I SPY LOTS OF LIGHTS!: TEACHER GUIDE

Subject: Physical Science
Grade Level: Middle School
Last Updated: May 31, 2006

Case Summary

You receive a letter from the US Department of Defense and an envelope marked "Top Secret." According to the letter, you have been assigned to a risky, top-secret night mission for which you now must carefully prepare. Your team of elite spies must decide what equipment you will need to bring, and the choices you make for each kind of equipment will determine whether or not your mission succeeds!

Credits

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Learning Objectives

Upon completion of this case, the students should be able to:

1. Describe the electromagnetic spectrum (ES)
2. Explain color blindness and color perception
3. Relate wavelength, frequency and angstroms
4. Discuss how light behaves in various contexts
5. Differentiate regular and diffuse reflection
6. Simulate wavelengths and frequencies of different regions of the ES
7. Describe how white light interacts with a prism to refract into the constituent colors of the visible spectrum
8. Explain how light interacts with light versus dark materials
9. Explain how mirrors can be used to manipulate angles of reflection
10. Explain how laser light diffuses in the presence of particulate materials

Georgia Performance Standards

SCSh3. Students will identify and investigate problems scientifically. (NSES Content Standard A).

S8P4. Students will explore the wave nature of sound and electromagnetic radiation. (NSES Content Standard B)

a. Identify the characteristics of electromagnetic and mechanical waves.
b. Describe how the behavior of light waves is manipulated causing reflection, refraction, diffraction, and absorption.

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c. Explain how the human eye sees objects and colors in terms of wavelengths.

Assessment

Each student was given one letter from J. Public, the US Secretary of Defense, and one stapled case packet that contained their multiple-choice and short-answer questions (*see the **letter** and **Case Packet** in the Student Materials document*). On Day 2 of the case, each student was given a messenger envelope to use while in class, which contained "Top Secret" information on the electromagnetic spectrum, color vision and color blindness, pinhole viewers, and basic properties of light, color and pigmentation. Each student had to: (a) complete their question packet, which entailed writing an *initial* answer with short explanation (hypothesis), completed after initial research; and (b) write a *final* answer with short answer explanation, completed after the laboratory activities and with the help of their Top Secret information packets. In addition, each student had to turn in their diagrams and written observations and interpretations for each laboratory activity (4 total), and a completed box chart (listing facts, questions, hypotheses, and learning issues in four quadrants of the chart) for each question of the case packet (6 total).

In addition to the answers for the 6 questions in the packet and the diagrams and written summaries for the four activities, students were graded on participation and effort using facilitator observations and peer commentary on the evaluation form filled out by every student at the end of the case. *See the **Self Evaluation Worksheet** in the Student Materials document*.

Implementation Strategy

This case included four laboratory activities and two classroom demonstrations, most of which require partial darkness to have full effect (closing all of the blinds and turning off the lights was found to be sufficient). Unless a specified source is listed, the activities were created specifically for the case. The laboratory activities include:

1. *Mirror Maze:* In this activity, students used a flashlight and two plane hand mirrors to demonstrate that manipulating the angle of one or more reflective surfaces will affect the angles of the reflected beams from a single light source. Each mirror was mounted on a paper cup that had two vertical slits cut into opposing ends of the mouth to provide balance and ease of manipulation. The students had to arrange the mounted mirrors so that the flashlight beam reflected off of both and ended in a third location, usually on the wall or another student's clothing. Once the desired effect was achieved, the students taped labels to the table next to each point of reflection (A, B and C) and drew diagrams mapping the directions of the beam (i.e. F to A to B to C). The facilitator then allowed the students to enact the scenario from Question 6 of their case packet, assuming the roles of agents and guards to demonstrate that the same properties could be manipulated so that agents could view guards from their hiding place without revealing themselves. The students kept notes of the activity and its relevance to their "mission."

2. *Refraction Rainbow:* This activity was adapted from the classroom science textbook to accommodate the cloudy weather present during case implementation. Instead of refracting sunlight, students placed prisms on the surface of an overhead projector and manipulated the angle of the prisms to refract the overhead light into rainbows on the classroom ceiling. The students created diagrams of the activity and completed short statements explaining what they had observed and its importance to understanding the nature of white light. A facilitator guided them to the realization that this had some bearing on their choice of flashlights in Question 1 (and thereby the question of color blindness in choosing flashlights in Question 2) and of clothing in Question 4 of their case packet.

3. *How Does Your Reflection Wink?:* This activity was taken directly from a Discover activity in the students' science book (Padilla, Ioannis, & Cyr, 2002, p. 570). The students examined their face in a plane mirror and winked, then taped two mirrors together at a right angle with the reflective surfaces facing each other. Looking into both mirrors, the students winked again, noting the difference between the winking-eye images produced from a single versus two angled mirrors. The students recorded their observations and made diagrams of what they had done, noting that this activity was also useful in answering question 6 of their case packet in that it explains how mirror angles can manipulate reflected images.

4. *Slinky Waves:* In this activity, pairs of students were given a plastic slinky toy. Each pair stood facing each other, and depending on what region of the electromagnetic spectrum the facilitator called out, the students waved the slinky back and forth on the floor at varying speeds and intensities to approximate the appropriate wavelengths and frequencies of the corresponding waves. To help the students remember, a color-printed overhead of the electromagnetic spectrum was displayed on the pull-down screen (this same overhead was used concurrently by the students working on the Refraction Rainbow activity with no problems).

It should be noted that a fifth activity was planned, in which students made and used a pinhole viewer out of waxed paper, a paper cup with a pin-size hole poked through the bottom, and a rubber band. This activity came from a Discover activity entitled "How Does a Pinhole Viewer Work?" on page 591 of the same science textbook. However, in multiple (8+) tries and in multiple lighting contexts, neither facilitator was able to view much of anything, never mind the inverted image intended by the activity. Consequently, the students were given a diagram of the activity (in their Top Secret envelope) from a classroom activity workbook explaining how a pinhole viewer works, and Question 3 from the case packet (involving a possible pinhole camera) remained in the case.

Two demonstrations were used to illustrate the remaining points rather than activities. The demonstrations were as follows:

1. *Laser Diffusion*: Due to the potential hazards of looking directly at a diode laser pointer, the two facilitators demonstrated this activity to the students rather than

allowing them to handle the laser pointer themselves. The lights were once again dimmed following a discussion of Question #5 and students' hypotheses, questions and learning issues. One of the options for getting through the laser field in Question 5 entailed spraying air freshener into the room; accordingly, one facilitator pointed the laser beam at a far wall while the other sprayed air freshener at and around the beam. The effects were discussed with the students in the context of particulate diffusion of light and the unique light properties of lasers.

2. *The Right Clothes*: This activity took the form of a demonstration simply because only a few students in a given class period were wearing the desired white cotton and black cotton t-shirts. Student volunteers were selected (if they were wearing one or the other color in cotton) and stood next to one of the facilitators in the front of the room. The facilitator held a swatch of shiny black vinyl, and the rest of the class was encouraged to discuss which fabric would be better to wear during their mission. Following a brief discussion, the lights were dimmed and the second facilitator shone a flashlight against each material, while the first facilitator described differences in the texture of cotton versus vinyl. The students were asked which type of fabric they thought diffused the light more, given that Question #4 indicated that to be the desired quality. Then the students were asked to discuss amongst themselves which color would reflect more light, since the clothing would ultimately be used for camouflage and minimizing the reflection off of the agents would be paramount.

Implementation Schedule: This case is designed for implementation over three class periods (one 60-minute period followed by two 90-minute periods), for a total of 240 class minutes.

Day 1 (60 min.): Students enter the room to find the government letter and case packet on their desks. They are instructed to read the case materials (~10 minutes), then move to sit with their groups. In groups, they spend the rest of the class period working on a box chart for each question in the packet (6 total).

Homework

- Finish all six box charts
- Write in initial answers and explanations (identified as hypotheses) to each question
- Begin independent research on identified learning issues

Day 2 (90 min.)

- Assemble in groups; share information from homework (~15 min.)
- Laboratory Activities: Each activity is set up at a different station around the classroom, and each group rotates around to each station (~10 minutes per station, ~40 minutes total)
- Demonstrations: Students return to their seats for the two facilitator demonstrations (5 min. for Laser Diffusion, 10 min. for The Right Clothing, 15 minutes total)

- Lab Diagrams: Begin illustrating each of the four lab activities completed, with short description and interpretation (~20 minutes)

Homework: Continue researching learning issues. Reexamine initial answers.

Day 3 (90 min.)

- Receive Top Secret information packet, assemble into groups.
- Lab Diagrams: Finish illustrations, descriptions and interpretations (~20 minutes)
- Case Packet: Using the lab diagrams, box charts and contents of the Top Secret Envelope contents (see Resources), work in groups to come up with final answers and explanations (compared with earlier hypotheses) to each question, with help from facilitators. (~60 minutes)
- Assessment and Wrap-Up: Pass in box charts (6), lab diagrams (4) and completed case packet; go over the answer options and outcomes; complete and turn in case evaluation.

Case Notes

What Went Well:

- We believe that this case went very well. The students enjoyed the premise and the choice-driven structure of the case. They expressed a lot of enthusiasm about assuming the roles of secret agents, and they understood and enjoyed the lab activities. Not surprisingly, they also very much enjoyed the laser demonstration! We observed the students to be on task and hardworking most of the time; given that this case was implemented just before spring break, we found this to be very encouraging. Their case packets and other materials were completed within the allotted time, and while grading is currently still in process, we are pleased with what we have seen so far.
- From our discussions with a special-needs/behavioral adjustment teacher who joined the case with two of her students, the case was also very successful in capturing the interest of special-needs students. The two students worked very well in their respective groups, were eager and interested in the material, and seemed to get a lot out of the case. This particular teacher also teaches social studies, and agreed with us that adding historical context to the case premise would be an excellent way to make connections across disciplines for the students (for example, the case takes place during the Cold War or World War II [with some modification of the technology, i.e. laser sensors] with agents and guards belonging to agencies appropriate to the time period).

What Could Be Improved:

- The question in the case packet concerning the inverted image was more difficult for students to answer because there was no activity to demonstrate the underlying concepts, due to the unexpected failure of the pinhole viewer. Since this activity is mentioned frequently as a useful demonstration of the linear path of light, we advise

practicing the activity further in advance of implementation, since we found it largely unsuccessful.

- Due to time constraints involving spring break, early-release days and standardized testing, we condensed this case into 2.5 class periods (one 60-minute period and 1.5 90-minute periods, for a total of 195 minutes) in order to complete it on time. We have presented a full, three-period implementation schedule because we feel that the students will feel less rushed, and more time can be spent on the material in-class rather than as homework.

Resources

Rather than utilize online research, we kept with the theme of the case and handed out manila envelopes stamped "TOP SECRET" in bold red ink. Inside these envelopes were printouts from the following online resources for the students to sift through. As there are no student computers in the classroom and the computer-lab is often reserved by other teachers, this was a useful way to allow the students to research independently in their groups in a more timely fashion. Also, given the dependence of students today on Internet resources, it was a useful exercise to make them go through hard copies, supplemented by their textbooks, to remind them that there are other ways to research besides going online.

The Classroom Textbook
Padilla, M. J., Ioannis, M., & Cyr, M. (2002). *Physical science: Prentice Hall science explorer*. Pearson Prentice Hall.

The following resources were included as printouts in the TOP SECRET folder:

Visible light in the electromagnetic spectrum, including an online calculator:
The University of California. (1996). Light wavelength size, observing objects in space, and electromagnetic spectrum. Retrieved March 22, 2005 from http://cse.ssl.berkeley.edu/light/right_frame.html

Great overview of the properties of light
Freudenrich, C. (2005). How light works. Retrieved March 22, 2005 from the HowStuffWorks Website: http://science.howstuffworks.com/light.htm/printable

How lasers work (very complicated for 6th graders, but useful for facilitators)
Weschler, M. (2004). How lasers work. Retrieved March 22, 2005 from the HowStuffWorks Web site: http://science.howstuffworks.com/laser.htm/printable

Color Vision and Color Blindness (for both of these sites, facilitators should search for "color blindness," cut and paste material as needed into Word documents or Power Point slides, since some of it's a little too advanced for 6th graders)
Healthwise, Inc. (2005). Color blindness: Topic overview. Retrieved March 22, 2005 from the WebMD Web site: http://www.webmd.com

The Editors of Consumer Guide. (2004). Color blindness. Retrieved March 22, 2005 from the HowStuffWorks Web site: http://www.howstuffworks.com