Session 1: Teaching Ocean Science

Overview

This introductory session of the course begins with students sharing and discussing their ideas about what ocean science is and what should be included in teaching ocean science. The goals of the course and the rationale for teaching ocean science, including its interdisciplinary nature, are discussed. The students then engage in three different grade-level appropriate, inquiry-based, hands-on activities. They then discuss how the exemplar activities differ by grade level and how the activities differ from the way they experienced science in elementary school.

Background Information for the Presenter

The National Science Foundation (NSF) has acknowledged that Ocean Science is nearly absent from the K–12 (and undergraduate) curriculum. It is unique in its underrepresentation in the *National Science Education Standards* and many state science standards. Fields like chemistry, life sciences, physics, astronomy, geology, and meteorology receive greater coverage than ocean sciences.

The goals of the Communicating Ocean Science course are:

- to introduce diverse future scientists to the importance of K-12 education and public outreach in order to enhance the breadth of the impact of their work in ocean sciences;
- to introduce diverse students working toward degrees in science to possible careers in K-12 teaching;
- to encourage thoughtful, mutually beneficial collaborations between ocean scientists and educators;
- to provide significant ocean science instruction and college-age role models for under-represented K-12 students.

College students are important role models who can make a real and substantive difference in the choices that elementary, middle and high school students make about their education. In California elementary schools, the 6–8 hours that the course participants spend teaching science may represent the majority of science the elementary students learn all year. The 6–8 hours that they teach will probably represent more ocean science than many elementary students will receive in the rest of their elementary years combined!

Session Objectives

In this introductory session, students:
— learn about the goals, design, and requirements of the course;
— discuss the interdisciplinary nature of ocean sciences;
— brainstorm ideas about which ocean science concepts should be addressed in the elementary school classroom;
— experience inquiry-based, hands-on ocean science activities used in elementary school classrooms.

Session Activities at a Glance

Thought Swap
This course begins with a "Thought Swap" in which pairs of students share their ideas in rotating pairs and discuss the questions: What is ocean science? What should be included in teaching ocean science? What do you want to get out of this course? Describe what it was like to do science when you were in elementary school.

Introduction to the Course
The course goals, requirements, schedules, and an overview of the sessions are shared with the class. This course is designed to "practice what we preach" in that it seeks to exemplify a flexible model of how people learn. This model is practiced in presenting the course content, in the hands-on science activities the students take into elementary classrooms during the outreach portion of the course, and in the lesson they design.

Hands-on Activities
Students experience three very different inquiry-based, hands-on science activities taken from different grade levels and ocean science disciplines. The opportunity to participate in these activities provides a common experience to serve as a basis for a reflective discussion about what it looks and feels like to ***do*** hands-on elementary school science.

Concept Discussion
Each small group of students is given a different question to discuss related to the hands-on activities they just participated in. After discussing the question in their small groups, they share their question and ideas with the class. Some of the questions include: What did you find to be most striking or notable about the activities?; What was the main point of each activity?; How does the material for different grade levels compare?

Wrap-up and Homework
Assign the first reading from the course reader and describe that in the next session they will be asked to respond to the reading with a Quick Write. A Quick Write is a prompt; they will be given about five minutes to write a response to the prompt.

Optional: If you are also using the on-line discussion warm-ups, remind them how to access the web-site and submit their responses.

Time Frame

Total Workshop: 2 hours 50 minutes

Thought Swap (20 minutes)
Introduction to the Course (20 minutes)
Rotation through Activities (Activity #1 - 20 minutes; Activity #2 - 30 minutes and Activity #3 - 35 minutes)
Concept Discussion (25 minutes)
Wrap-up and Homework (10 minutes)

Materials

For the Hands-on Activities

For the class:

- overhead transparency of the "Anticipatory Guide" (master page 23)
- 1 copy of "Anticipatory Guide"

Beach Buckets

For each group of 5–6 students:

- 1 plastic shoe box or other similar size container
- sand to make a two inch layer in each shoe box
- shells, rocks, feathers, driftwood, seaweed, aluminum cans (crushed), fishing line, paper and other items found on a beach for each shoe box
- large sheet of chart paper and colored markers
- 5–6 hand lenses

For the class:

- 1 package of Jolly Ranchers or other hard candy such as butterscotch or peppermints
- 1–2 small plastic containers with tight fitting lid (Tupperware or plastic peanut butter jars work great)

Oyster Beds

For the class:

- 3 sets of stickers or colored sticky dots (2 of each kind)
- 10 whole oyster shells which equals 20 halves (you will need more if you have more than 20 students)
- 10 rubber bands

For each small group of 5-6 students:

- 2-3 rulers
- 5 x 8 index cards
- 5–6 pencils
- one quart size plastic freezer bag containing 5–6 oyster valves (1/2 oyster shell = a valve)

For Red Fish Roundup

For the class:

- glass baking dish or plastic shoe box
- mirror (must fit in baking dish and extend several inches out of the water)
- water to almost fill dish
- 1 piece of 3″ x 3″ diffraction gradient
- overhead projector
- tape

Color Spinners Activity

For each group of five students:

- 5 pieces white cardstock or cardboard large enough to make an 8 cm circle
- 5 scissors
- 5 rulers
- 3 sets of seven different primary colors of colored markers
- 5 golf pencils

Wavelengths Activity

For the class:

- one cotton rope (a climbing or cotton jump rope works great)
- large drawing of a rainbow

Underwater Dive

For the class:

- 2 rolls of blue cellophane
- masking tape
- stapler
- fish posters (optional)
- red construction paper 4″ x 8″ (30 sheets)
- fish pattern (optional)
- string or yarn for ties
- 20 sheets 8 1/2″ x 11″ construction paper (any color)
- scissors
- wavelength worksheet (attached)
- goggles pattern (see attached)

Preparation of Materials

1. Duplicate the "Anticipatory Guide" and cut it into strips—one question per strip.

For the Hands-on Activities

Make the overhead transparency or chart called Anticipatory Guide for students to refer to as they do the activities. (See master page 24).

Anticipatory Guide

- What did you find to be most striking or notable about these activities?
- How were they similar or different from how you did science in elementary school?
- What was the main point or key concept of each activity?
- What kind of information was presented and what was omitted?
- How does the material for different grade levels compare?

For Beach Buckets

1. Make 2–3 beach buckets as follows: Place 2–3 inches of sand in a plastic shoe box and add shells, small rocks, sand dollars, and trash to the surface of the sand.

2. Fold a sheet of chart paper into four sections and label each section with one of the following categories: animal (non–human); plant or seaweed; people; and unknown.

3. Unwrap 7–10 Jolly Ranchers and place in plastic jar with lid.

For Oyster Beds

1. For this activity you will need 10 whole oysters for a class of twenty students [the equivalent of 1/2 (or one side) of an oyster shell for each student]. It is imperative that you have both sides of the oyster for this activity. Buy live, whole oysters at your seafood market (they will order them for you if the store doesn't usually carry them). Cook them on a BBQ until they just open. Wash the shells thoroughly and separate them carefully at the hinge so as to not break them. Wrap a rubber band around the shell to keep the matching valves together. Some oyster bars or restaurants will save you both sides of the oysters if you ask them—otherwise as they are shucking them, the shells quickly become separated from their match.

2. Lay out four quart-size freezer bags and place identical stickers on two of them (or write the same letter on two of them with an indelible marker). Repeat with the other two bags so that you have two sets of twin bags, e.g. two bags with the letter A (A1 and A2) and two bags with the letter B (B1 and B2).

3. For the two A bags, take one of the whole oyster shells (made up of two valves), remove the rubber band, and place one valve in A1 and the other valve in A2 so that you are separating the matched valves. Repeat this four more times so that you end up with two bags of five shells each. Try to alternate placing the flat and cup-shaped valves into the bags so that there is a mixture of shapes and sizes in each bag. Now repeat for the two B bags. You will now have four bags of five shells each. The valves in A1 have their match in the A2 bag and the valves in B1 have their match in the B2 bag.

4. If you have more than 20 students, simply add oyster shells; one whole oyster shell for every two students. If possible, try to use an even number of groups.

For Red Fish Roundup

Making the dive goggles and red fish

1. Purchase blue cellophane for the goggles. If the cellophane you find is relatively light in color and weight, you will probably need to use 6 or so layers to achieve the desired effect. If you use blue acetate (costlier) you need only use one layer. Do a test of the effectiveness of the blue filter before making the goggles by darkening the room, placing the cellophane over your eyes and looking at something red in the room. The red color should be filtered out leaving only a shade of gray. You can also modify how many layers of cellophane you need to use by adjusting the light levels in the room. Change the number of layers of cellophane until the desired effect is achieved.

2. Colored markers for doing the color spinners need to include the colors of the rainbow: red, orange, yellow, green, blue, indigo, and violet. The blue should be light blue and the indigo is dark blue like the color of blue jeans.

3. Trace and cut out construction paper goggles for each student using the pattern provided. Fold or cut six layers (depending on how many layers you determined you need to use to achieve the desired effect) of blue cellophane, place them between the two goggle pattern cutouts and tape them in place covering the eye holes. Staple the two sides of the goggles together, sandwiching the cellophane between them. Staple string or yarn for ties.

4. Make fish out of red construction paper using the pattern provided or a design of your own.

Just before the Underwater Dive

1. Send students out of the room and have them put on goggles. While they are out, tape all their red fish to the walls, bulletin boards, posters, curtains, etc., using a variety of light and dark backgrounds. Tape the fish around the periphery of the room so that when the students enter the room you can have them all circle the room in the same direction.

2. After taping up all the red fish, but before inviting the students back into the room, turn off the lights, close the curtains, and put on a pair of goggles to test the light levels and effectiveness of the camouflage. If the room is too dark, students will not be able to see anything and if too light, the red fish will be very obvious. The red fish should just disappear against a dark background (black, red or blue) and although their outline will be apparent against a light background, the red color should not be seen.

For the Wavelengths and Making Rainbows

1. Draw a picture of a rainbow on chart paper, coloring in the seven different wavelengths of light in the following order: red, orange, yellow, green, blue, indigo, violet from the outside inward.

2. Copy the wavelength worksheet onto chart paper or make into an overhead transparency and color in the wavelengths of light using the colors of the rainbow.

3. Draw a picture of a wave and include labels of the crest, trough and wavelength.

4. Tape a sheet of diffraction gradient to the light of an overhead projector. You will need to cover all but a narrow slit of the overhead platform with paper to narrow the image to a single rainbow. Play around with the image a bit until it is focused into just one rainbow.

Instructor's Guide – Session Details

Thought Swap

1. Introduce thought swap. Tell participants they will get a chance to talk with different classmates. They will be discussing a series of questions to get them thinking about the session's topic—Teaching Ocean Science.

2. Participants stand in two lines. Have participants stand shoulder to shoulder to form two parallel lines, so each person is facing a partner. Participants standing side by side should be at least 6" apart.

3. Ask question for partners to discuss. Describe that you will ask a question for them to talk about with their partner facing them. They will have about a minute to talk. You will signal them to be quiet to prepare for the next question or statement by gently tapping on the shoulder the first two participants at the end of the lines. These two will then pass the tap on down the line, till the entire group is quiet.

4. Pose first question. Pose the first question for participants to discuss: **What is ocean science?**

5. Give signal for discussions to stop. After about a minute or when conversations start to wind down, tap the first two participants at the end of the lines and wait for the entire group to become silent. Repeat the question "What is ocean science?" and ask a few students to share with the large group what their partner told them. Record their ideas on chart paper.

6. Participants get new partner. Tell participants one of the lines needs to move with each question, while the other remains in place. Have one of the lines move one position to the left so everyone is facing a new person—the person at the end of that line walks around to the beginning. Everyone now has a new partner.

7. Pose next question and follow procedure as before. Pose the next question/discussion topic for participants to discuss from the list below. Repeat #5 and #6, shifting partners each time, until you've been through all the questions.

- What should be included in teaching ocean science? Why?
- What do you want to get out of this course?
- Describe what it was like to do science when you were in elementary school.

8. Participants return to seats. Ask participants to return to their seats.

Introduction to the Course

1. Describe goals. Describe the goals of this course to the participants. Tell them that some of the goals include helping science majors (some with interest or specific background in ocean sciences) to become more aware of K-12 science education in hopes that:

(1) if they become scientists, they'll care about teaching (including their own) and public education; and will devote some of their efforts to "K–12 outreach";
(2) they'll be informed voters regardless of what career they choose;
(3) some students might even consider choosing a career in K-12 education or informal education.

2. Share background information. Share some or all of the following information with the participants.

- The National Science Foundation (NSF) has acknowledged that Ocean Science is nearly absent from the K–12 (and undergraduate) curriculum. It is unique in its underrepresentation in the *National Science Education Standards* and many state science standards. Chemistry, life sciences, ecology, physics, astronomy, geology, earth sciences, meteorology, etc., are all included more than ocean sciences (or even oceanography).

- College students like themselves are important role models who can make a real and substantive difference in the choices that elementary, middle, and high school students make about their education. In California elementary schools, the 6–8 hours that they will spend teaching science may represent the majority of science the elementary students learn all year. The 6–8 hours they teach will probably represent more ocean science than the elementary students will receive in the rest of their elementary years combined!

3. Explain "practice what we preach" model. Tell participants that the course is designed to "practice what we preach," in that it seeks to exemplify a flexible model of how people learn. That model will be practiced in presenting the course content, in the hands-on science activities they take into elementary classrooms during the outreach portion of the course, and in the lesson they design.

4. Describe course requirements. Finally, describe the course requirements, schedule for classroom placements, and any other necessary information. *(See course mechanics section for examples.)*

Hands-on Activities

1. Introduce activities. Tell participants they will now have the opportunity to participate in a series of inquiry-based, hands-on ocean science activities reflective of the kinds of lessons they will take into classrooms during the outreach portion of the course.

Note: We have chosen to use three exemplar activities from the MARE (Marine Activities, Resources & Education) curriculum from the Lawrence Hall of Science, University of California Berkeley. The activities were chosen as representatives of different grade levels and types of activities. The activities are included here, but you may of course decide to use different activities or focus on different grade levels.

2. Describe purpose of activities. Describe that the opportunity to participate in these activities provides all of us with a common experience to serve as a basis for a reflective discussion about what it looks and feels like to ***do*** hands-on elementary school science.

3. Describe three diverse activities. Tell the participants that they will experience three different activities representative of three different grade levels, content areas and concept focus. Describe each of the activities very briefly as follows:

> ***Activity #1***
> *Seashore Sleuthing: Beach Buckets* for grades K–1. This is one of three stations in this primary grade activity. This station provides the opportunity for free exploration and guided discovery.
>
> ***Activity #2***
> *Oyster Beds* for grade 3. This activity focuses on the process of science and what scientists do.
>
> ***Activity #3***
> *Red Fish Roundup* for grade 4. This upper elementary activity addresses the concepts of light, wavelengths, and camouflage at depth.

4. Display slide with prompts. Display a PowerPoint slide or chart with the following questions and ask participants to keep these in mind as they do the hands-on activities:

- What did you find to be most striking or notable about these activities?

- How were they similar or different from how you did science in elementary school?
- What was the main point or key concept of each activity?
- What kind of information was presented and what was omitted?
- How does the material for different grade levels compare?

Note: Following are instructions for presenting a portion of three different MARE units. Be sure to give enough time for the participants taking the course to experience at least a taste of what students would experience in a classroom presentation, and to get a feel for the overall flow of the lesson, but keep in mind the time frame for each activity. It's okay to abbreviate and shortcut certain portions, once the participants understand what's intended to happen in the elementary classroom.

Activity #1: Seashore Sleuthing

Shake, Rattle, Rock and Roll

Students investigate where sand comes from.

1. Ask question about prior knowledge about sand. Ask the participants to describe where they think sand comes from. Participants may come up with the idea that sand comes from rocks and/or shells that are banged together and broken apart into smaller pieces. Tell them that we are going to try to figure out how that might happen.

2. Display items from Beach Bucket. Point out some of the things in the Beach Bucket that wash up on beaches (shells, rocks, cans, seaweed, plastic, etc.). Ask participants what would happen to those objects if 10,000 waves a day pounded on them? [They will break up into ever-smaller pieces.]

3. Introduce Jolly Ranchers as model of beach items. Describe that in this investigation, Jolly Ranchers or other colorful hard candies are used as a model to represent different objects that wash up on a beach and are tossed about by the waves: red candies can be rocks; pink can be shells; green can be plants; etc. Fill a small plastic container with a lid about a third full of hard candies. Ask participants to imagine the power of a wave crashing on a beach. Participants take turns being waves—shaking the container vigorously about five times and then passing it to the next participant.

4. Observing results. After everyone has had a turn, ask the participants to describe what they see in the container. Ask, what do the "rocks"(Jolly Ranchers) look like now? Is there any "sand" in the container? Ask the participants if they can figure out just by looking at the "sand" which colors or flavors the "rocks" were. Have them look closely to see that there are several different colors. Compare this to real sand, and note that the colors give us clues about what the sand is made of.

Beach Buckets

Students investigate items that might be found on a sandy beach.

1. Introduce Beach Buckets investigation. Tell participants that even though they can't go to a real beach today, they will now have a chance to examine what a real beach might look like—right here in class. Distribute a beach bucket to each small group of 5–6 participants. Give them time to freely explore the buckets. You might also have them look closely at the items using a hand lens.

2. Participants find three different items. After five minutes or so, ask participants to find three different kinds of things on their beach as follows:

- things that show that an animal was there (non-human)
- things that show that a plant or seaweed was there
- things that show that a person was there

Tell them that these things could also be described as clues or evidence.

3. Model how to sort items into three categories. Show participants the chart paper labeled with the names of the three categories above. Model how to remove items from the bucket and place them on the chart paper within one of the categories. Also model for them how they could label the chart paper with the names of each of the items within the category.

4. Participants explore and sort. Give the groups further time to explore their beaches with the idea of looking for clues or evidence. Have them take turns removing items from the buckets and placing them in one of the categories. Ask them to describe why they decided to place an item in a particular category. What is their "evidence" that it belongs with others in that group? Are there some items that might fit into two of the categories? Are there some items they are unsure about? Have them set aside things they are unsure about into a fourth category.

5. Groups share one item from their sort. Ask each group to decide what one thing they would like to share with the whole group. Then have a student in each group hold up an item and identify the

category where they had sorted it. If there are things that none of the students can identify, help them to figure out how they might go about finding out about the item, using books or other resources.

6. Pose question about what's left in bucket after sorting. Ask participants if everything from animals, seaweed and plants, and people was taken out of their beaches, what would be left? (*sand and rocks*).

7. Pose question about clues and composition of sand. Ask participants, if we looked very closely at the sand on a beach, do you think it might be able to give us some clues about what the sand might be made of? [Hold up the container of candy "sand" to compare with the beach bucket sand.] Have participants talk to a partner for a moment about their ideas.

8. Lead group discussion. Lead a group discussion about their ideas regarding clues and what the clues can tell us about the composition of sand.

Activity #2: Oyster Beds

Overview

Naturalists and scientists use many skills when trying to understand how animals live and why they behave the way they do. The depth of their understanding is only as keen as the questions they ask and the accuracy of their observation skills. A good naturalist has to have very perceptive senses and a great deal of patience to understand the natural world and the creatures that live in it.

Sharing observations with others is very important in the field of science. Adding new information to what we already know about our planet is important for its long-term health. Clear ways of communicating observations are almost as important as the observations themselves. One of the organisms that scientists, food-lovers, and poets have been sharing information about for several thousand years is the oyster!

Introduction

1. Introduce activity. Have participants work in groups of 5–6 with all the groups the same size, if possible. Give each group a bag that contains one side (valve) of an oyster shell for each participant. [Remember that you placed the other half or match of the oyster shells in another group's bag labeled with the same number or sticker—but don't tell the participants about that yet.]

2. Participants examine oyster shell. Ask each participant to take an oyster shell (it is actually 1/2 an oyster shell) from the bag and examine it for two or three minutes. Then have them return their shells to the bag.

Note: *Use your own judgment, but you may need to warn the participants NOT to mark on the shells in any way—it spoils some of the fun and definitely defeats the purpose of honing observation and communication skills.*

3. Participants find "their" shell again. Have one participant gently mix up the shells in the bag and then gently dump them back out on the table. Ask participants to pick out the shell they had previously examined.

How is Your Shell Different?

Tell the participants that you think they will find the next part of the activity a little more difficult...

1. Participants record observations on index card. When participants have relocated their shells, give them an index card. Ask them to examine their shells once again, but this time tell them to communicate 4–5 observations on the index card. Remind them that their written or drawn communications need to be clear enough that someone else can understand them. **They shouldn't write their names on the cards**.

2. Point out resources to quantify observations. Show them the other resources around the room that they can use to make or quantify their observations. Possibilities include rulers, scales, string, or calipers.

3. Collect cards and bags of shells. After about five minutes, have the participants place the shells back in the bag. Have one participant in each group collect the cards. Keep the cards and shells from one group together, but don't put the cards in the bag.

Using Observations as Clues

Tell participants that this next part of the activity will be even more difficult.

1. Groups switch bags of shells and cards with another group. Have each table switch cards and shells with another group that has the same sticker on their bag. [Remember, participants don't know it, but you have placed the match to their shell in another similarly marked bag so you can keep track of which groups should get together for the upcoming "Match Game."]

2. Participants match cards and shells. Have a participant randomly distribute the cards among their group. Ask participants to first examine the card and then try to locate the shell it describes. Participants can work together or as a group, but everyone has to agree that each card is correctly matched to a shell for a group to be finished.

3. Lead group discussion about what helped to match cards and shells. Once every group has matched up the cards and shells, ask them what helped them to easily and without any doubts make a match. [Participants often say it was a tracing that was most helpful; other things that helped include being really specific and quantifying their observations, (i.e. there are three barnacles on the pointed end or it is 8 cm long and 5 cm wide, etc.)]

4. Group discussion about what didn't help to make matches. Now ask them what didn't help them to make a match? [They will usually say that feelings or inferences aren't very helpful for matching cards and shells, (i.e. it is yucky, looks like a raccoon or my foot, or it stinks.)]

Very general observations that are true for almost all oyster shells are also not very useful. [i.e. white and smooth on the inside, greenish and rough on the outside.] Remind participants that the very general observations **are not bad observations** and they **are** based on one of the five senses. It is just that they are too general to be helpful in this case and for these purposes.

The Match Game

Tell participants that now comes the really hard part... the most difficult part of all. Somewhere in the room is the other half or match of "their" oyster shell and they need to find it.

1. Introduce match game. Tell the participants which groups should work together to find matches to their shells. Before you direct them to start, tell them that **immediately** upon finding their match, they are to sit with their new partner. They can sit anywhere, but they must sit quickly. That way people who are still looking for matches can get together.

2. Participants work with partner and list questions. Tell them that once they find their match and sit down, they are to work together with their partner to make a list of questions (at least three) on the back of their 5 x 8 card, that they now have about oysters and their life history.

3. Participants start match game. Tell participants to stand up, take one shell from their table group (it doesn't have to be their original shell) and "find their match!" If the groups are uneven in size, one participant may need to find the match to two shells. Be sure there are no shells left on the tables, otherwise someone won't find their match. Walk around the room, helping to facilitate match-making.

If participants have difficulty matching oyster shells, it's usually because they expect the two halves of one shell to look identical to each other—like a clam. Many participants are very surprised to discover that one side is flat and the other side rounded and they fit intricately together like a soup bowl with a tight-fitting lid.

4. Participants wrap matches with rubber band. After all matches have been made, and partners have had time to list at least three new observations they have about oysters, have the participants wrap a rubber band around the matched shells so you don't have to search for the matches again later.

5. Form new groups of six participants. Have each pair join with two other pairs to form a new cooperative group for the next activity, *Red Fish Roundup*.

Activity #3: Red Fish Roundup

Overview

The ocean acts as a filter and allows only certain colors to pass through to the deep, while it absorbs other colors in the top few meters. Violet and the orange-red wavelengths are the first to be absorbed. Blue and green wavelengths travel the deepest. In very clear tropical waters, while all the red light is absorbed in the upper 10 meters, a small amount of blue light can actually make it all the way down as far as 100 meters. Many deep sea animals are red because there is no red light at these depths to be reflected to a predator's eye, and so the potential prey is essentially camouflaged.

In this activity, participants engage in hands-on activities as they experiment with color, light, and rainbows. They discover that the white light that comes from the sun is actually a mixture of the seven different colors seen in a rainbow. Then the participants search for camouflaged fish during a "scuba diving" experience while wearing blue cellophane goggles to simulate the underwater light conditions. Participants discover that some fish hide from predators at depth by using camouflage color.

Making Rainbows Demonstration

1. Introduce demonstration. Show participants the glass baking dish or plastic shoe box 3/4 filled with water. Place a mirror in the water and tell them that if you took this outside, you could direct the mirror in such a way as to form a rainbow. *(This is what the elementary students doing the activity would actually do, rather than using the diffraction gradient.)*

2. Display rainbow using diffraction gradient. Tell participants that we can also make a rainbow here in class by using diffraction gradient. Turn on the overhead projector to display the rainbow pattern created by the diffraction gradient. Show the Rainbow poster and ask if it matches what they see with the diffraction gradient. Say that we will refer to these rainbows created in the class as we do the next set of activities.

Color Spinners

1. Introduce color spinners. Tell participants that they will now make a color spinner to investigate rainbows further.

2. Distribute materials for color spinners. Distribute materials to each group of 5–6 students. Have each student cut out a circle about 8 cm across from a 5 x 7 card, white stock, or cardboard. (Plastic cottage cheese lids work great as a pattern.) Next have them divide the resulting disc into seven equal areas.

3. Participants color spinners. Have participants choose seven different colored markers most similar to the colors of the rainbow. Have them color each of the seven areas with a different color of the rainbow spectrum. Tell them that they don't need to color the areas in the same order as the colors appear on the rainbow. Participants within the same group can use different combinations of the same seven colors so they can compare results.

4. Spin the disc. After coloring the entire disc, have the students push a pencil stub, point downwards, through the center of each spinner disc (short pencil stubs are easier to spin). Position the disc flat on the tabletop with the pencil through the center and then set the disc spinning as rapidly as possible.

5. Participants describe observations. Ask participants to describe what they observe. [The individual colors disappear and the spinner appears to be off-white in color.] Ask them some of the following questions: Can someone explain why the colors seemed to disappear? Who has a different idea about that or can explain it in different words? *[If equal amounts of all the colors of a rainbow are mixed together, the result is white light. Because the disc spins so quickly, your eyes cannot make out the separate colors; they merge together so that the disc looks gray-white. Don't worry if it looks a bit dirty—you can never get a perfect white because the card and markers are not pure colors.]*

Wavelengths—A Demonstration

1. Introduce wavelengths demo. Tell participants that it may seem like rainbows and waves are unconnected, but actually light travels in waves. In this activity, we are going to use a rope as a model of how light travels in waves.

2. Start whole group demonstration. Do activity as a class demonstration. Hold one end of a rope and have a participant hold the opposite end. Stretch it out so it is off the ground for its entire length. Slowly shake the end up and down several times. Encourage participants to observe carefully.

3. Introduce vocabulary about waves. Tell participants that the up and down wave motions seen are like water waves in that they have high and low parts called **crests** and **troughs**. Display the wavelength drawing. Show students that the distance between wave crests is called the **wavelength**.

4. Shake rope vigorously. Now shake your end of the rope more rapidly. Lead a group discussion using the following prompts:

- What happens to the wavelength now? (It gets shorter.)
- Am I using more or less energy to shake the rope? (more)

- How many crests do you see?

5. Shake rope even more vigorously. Shake the rope even more vigorously and ask the same questions as above as you lead a whole group discussion.

6. Lead group discussion about waves and energy. Lead a group discussion using the following prompts:

- Which wave seems to have more energy? Be sure to ask for evidence and an explanation about their ideas. [Possible answers: The rapidly moving rope had more energy because it takes more energy to shake the rope rapidly than to shake it slowly.]
- How did the wavelength appear to change with an increase and decrease of energy? [When the rope was moving slowly it made long wavelengths. When the rope was moving rapidly, it made short wavelengths.]

Debrief

1. Relate demonstration to wavelengths and colors of light. Explain to participants that this demonstration compares the wavelength and the amount of energy in two colors of light. The first demonstration, with the rope moving slowly resulting in long wavelengths, represented red light. The second demonstration, with greater energy going into shaking the rope more vigorously, represented blue light. Blue light has a shorter wavelength and possesses greater energy than does red light.

2. Discuss what we see. Tell students that our eyes are able to see different wavelengths of light as different colors. Each wavelength of light or combination of wavelengths is a particular color. The longest wavelength that we can see is red light, the shortest are blue and violet.

3. Introduce rainbow spectrum. Refer to the drawing of the Rainbow and discuss how the spectrum always appears in the same order. One way to memorize the order is by using the mnemonic device: ROY G BIV (for red, orange, yellow, green, blue, indigo, violet.)

4. Discussion about colors of light and ocean habitats. Lead a brief discussion about what they think the colors of light might have to do with the kelp forest and other ocean habitats? Tell participants that in the next activity they will discover the connection between light from the sun and how organisms in the ocean take advantage of the different wavelengths.

The Underwater Dive

1. Participants leave room. Send participants out of the classroom so that you can tape the red fish to the walls. Don't allow them to wear the goggles outside for any length of time and warn them not look at the Sun.

2. Introduce diving activity. Meet the participants outside the classroom and have them form buddy pairs to go "scuba diving." Remind them that when they enter the room they will be diving in the kelp forest.

3. Give directions for dive. Tell them that when they enter the room, the whole class will circle in one direction and each buddy pair will silently count all the red fish they can find. They can only use hand signals to communicate with their buddy since they will be simulating a dive underwater.

4. Increase the light levels for the dive. After the entire class has toured the room once, increase the light levels slightly (open the curtains a little or turn on a few lights) and tell them they are now starting to surface through the kelp so the amount of light has increased. Have them tour the classroom again and count how many red fish they can find this time.

5. Participants tour classroom again with lights on. Finally, repeat the search with the lights on and the goggles off to compare the number of fish they can now see or the time it takes to find all the fish.

Debrief

1. Group discussion about observations during the dive. Lead a discussion using some of the following prompts:

- Why do you think we used blue goggles? In other words, what did they represent? (blue water)
- What does the blue color of the goggles appear to be doing to the red color? (Goggles make it so we can't see the red.)
- When wearing blue goggles in dim light, what color did the red fish appear to be? (gray)
- Which colors were unaffected?

2. Display Wavelength Chart. Show participants the Wavelength Chart and review with them that blue wavelengths are the primary colors that penetrate the furthest into the water. Red is one of the first colors to be filtered out. At depth, there is no red light to be reflected into our eyes. The result is that any brightly colored red fish will actually look gray at depth. The blue goggles represent the blue water and work as a filter to only let blue light travel to the depths.

3. Apply observations to ocean habitats. Ask the students how they think beautiful kelp forest fish pictures seen on calendars are taken? [The colors in beautiful pictures of fish on calendar pages are only visible because the photographer took a flash down to depth and shot the picture with a blast of white light. The diver was bringing red light down to a depth that it could not penetrate on its own.]

Concept Discussion

1. Refer back to Anticipatory Guide questions. Refer back to the "Anticipatory Guide" questions the participants were asked to keep in mind as they experienced the three different activities.

2. Assign one question to each group. Assign each table group one of the questions to discuss among themselves for about five minutes and then they will be asked to share out their ideas with the entire group.

3. Groups share ideas about Anticipatory Guide. After about five minutes, ask each table group to share their ideas with the whole group. Encourage other groups to participate in the discussion by asking questions such as: "Does anyone have a different idea?" Might someone be able to explain that in a different way? Can you tell me more about that? Call on a few participants and try to keep your acknowledgments of and responses to their comments as neutral, yet encouraging, as possible.

4. Lead group discussion about main concept of each activity. Describe to the participants that it is important to ask elementary (and other!) students to describe what they did and what they learned from an activity. As an instructor, you can tell quite quickly if your students "got it" or not. It also helps the students to cement the learning as they try to put into words what they just experienced. Ask the following questions:

- What do you think was the main point or key concept of each activity?
- Do you think the activity was effective in presenting and teaching that concept? Why or why not.

5. Preview upcoming session. Tell participants that we will talk more about other activities, kits, and classroom management in session four of the course.

Wrap-Up

1. Participants do a Quick Write response for the session. Tell each participant to get out a piece of paper and write their thoughts about the course and how the session has affected their ideas. Display the following slide:

- What questions/concerns do you have about the course?
- What about the course seems exciting to you?
- Have your ideas changed about teaching hands-on science? Please describe.
- What do you think made your ideas change?

Homework

Assign the first reading in the course reader as homework and describe how you will use a Quick Write in the next session to assess their understanding/completion of the reading.

The reading is *Surely You're Joking Mr. Feynman! (Adventures of a Curious Character)* (Feynman, 1985), section titled "The Amateur Scientist."

If you are using an online discussion prompt, assign the first prompt and describe how to access the system.

Anticipatory Guide

- What did you find to be most striking or notable about these activities?
- How were they similar or different from how you did science in elementary school?
- What kind of information was presented and what was omitted?
- How does the material for different grade levels compare?
- What issues do you think might arise if you were to take these activities into an elementary classroom?

