Sharing the Fun of Optics—Working with Groups of Youngsters

This article stems from a very gratifying experience presenting an optics workshop to my Girl Scout troop—around 25 active, boisterous sixth graders. I wasn't sure what they would think of having to do optics at the end of a long day when they were ready for fun. As it turns out, they loved it. One of the girls went home and excitedly told her mom about it, saying that she'd never realized before that science could be fun. The girls seemed fascinated and came up with lots of good questions and experiments of their own. Even my scout who is learning- and emotionally-disabled, and generally doesn't participate or speak much, participated in everything and came back to me later asking where she could buy a laser.

This article is intended primarily for engineers and scientists working with optics, but the concepts may be applied by anyone who would like to share something with a young group. I'll first discuss the experiments we did at the workshop, and then give some general guidelines for adapting a program to your needs and the needs of the children with whom you're working. Depending on the age of your group and the materials you have on hand, you may wish to use different experiments than those given below.

Workshop Setup

This workshop was designed to accommodate 20-25 11-year old girls in the mood for active fun. We split into five random groups, and each group was given a worksheet for each work station. An adult oversaw each station, although none of the adults was familiar with optics. I suggested that one girl read the questions and the others do the experiment, trading readers at each work station. We allowed approximately 15 minutes per station.

Station A: Lasers

This experiment was set up in a small room that could be darkened. In the room were two HeNe lasers, two color filters, and a cheap drinking glass designed to look like cut crystal, *i.e.*, with lots of planes and angles on the outside surface. The girls were given the following instructions, with the answers shown at the end of this article. The adult helped moderate the discussion and ensure the safe use of the lasers.

1. Turn on the laser. Do not look directly into the beam. Try aiming it across the room or out the window. What do you notice about the size of the beam?
2. Does the beam feel hot on your hand?
3. Try bouncing the light off a wall, and look at the light reflected onto the other wall. See if you can see a speckle pattern (flashlights don't do this). See if there are other ways you can get a speckle pattern.
4. Try aiming the laser beam at a glass. Notice how it is bent and directed in many directions.
5. Try aiming the laser through the red filter and through the blue filter. Which one lets the light through?

Station B: Light Polarization

In this experiment, I had a couple of sheets of paper each with a dark pencil dot on it, two pieces of calcite, and four sheets of polarizing film.

1. Polarization refers to the direction in which light energy vibrates, *e.g.*, vertical or horizontal polarization. Place the crystal calcite over the paper with the black dot and look at the dot through the calcite. What do you see?
2. The calcite splits the light into two parts, such as vertically and horizontally polarized parts. Try rotating the calcite. What happens?
3. Hold the grey piece of plastic over the calcite. This blocks the light polarization in one direction, if it is turned in the right direction; it is called a polarizer. What happens as you turn the polarizer?
4. Hold up one of the grey polarizers and look at a few objects, rotating the polarizer as you look. Most things will not change in brightness. Now look through two polarizers and hold one still while rotating the other. What happens?
5. In #4, if the two polarizers are held just right, one will block the horizontally polarized light, and the other will block the vertically polarized light so no light gets through. Now try holding the two polarizers over the calcite and look through first one then the other. Can you get them to block the same dot? Can you get them to block different dots?

Station C: Scattering and Absorption

In this room, the girls had glasses, food coloring, a little milk, and some flashlights. I also let the girls shine flashlights through the glasses. We had both clear flashlights and flashlights with the front colored with ink (see "Light Touch," March 1993, p. 68). I stationed myself at this experiment because I felt that it was most apt to spur questions.

1. Try shining the red, blue, and green flashlight beams together and separately on the white wall. What do you see?
2. Look through a glass of clear water. Find something you can see clearly. Now put a few drops of red food coloring in it. Notice how pretty the swirls are. Now look at the object through the glass. How has it changed? Also try shining a white flashlight beam through it.
3. Repeat #2 with blue food coloring in another glass. Dip a red plastic toy and a blue plastic toy first in one glass, then in the other. Which toy gets dark?
4. What if you try to look through both glasses at the same time? How about shining flashlight beams through both at the same time?
5. The above experiments show what is called *absorption*. The dye absorbs some of the light. Now try a clean glass of water and put a few drops

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EXPERIMENT A-4

EXPERIMENT C-2

of milk in it, and look through the glass at an object. Can you still see it? This is called *scattering* because the light is bounced or scattered in all directions. Now try shining a flashlight beam through the milky water. How is the light different from the way it was with other glasses?

Station D: Basics of Crystals
In this area we had several rocks and crystals laid out on a roll of paper. Each item was numbered. The samples included quartz, mica, granite, and several other rocks and minerals. I had also stacked some sugar cubes into three different forms: a cube, a wall, and a line.

1. Look at sample #3, quartz; this is a crystal. Sample #2 is not; it is a rock. How would you describe a crystal as being different from a rock?
2. Visualize a brick wall and a rock wall. In the rock wall, the rocks are all different sizes and shapes, and they cannot be stacked neatly. A brick wall can be stacked neatly so it has smooth sides and sharp edges. Similarly, in a crystal, the molecules are all stacked in a regular form like a brick wall. Now look at the sugar cube models. In these models, the sugar cubes are meant to represent the atoms and the final form of the stacked cubes represents the crystal.
   a) Find a crystal with a form something like or block or cube.
   b) Find a crystal with a form something like a wall or plane.
   c) Find a crystal with a form something like a line (it looks like string cheese).
3. Sometimes crystals grow on top of rocks. Find an example of this.
4. Sometimes small crystals grow within rocks. Find an example of this.
5. If you were a monster and tore up a bunch of brick walls and threw them in a pile, the pile would not be neatly ordered, but there would be sections of brick wall within the pile that were neatly ordered. This can also happen with crystals. Can you guess which of the crystals is an example of this?
6. Which crystal do you think is prettiest?

Station E: Growing Crystals
For this, I dissolved Epsom salts in boiling water, about 1/2 cup per 2 cups water. I let some of this solution cool in advance on a hand mirror where it had formed very nice linear crystals—this was also available for the girls' inspection. During the workshop, the dissolved epsom salts were kept warm. There was a tray full of rough quartz crystals of a variety of forms. Three microscopes were set up with glass slides of salt and epsom salt. Clean slides were provided.

1. Look in the microscopes. One has salt that looks like blocks, and one has Epsom salt that looks like lines.
2. Swab a thin layer of dissolved Epsom salts (on the stove) on a clean glass slide. Put it under the microscope. Find the edge of the liquid under the microscope. Now watch the crystal grow.
3. Crystals, even of one kind of material, can take lots of forms. Look at the box of quartz crystals to see the different forms that quartz can take.
4. There are a few samples covered with dirt as they were found in the ground. If you would like, your group may clean one of these.
5. You may take one sample from the shoe box to keep.

Adapting the Program

The program is intended to give you a general idea of the sort of experiments you can set up. You may find that you have to use different experiments. For example, you may not have a rock collection or a laser handy. Or perhaps the age group is too young or too old for the above experiments. Or you may be thinking of great ways the experiments could have been improved or explained better. The important point is to think about how you can successfully share your knowledge with children.

In adapting a program for a group

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of youngsters, the most important step is grabbing their attention; the second most important step is keeping it. Ah yes, but how? Here are some ideas.

- Show them something they've never seen before, such as the crystal growing experiment or a laser. Before our meeting even started, girls had lined up at the microscopes wanting to see what the others were so enthusiastic about.
- Let them do hands-on experiments as much as possible. Leave room for them to invent their own experiments. In the laser room, the girls wanted to try splashing water into the laser beam to see how it would look, and in the absorption experiment, they especially liked shining lights through the glasses and trying different color combinations of beams and dyes.
- Try to have something pretty or something the kids might consider "cool." The laser shining on the multi-patterned drinking glass was beautiful and entranced the girls, as did the swirling of the dye in the water glasses. They thought shining a laser beam on their hands was really cool.
- It is okay to have some experiments that they won't understand but will be able to observe, such as noticing that the laser beam is still quite small when you shine it out the window at a wall across the street. On the other hand, it's nice to have some experiments that help them understand common phenomenon, such as the role of absorption in light interactions.
- Kids generally like games. They treated the 'intro to crystals' as a game and enjoyed trying to figure out the answers.
- Spark their curiosity, if you can, with a simple observation. The sudden difference between the behavior of a flashlight beam going through milky water versus dyed water brought on lots of questions such as, "It looks like clouds. Why does it do that?" and, "Look how it shines out of the sides of the glass."
- Try to find an experiment that will surprise them, and ask them (in advance) what they think will happen. The girls expected that when they placed the blue toy in the red water it would look purple. The fact that it looked black was a surprise that made them want to figure out what happened.
- Try not to use jargon they don't know, unless you explain the terms. Much of our technical vocabulary is not common to the vocabulary of a young child. Be careful not to convince children that they are too stupid for science simply because they don't know the same words you do.
- Watch expressions. Most children have not learned to hide their emotions, so they will provide you very honest calibration sensors for how you're coming across. If eyes glaze over, jump very quickly to hands-on activities. Remember, in an environment like this they don't all have to understand everything. If most of them come away excited about something they did, you're ahead of the game.
- Try the experiments before you are surrounded by bright and shining faces. Some experiments have pretty dramatic results, while others are surprisingly disappointing. Still others are confusing or dangerous. Work the bugs out on your own and try to think through how you can explain these concepts in a clear yet simple way.

Finding an Audience

In finding an appropriate group, remember that most teachers and youth group leaders are overworked and will be delighted to have fresh input. On the other hand, teachers are required to teach a certain amount of set programs, and youth group leaders are often busy presenting the program their youngsters have voted to do, such as art or boating. Not all groups will be able to spend an evening on optics, and those that do may need some advance notice for planning. Don't be discouraged; there are other groups out there who will love to have you. (Both Boy Scout and Girl Scout groups would especially appreciate your doing a complete science badge with them.)

These activities need not be limited to optics. I've done demonstrations for groups of kids on the physics of music, games to help understand how cars work, and projects to learn about machine screws, wood screws, and nails. The general rules are the same. Think of what might be fun to learn, what materials you have on hand, and how you can lead someone who knows very little about the subject to a better understanding. Then go for it and have fun. And, since I'm not a teacher, I can say that you will come out with a lot of respect for those who are.

A N S W E R S

Station A answers: 1) It remains small. It doesn't spread out like a flashlight. 2) No. 3) The red filter.

Station B answers: 1) Two dots. 2) The dots revolve around each other. 3) First one dot, then the other disappears. 4) It gets black when they are turned at the right orientation. 5) If they are held in the cross polarization orientation, one blocks one dot, and the other blocks the other.

Station C answers: 1) They look white when they are put together. 2) It's darker, and red, but you still can see the object. 3) The red toy gets dark in the blue glass because the blue dye only lets through the blue light and it blocks the red light; the blue toy gets dark in the red glass because the red dye blocks the blue light. 4) Most of the light is blocked. 5) You can no longer see the object. The flashlight beam makes the milk glow.

Station D answers: 1) Smooth sides, sharp edges, sometimes transparent. (The remaining answers identified which specimens fit the questions above, *i.e.* specimen #6 etc.)