners, architects, construction contractors, or city government representatives. Groups should prepare five-minute presentations using multimedia presentation software.

SUGGESTIONS

- Familiarize yourself with the laptop interface box and probe technology.
- Establish learning stations around the classroom to allow student teams to work through different sections of their investigation at staggered intervals.
- Schedule the activity close to changes in daylight-saving time to maximize the probability of good weather.
- If travel and time difficulties reduce the number of students who are able to participate, share the data later with the entire class.
- Groups should carry walkie-talkies or cell phones for safety. Inviting parents and community members provides security, and involves them in an exciting science investigation.

ASSESSMENT

Students should take a large role in assessing their own performance and learning. Student groups determine when they have completed their investigations, when they need additional information from another source, when they have organized and analyzed the

data sufficiently, and when they have sufficient evidence to support their recommendation to the panel for proposed modifications or changes. Depending on the level of the student, the teacher may take an active role in helping student, or may just listen, ask questions, and offer comments.

Throughout the investigation, assess student answers to open ended questions. Students will learn to write well organized, complete lab reports of an investigation, and can monitor their own work.

The presentations to an expert panel should produce high quality reports, since students will work hard for the authentic audience. Ask the panel to provide brief comments for each group to determine if the group's reasoning is logical, and if their conclusions are valid. Ask the panel to sign a certificate of commendation for every student who successfully demonstrates satisfactory work.

REFERENCES

Books

National Council of Teachers of Mathematics. *Curriculum and Evaluation Standards for School Mathematics*. Reston, VA: NCTM, 1989.

National Research Council. *National Science Education Standards*. Washington DC: National Academy Press, 1996.

Ohio Department of Education. *A Resource Manual for Teacher's of Sixth Grade, Ohio Sixth Grade Proficiency Tests.* Columbus, OH: Ohio Department of Education, 1996.

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Web sites

Earth and Moon Viewer: http://www.fourmilab.to/earthview/

International DarkSky Association: http://www.darksky.org/~ida/index.html