

FOSS © SOLAR ENERGY TEACHER PREPARATION VIDEO TRANSCRIPT

<Larry Lowery Introduction to FOSS Program>

Lowery: Hello. Welcome to the Full Option Science System. This program was funded by the National Science Foundation. Its goal was to develop materials that would involve youngsters with both the processes and the content of science.

The program is developed at the Lawrence Hall of Science, with scientists, science educators and teachers working together as a team to develop the materials. The materials are tested in the hands of teachers and children in classrooms. It takes about two years to turn out a module.

Each module begins with firsthand experiences. This is done because it has been found that firsthand experiences are the best way for youngsters to learn about the concepts of science. As the module progresses, children are introduced to abstractions and reading materials. The sequence from firsthand experiences through reading materials is deliberate because it has been found that youngsters, when they have some experience before they read, learn and understand more from the reading. Authors of reading materials can then take youngsters to greater abstractions.

Trust the materials that you are getting acquainted with. They have been well-tested. We found that they work extremely well in the hands of all teachers and are effective for youngsters in learning about science.

<Larry Lowery Introduction to Module>

Lowery: Throughout human history, people have found energy sources to do work for them. The sun is a major source of energy, and people have learned how to put this energy to work. This module begins with a study of sunlight and how it can be converted to heat. When sunlight strikes matter, some of the light is transformed into heat. Students learn that this heat can be put to use. Toward the end of this module, students use their knowledge of solar energy to build models of operational solar homes.

<Jerry Valadez Introduction to Module>

Jerry Valadez/Narrator: Hi. I'm Jerry Valadez. I'm here to get you started with the FOSS Solar Energy kit. The solar energy module consists of four investigations that will introduce students to important concepts of how solar energy affects the earth.

Most of the materials you will need to teach this module come in this kit. Everything you see here comes in these two boxes. There is enough permanent equipment in the kit for a class of 32 students and enough consumable equipment for at least two classes. You will need to check the Inventory sheet in the Materials folio to see which materials are consumable and which are permanent.

These are the materials you'll need from the FOSS measurement kit and these are the materials you'll need to supply. We will go over each part as we get to it. This is one type of heat lamp you may consider in your Cloudy Day Strategies.

Before you begin teaching this module, it's important that you look through the entire Teacher's Guide. There are many details in the Teacher Guide that are not included in the video. The first thing you will find in the Teacher Guide is the Overview folio which points out the national standards addressed in this module as well as information on how to make best use of the Teacher's Guide. It also includes valuable background information specially written for teachers who do not have extensive science background. The suggested teaching schedule in the overview will be particularly helpful as you plan.

Next you'll find the Materials folio. If you are the first teacher using the new kit, you'll want to turn to the section that describes first time prep. If the kit has been used before, check the section called Preparing Your Kit For Your Classroom. Both of these sections will give you helpful hints that will save you lots of preparation time later. This folio also contains Cloudy Day Strategies for many of the investigations.

The next four folios are the investigation folios. These are the heart of the program. Each takes one or two weeks to complete. The first page provides overview information. The At A Glance chart summarizes the investigation and helps you plan for assessment and extension activities. Next you'll find background information specific to this investigation. There is a section called Teaching Children About, which gives you some insight into research about how children think and learn.

Each investigation has several parts. For each part of the investigation, you will find a Materials list, Getting Ready section and step-by-step instructions for how to proceed through the investigation. At the end of the folio, you'll find Interdisciplinary Extensions. You can do some of these extensions with the class or save them for students to use as projects at the end of the module.

Next are the investigation duplication masters. Each master is labeled with a number so it will be easy to find when you need it. Shortly before beginning this module, make copies of the Letter To Parents and send it home with the students. This letter tells parents about the module and suggests some activities that they can do at home with their children.

It's important to read the Assessment folio before you begin teaching. It describes a system for assessing students throughout the investigations and also gives you ideas for end-of-the-module testing and portfolio assembly. The folio contains scoring guides for each of the assessments suggested.

Next are the assessment duplication masters. Here you'll find all of the masters for the assessment charts and end-of-the-module assessments. As part of the kit there are Science Stories for the students to read. The Science Stories folio gives you background information, recommends when to read the stories and suggests follow-up activities. You may want to read the Science Stories during a reading period rather than during science time, especially if you only teach science a couple of times a week.

In the Resource folio, you will find lists of trade books, videos, computer software and other resources that you can use to enrich the program. The final tab is the FOSS Website folio. At www.fossweb.com you'll find activities and resources for both students and educators. Each module for Grades 3 to 6 has interactive simulations, movies, Internet links, career information and opportunities to find out what other classes are doing with FOSS. In addition, teachers will find sections on tips and tricks, standards correlations, teacher exchange and implementation information.

Now you are ready to begin with Investigation 1.

<Investigation 1, Part 1>

Narrator: This investigation begins with students comparing their shadows in the morning and afternoon. Here is what you'll need for this part: From the kit you'll need the chalk and you will need to provide lined paper. Copy the student sheet called Solar Energy Journal and make one copy of Assessment Chart For Investigation 1.

At the fifth and sixth grade level it is a good idea to teach students how to keep notes in a journal. And this is how you make a journal. To the copy of the cover you staple ten pages of lined paper. Make one for each student.

In this part, students will be making outlines of shadows with chalk. It is important to find a paved playground that's level and away from buildings that might create shadows. Make a Project Folder for the class. As students think of ideas for projects during their investigations, ask them to write them down and put them in the folder to choose from at the end of the module.

Assessment opportunities are embedded throughout the module. Before you begin, it is important to check the Getting Ready section and the Assessment folio. Embedded assessments are important as evidence of student work and checking for understanding. Prepare Word Bank and Content/Inquiry charts using large sheets of paper or a flip chart.

This session begins with the teacher asking students what they know about shadows.

Teacher: Who can tell me what a shadow is? What is a shadow?
Emile?

Student: A shadow is when the sun reflects the -- reflects your body and your body blocks off part of the light.

Teacher: Okay.

Narrator: At this point the teacher does not comment on the incorrect use of the word reflect. She is establishing what the students believe at this point. She also asks: What do you need in order to have a shadow? Do you have a shadow all the time? And what would happen to your shadow if you stood in the same spot all day?

She concludes the discussion by telling the students they will go outside and find out more about

shadows. The students work in pairs taking turns tracing the outline of each others' feet. They need to check their shadow does not cross anybody else's shadow. Each student then traces his or her partner's shadow. The teacher reminds students that each shadow needs to be labeled with their name and the time of the day.

Teacher: I have some challenges for you.

Narrator: Now the teacher engages the students in a game.

Teacher: I want you to take your shadow hand, whichever, either your right or your left, and touch it to your shadow head. Shadow hand to your head. Good. Okay. Now take your real hand to your shadow head. Try it.

Student: I got it.

Student: I got it.

Student: Got it.

Teacher: Now don't touch your shadow at all.

Next challenge: Shake a friend's hand with your shadow. So both of your shadows are shaking hands. All right. Now make your shadow as small as possible. Make your shadow as small as possible.

Student: Mine is smaller.

Student: This is hard.

Narrator: Back in the classroom the teacher asks the students to record their observations in their journals and to predict how the shadows will look later in the day. They also record their experiences with the shadow challenges. After several hours, the students return to their shadows.

Student: Look how big they are.

Student: My shadow got smaller.

Teacher: Okay. So what happens to your shadow over the period of a day?

Student: Mine moved back -- the sun might come up this way and go down this way. And the shadow might move from one side to the other and get bigger or smaller.

Teacher: Okay. Great. Why do shadows change shapes and orientations throughout the day?

Student: Because the sun moves.

Narrator: The teacher continues the discussion by confirming that shadows change shape and

orientation. The teacher wraps up by asking the students what keywords they used today.

Student: Orientation.

Teacher: And an orientation is?

Narrator: To generate concept statements, the teacher asks key questions. It is very important to use the questions in the Teacher Guide to help students work towards understanding. Remember that students develop the understanding of key concepts throughout the module.

In this part, students learn that shadows are the dark areas that result when the light from the sun or other light source is blocked. Also, shadows change during the day because the position of the sun changes in the sky. Be sure to look over the Science Stories folio and plan time for students to read these stories. This is a great opportunity for integration with language arts.

<Investigation 1, Part 2>

Narrator: In Part 2 of this investigation, students will construct a sun tracker to track the position of the sun over several hours. For each part you will want to provide a Materials Station to make the distribution of materials easier. And here is what you'll need for this part: From the kit you will need compasses, double A batteries, golf tees, flashlights and transparent tape. You will need to supply pencils, white glue, a ruler, scratch paper, a clock with a secondhand, a globe and the journals started in Part 1.

Copy the student sheet called Shadow Tracker and the student sheet called Response Sheet - Sun Tracking, which you can use for assessment. Make a transparency of the student sheet called Compass Poster. Also have Assessment Chart For Investigation 1 available so you can make notes as you work with students. Consult the Assessment folio for details.

If you are not familiar with the use of a compass, practice with it before beginning this activity. You will need to demonstrate for the students how to orient the compass so the red point, which is magnetic north, is on the end of the compass.

Be sure to check the double A batteries in the flashlights. It is a good idea to remove the batteries from the flashlights when storing. Also it's a good idea to have a couple of spare batteries on hand.

Construct a shadow tracker like this. First, place the compass on the compass on the student sheet. Orient the compass so the ends are lined up. And then tape the compass down to the student sheet. Next you want to put glue at the bottom of the golf tee and place the golf tee upright in the center of the circle where the north-south and east-west lines cross.

Now, practice using the sun tracker using the flashlight. There is no good indoor substitute for shadow tracking. You can read Science Stories or do some of the extensions from the folio if you have to wait for a sunny day.

Teacher: You and your group are going to make a tracker.

Narrator: When you do have a sunny day, ask the students how they can use shadows to predict

the shadows of the sun and introduce the shadow tracker.

Teacher: -- point of your shadow as your object. We're also going to put on a compass to help you with your direction.

Narrator: All of the materials are at the Materials Station so the getters can easily get what they need. The starter begins construction. The teacher has asked the students to use just a couple of small pieces of tape because they will remove these sheets at the end of this part and use the cardboard many more times.

Student: There.

Student: So east is that way. West is that way. The sun comes up over there. Yeah.

Narrator: Before taping the compass to the sheet, the teacher allows the students some free exploration time with the compass.

Student: This goes south.

Student: This one is on west.

Teacher: So which way is north?

Student: That way.

Teacher: See how your position moves.

Narrator: The students are very careful to make sure the orientation of the compass matches the compass drawn on the student sheet. The students take their trackers outside and place them on the ground in the sun. They orient them so the north-south line points north.

Student: Okay. That's good.

Narrator: They draw a line around it with chalk and label the outline with their names so they can easily return to the same outline each time. They put a dot at the tip of the shadow and record the time by the dot. When they get back to the classroom, the students will draw a picture in their journals predicting what they think the pattern of shadow dots will look like over several hours.

Once every hour, one student from each group returns to the schoolyard to make another recording. Before the end of the day, the tracker may look like this. The teacher asks the students to look at the trackers to see if every group got a similar pattern. If the students follow the procedure correctly, the patterns will be similar, and the students should realize if they track shadows the next day the patterns would be similar, also.

The teacher turns the lights off and the students try to reproduce the shadows with a flashlight as the light source.

Student: If you go down --

Narrator: Using the globe and flashlight, the teacher reminds the students that the sun is stationary and the earth rotates on its axis. The teacher suggests that they move the tracker and keep the flashlight stationary.

Student: 1:45.

Narrator: The students now dismantle the sun tracker. Remember, the only consumable part of this is the student sheet. The students must return the materials to the Materials Station. Before ending this session, the students complete the response sheet Sun Tracking. This will help the teacher assess how well the students understand the relationship between shadows and the sun.

In this part, students learn that as the sun rises in the sky, shadows shorten. Also shadows are longest early and late in the day. Before ending this session, introduce the Project Folder. Explain to students that at the end of the module, they will do projects based on questions and ideas that they have entered into the folder. This is a good time for them to begin to enter those questions and ideas.

This brings us to the end of Investigation 1. Be sure to have your students do the interdisciplinary activities and the mathematics problem of the week before moving on.

<Investigation 2, Part 1>

Narrator: In the first part of this investigation, students use a thermometer to measure and compare the temperature in the sun and in the shade. Here is what you'll need for this part: From the kit you'll need thermometers, cardboard sheets and transparent tape. You will need to provide the Solar Energy Journals, a watch with a secondhand and a permanent marker.

You'll need to make copies of the student sheet called Thermometer In the Sun and Shade. If you need to review reading thermometers, make a transparency of the teacher sheet called Thermometer Reading. Make a copy of Assessment Chart For Investigation 2, which you should keep with you so you can record your observations of students' work.

Choose two level sites in the playground. One should be in the sun, and one should be in the shade. The thermometers in the kit may not read exactly the same. Place all the thermometers out at room temperature and look for pairs that read the same temperature. Use a permanent marking pen to label them in pairs, two 1s, two 2s, like this. Be sure to advise students that thermometers are fragile and should be handled with care. If students need to review the use of thermometers and how to read Celsius degrees, do that at this time.

Teacher: Today we're going to be using the tool of -- what's this?

Narrator: Begin this lesson by showing the students one of the thermometers. The students identify it as a thermometer, the tool used to measure temperature. The teacher explains that this thermometer measures degrees Celsius and the students will have a chance to practice using it.

The teacher explains the thin glass tube is filled with alcohol. As the temperature increases, the alcohol expands and travels up the tube. When the temperature decreases, the alcohol contracts

and goes back down the tube.

Teacher: What we're going to do today is we're going to measure different temperatures in the room.

Student: It's 21 degrees.

Student: 21.

Narrator: The teacher asks each pair of students to measure the temperature in different places in the room and record the records in their journals. She asks them to think about what is the best way to hold the thermometer. She also asks how long it takes for the alcohol in the tube to reach the temperature of its surrounding.

Student: 64 degrees Celsius.

Student: It's dropping.

Student: It's going lower and lower. It was on 50. Now it's on 40.

Teacher: Can anybody tell me what was the hottest place that you found in the room?
Courtney?

Student: My temperature was 67.

Teacher: Where did you find that temperature?

Student: At the heater.

Narrator: After the students have taken a few readings around the room, they return to their seats and share some of their findings. Discuss any discrepancies that may come up. Not all thermometers measure exactly the same and students have to be very careful to read their thermometers accurately to the nearest degree.

The teacher then explains what elapsed time means. The students will be taking temperature readings once a minute for five minutes in the sun and then once a minute for five minutes in the shade. After the getters pick up the materials for their groups, each pair of student tapes a student sheet to a piece of cardboard and then tapes the thermometer to the sheet. The students record the time of day and then record the temperature in the space marked 0 minutes. That is the starting temperature.

Teacher: Okay. You're watching it for a minute, guys. I'll tell you when a minute is up.

Narrator: Once outside, the students sit in a line facing the sun making sure their shadows don't shade their thermometers.

Teacher: Okay. That's a minute. Read your thermometer and put down the temperature at one minute. Where it says in shade --

Narrator: Now the class moves into the shade and takes temperature readings for another five minutes. Keep in mind, temperatures vary depending on location and season.

Teacher: You're going to take your five-minute reading. You're going to write it where it says five minutes.

Narrator: Back in the classroom the teacher asks the students to complete the two problems on the bottom of their student sheets. The students figure out the temperature change after five minutes in the sun and calculate the temperature change after five minutes in the shade.

Teacher: Look at your temperature. What temperature was the highest? What temperature did you find the highest?
Chris?

Student: The three minute one and the four minute one and the five minute one.

Teacher: Good. What about the lowest temperature?

Student: 17 degrees.

Narrator: The students discuss what they found out. The temperatures are higher in the sun as compared to the shade.

In this part, students learn a thermometer is a tool that can be used to measure temperature. They also learn that temperature in the sunlight is usually higher than temperature in the shade. Check the folio for the FOSS Science Stories so that you can integrate the readings while you do this investigation.

<Investigation 2, Part 2>

Narrator: In this part, students set up an investigation to find out what happens to four earth materials when exposed to the sun. And here is what you'll need for this part: From the kit you will need plastic containers with lids, transparent tape, thermometers, stirring sticks, plastic cups, sand and potting soil. From the measurement kit you will need one liter containers, syringes, containers for water, and you will need to provide the water, Solar Energy Journals, a watch with a secondhand, colored pencils, a black marker, and newspaper.

You'll need to make copies of these five student sheets: Earth materials In Sun and Shade, Tree Shadow Puzzle, Two Groups' Data - Materials In the Sun and Shade, Graph of Earth Materials Temperatures and Response Sheet - Heating the Earth. Have Assessment Chart For Investigation 2 available.

This activity needs two playground sites, one in the sun and one in the shade. The best time of day is some time between 10:30 a.m. and 2 p.m. This part requires completely dry soil. If your soil is not dry, spread it on newspaper and let it dry for a few days. Stir it from time to time to bring the damp soil to the top.

You will need to fill the cup with 100 milliliters of water. To do so, you will need to completely

fill the syringe twice until the stopper stops. The students are actually going to use these cups to measure 100 milliliters of dry material. And to do that, we are going to mark the level of the water with a permanent dry marker. You'll need to make a total of four cups in this manner.

Set up three stations for the distribution of earth materials. At one station, have two one-liter containers with sand and two marked cups. At the second station have two containers of dry soil and two marked cups. At the third station have two containers of water, four syringes and stirring sticks.

Since you will need 40 minutes outdoors, you may want to do the setup on one day and the temperature readings on the next. If that's the case, you will need to store the material for the next day.

Prepare the Tree Shadow Puzzle sheets for students to work on while waiting between temperature readings. Begin this session by reviewing what is meant by an earth material.

Teacher: I have some earth materials here that we're going to look at. We're going to look at water, dirt or soil, and sand. What do you think would happen to these earth materials if we put them in the sun?

Chris?

Student: The dirt and the sand might get hot.

Narrator: The teacher asks the students what they think will happen to these earth materials when they are placed in the sun. She wants to know if the temperature change will be the same in all materials and what would happen to the temperature of the materials if they were placed in the shade? Although the students have some ideas, they are not sure. So they design an investigation to find out.

The investigation starts with each pair of students taping the student sheet to a piece of cardboard. The teacher assigns two materials for each group, either sand for one pair and water for the other pair or dry soil for one pair and wet soil for the other pair.

Students add the materials to their containers using the syringe to measure 100 milliliters of water and the marked cups to measure 100 milliliters of dry materials. In order to get wet soil, students add 50 milliliters of water to the dry soil and stir the mixture.

The teacher has distributed matched pairs of thermometers to each group. The students carefully push the thermometer up through the bottom of the lid and then place the lid on their container so the bulb is under the surface of the earth material. If the lid tears, repair it with transparent tape. If you choose not to complete the lesson at this time, have the students place the containers on the cardboard and store them overnight.

When the lesson continues, the teacher reviews directions for the investigation. Each pair is responsible for one container. Each group should sit together once they are outside so that they can compare both results. The teacher brings extra thermometers to measure the air temperature in the sun and in the shade. The students immediately take the starting temperature and record it in the 0 minutes box. The teacher is the timer and will call for a new temperature reading every

five minutes. While the students are waiting, they work on the tree shadow puzzles.

Teacher: Okay, guys. Now I want you to look at your thermometer.

Narrator: After 20 minutes the students move to the shade and take the temperature of the materials at five-minute intervals. At this time someone reads the thermometer the teacher placed in the shade earlier. The students record this as air temperature on the Earth Materials in the Sun and Shade sheets. At the end of 20 minutes in the shade, the students take their final temperature reading. Back in the classroom, the students put the wet soil on newspaper to dry and return all the materials back to their containers.

The students calculate how much their earth material heated up in the sun and how much it cooled off in the shade. They record the two temperature changes in the boxes at the bottom of their student sheets. The teacher collects the data from the class and together they find the averages. Each student uses the class data to draw a graph showing the temperature changes. They include the data for all four earth materials on the same graph. They can now use this graph to make comparisons.

Teacher: Did all of our earth materials get the same amount of sun?

Narrator: After looking at the average temperature changes for each of the earth materials, the teacher guides the students into describing the properties of materials that could account for temperature differences. For example, the soil is dark colored; did it absorb more of the sun's energy?

She goes on to introduce heat sink, a very special property of water. It takes five times more heat to raise water one degree than it takes to raise dry soil or sand one degree. It takes longer to heat water. But it loses heat slower. Any material that can receive or absorb heat and give off the heat slowly is called a heat sink.

In this part, students learn that water heats up more slowly and cools down more slowly than solid, dry earth materials. They have also learned water is a good example of a heat sink. Encourage students to add ideas and questions to the Project Folder.

This brings us to the end of Investigation 2. Be sure to select several of the interdisciplinary activities for your students to complete and also have them do the mathematics problem of the week.

<Investigation 3, Part 1>

Narrator: In this part, students set up solar water heaters to test the effect of two different variables. Here is what you'll need for this part: From the kit you'll need plastic containers with lids, cardboard sheets, thermometers, transparent tape, black plastic sheet and white plastic sheet. From the measurement kit you will need one liter plastic containers, syringes, pitchers for carrying water. You will need to provide the water, student journals, a watch with a secondhand, scissors, and colored pencils.

You will need copies of the sheets Solar Water Heaters, Solar Water Heaters Conference Chart and Solar Energy Graph. Also make a transparency of the teacher sheet called Solar Water

Heaters Class Chart. Then make one copy of teacher sheet called Circle Template and one copy of Assessment Chart For Investigation 3.

This investigation gets better results if done outdoors, although, you can conduct it inside with a heat lamp. Refer to your Cloudy Day Strategies for more information.

You will need room temperature water. Fill two pitchers about 30 minutes before starting this activity. The students will be waiting in between temperature readings. This is a good opportunity to use some of the language extensions.

Check the kit for plastic squares, rectangles and circles. If the kit is new, you'll need to cut them out of these large sheets of plastic. Use the diagram in the Teacher Guide. Make 12 squares like this. Then take two of these squares, cut them in half to make four rectangles like this. You'll end up with nine large squares, four rectangles and four small squares.

Cut out the circle template and then use it to cut out eight black circles. From the white sheet of plastic cut out nine squares 28 by 28 centimeters and using the circle template, eight circles. All these shapes then become permanent equipment.

Practice setting up a solar water heater like this. I'm going to put the tape at the bottom of the circle so it's held to the bottom of the plastic container. We want to make sure the edges of the plastic do not fold over the edge of the container. Then take your thermometer and push through from the bottom of the lid. You may have to use tape to hold the plastic sheet in place.

Then take your syringe and filling it to the 50 milliliter mark, you want to fill the container with 100 milliliters of water. Again, that will take two syringes full. As soon as we have 100 milliliters of water in the container, you want to put the lid on the container making sure that the bulb is fully immersed into the water.

Begin this session by discussing how water is heated and how hot water is used.

Teacher: How do you guys use hot water?

Student: Showers.

Teacher: Okay. How else do you use hot water?

Student: To make tea.

Teacher: To make tea. Okay.

Student: To make coffee.

Student: To wash dishes.

Narrator: The students have many ideas about using hot water.

Teacher: You swim in hot water?

Student: No. In a jacuzzi.

Narrator: The teacher asks how the water can be heated.

Student: Boil it.

Teacher: To boil it.

Student: Yeah.

Teacher: On a stove?

Student: Yeah.

Teacher: How else is it heated?

Student: By a generator.

Student: By fire.

Teacher: How could solar energy be used to heat water?

Student: You take like a piece of glass and put it up to the sun. And you have like water. And then it like reflects and goes to the water and heats up.

Student: Well, sometimes like in swimming, there's little puddles of water. And it heats up the water.

Teacher: The sun does?

Student: Yeah.

Student: You would have to put it in an open area.

Narrator: The teacher asks students to think about what they observed during the last investigation. She listens to their ideas and tells them they will be designing solar water heaters.

Teacher: What did we use in the last investigation to collect the solar energy?

Narrator: The students recall they used sand, soil and water as collectors in the last investigation. The teacher explains that all solar water heaters use some kind of collector to soak up the sun's energy. She shows the students the plastic they will be using as collectors. Their challenge is to find out which works better.

First the students use a loop of tape to secure the bottom of the collector to the bottom of the container. Then they tape the edge of the plastic circle into the container. Half will use white. Half will use black. They only need to tape in a few places.

The students tape a copy of Solar Water Heaters to a cardboard sheet and circle the color of their collector. The students add 100 milliliters of water to the container being very careful it all stays in the plastic lining. The teacher asks if the students think it will make a difference if the heaters are covered or uncovered.

The students are not sure. Half the groups place a thermometer in the lid and place it on the container being sure the thermometer is resting in the water. The other half place the thermometer in the container but leave it uncovered.

After the students circle whether they are using a lid or not, they place their water heaters in the circle on their student sheet and walk to the yard. They sit facing the sun and place their water heaters in front of them with the tops of the thermometers facing the sun.

Teacher: When I say start, I want you to look at your temperature, read your temperature. Go.

Narrator: The teacher will call time every five minutes and the students will record the temperature over a 20-minute period. The students work on some Hot Discussion Topics between temperature readings. The students feel the large squares of black plastic and white plastic to see if they can feel a temperature difference between the two.

Teacher: Can you see through the top?

Student: No.

Teacher: Why not?

Student: Because it's covered with --

Student: The water evaporated. Then the top got a thing --

Narrator: The teacher has drawn the students' attention to some condensation on the lid. When all of the data has been recorded, the students figure out the temperature change at each five-minute reading. The data your students collect will vary depending on the season and location. These readings were taken during the winter in the San Francisco Bay area.

You'll see that on this Student Sheet that the students used a white covered solar water heater. The data sheet also shows that over the 20-minute period, they recorded the temperature change in this column here. The teacher forms the students into four groups, one for each type of solar water heater. You can see from the sheet that this indicates it's a white covered solar heater. The students then enter their data into the chart and come up with an average for each interval. The averages for all four groups are then entered on the class chart.

The students then graph their data on the Solar Energy Graph. As you can see from this graph, the students find out that the black covered solar water heater is the most effective.

Teacher: What happened yesterday between --

Narrator: The teacher asks the students to compare the graph results from the water heaters to

their observations of the black and white plastic sheets exposed to the sun.

Teacher: Why did the black collectors get warmer?
Brian?

Student: Black absorbs more heat than white.

Teacher: That's correct, Brian. The black collector absorbed the sun's energy. What happened with the white collectors?

Student: It reflected the sun.

Teacher: Right.

Narrator: The teacher asks each group to discuss what they know about greenhouses. She asks them to think about the hot water heater experiment and see if that helps them figure out why the air in greenhouses is usually warmer than the air outside.

Student: The plants can get sun and stuff.

Teacher: Why does a greenhouse stay warmer on the inside than on the outside? Why is it warmer on the inside of the house than on the outside?

Student: The windows attract the sun so it can heat up the air. And it doesn't get out because it locks in the heat.

Teacher: What doesn't get out?

Student: The hot air.

Narrator: The teacher confirms that sunlight passes through the glass of the greenhouse and is transformed to heat when it contacts the materials inside. She identifies this process as energy transfer. The heat from those materials warms the air inside the greenhouse. The air can't escape and continues to warm.

Teacher: So how is a greenhouse like a car?

Student: Because --

Narrator: The students realize that when the car is closed up on a sunny day, the sun comes through the car windows and warms the seats and other surfaces inside and then warms the air. The air can't escape and continues to warm up as the sunlight shines in. This is true even on cold days.

Teacher: How many of you have ever heard of the Greenhouse Effect whether you've read it in a newspaper or heard it on the news?

Student: It's caused by like all of the chemicals people are using and them cutting down trees

and forests and rain forests and everything like that and making farms.

Narrator: Several of these students have heard discussions of the Greenhouse Effect on earth and global warming. The teacher connects this very important issue with what they already know and what they learned about greenhouses. She explains that human activity such as burning fossil fuels and burning vegetation to clear land adds excess greenhouse gases to the atmosphere. These gases absorb and hold heat energy causing our air to warm up faster.

Teacher: Why are scientists concerned and why should we be concerned?

Student: It can get too hot.

Narrator: Their questions about global warming and the Greenhouse Effect are added to the Project Folder for further study.

Student: We can get like sunburns. And it's like bad for your skin.

Narrator: In this part, the students have learned that a black collector absorbs more energy and heats the water more. They have also learned a lid captures the heat inside the container. Check the folio for the FOSS Science Stories so you can integrate the readings while you're doing this investigation.

<Investigation 3, Part 2>

Narrator: In this part, students experiment with the surface area of black collectors to find out if size makes a difference. Here is what you'll need for this part: From the kit you'll need the black plastic squares, rectangles, and small squares. The cardboard sheets, thermometers, transparent tape and resealable plastic bags. From the measurement kit you will need one liter plastic containers, syringes, pitchers to carry water. You will need to provide the water, student journals and a watch with a secondhand.

Copy the student sheet called Solar Energy Graph and the student sheet called Response Sheet - Solar Water Heaters, which you can use for assessment. Have Assessment Chart For Investigation 3 available.

You need room temperature water. Fill two pitchers with water about 30 minutes before beginning this part. You may want to practice pressing the air out of a zip bag without spilling the water. To begin this part, review what students have learned about solar water heaters.

Teacher: Which collector collected more heat, the black one or the white one?
Jensen?

Student: Black.

Narrator: The students recall that the black collector and the covered water heater heated the water the most.

Teacher: We have a bigger one, medium one and a smaller one. Which do you think is going to collect the most heat?

Student: The big one.

Teacher: You think the big one?

Narrator: She explains the size of the plastic sheets is described as surface area. Some students think the biggest will be the most effective and some students think the smallest will work best because it will concentrate the sun's energy.

Teacher: This is the whole surface area. The whole bag is the surface area. So it has a bigger surface area. So you think the bigger is going to collect more heat because it's bigger? Does anybody else have an idea?

Student: I think it's the smaller one because the big one, the sunlight has to go all over it. And the small one just has to go on one spot.

Narrator: The teacher asks each group to come up with a plan for testing the variable of surface area while keeping all of the other variables constant. After each reporter shares their groups' ideas, the teacher helps them finalize the plan for the class. Each pair of students will use a collector of different sizes. They tape it to the cardboard using two pieces of tape. One pair will use only the cardboard with no collector at all.

Each group has a syringe and a container of water. While one pair prepares a chart for collecting data, the other pair places a thermometer and 200 milliliters of the water in a zip bag. They seal it part way and press any air out of the bag before sealing it all the way.

Student: It's hard to do this with water in it. That's good enough.

Narrator: Before going outside, the students record the collector size and the water temperature on the chart they have drawn in their journals. Once outside, the students sit in a line making sure their shadows don't cover the water heaters. They have brought their journals to record their data.

Student: After that it went up 2 degrees.

Narrator: When the teacher calls time after every five minutes, the students hold the bag at the zip end and wait a few seconds for the water to mix. They record the temperature and calculate the change from the starting temperature.

Student: It's 24.

Student: 23.

Narrator: After 20 minutes, the students return to the classroom and complete their chart.

Teacher: If this is one unit of surface area -- the small square is one unit, what would this rectangle be?

Brittany?

Student: Two units.

Teacher: Two units. And what would this big square be Elham?

Student: Four units.

Teacher: Four units of surface area. That's correct. We have one unit, two units and four units.

Narrator: The teacher sets up a graph on the board and collects the students' data at the 20-minute point.

Student: Plus 1.

Teacher: Plus 1.

Narrator: When all of the data is recorded, the class discusses possible causes for the differences in each row of numbers. Not all thermometers measure exactly the same. Maybe the reader didn't get an accurate reading. But when they figure out the average temperature change for each collector, they see a definite trend.

This student sheet compares the average temperatures between four different collectors. From this graph students may infer what the temperature would be for a surface area of three units. The teacher explains that the solar heaters the students investigated are examples of passive systems. Passive systems only collect, store or distribute the energy. Active solar technologies transform solar energy into other usable forms such as electricity.

The students have learned that the surface area of a solar collector affects the rate and the amount of temperature change in a solar water heater. Continue to add student questions and ideas to the Project Folder.

This brings us to the end of Investigation 3. Be sure to select several of the interdisciplinary activities for your students to complete and have them do the mathematics problem of the week.

<Investigation 4, Part 1>

Narrator: In this investigation, students are challenged to find out the most effective way to heat a house using solar energy. And here is what you will need for this part: From the kit you will need the solar houses, clear acetate, rubber bands, transparent tape, thermometers and cardboard sheets. You will need to provide a watch with a secondhand and student journals.

Make one copy of the teacher sheet called Model Solar House Diagram and one copy of Assessment Chart For Investigation 4. Plan an activity for the wait time between readings. Ask the students to discuss other possible experiments with the houses using solar energy. You may also want to use the language extensions in the Teacher's Guide.

Each solar house needs a window made from acetate. If this is the first time the house has been used, take each sheet of acetate and cut it into three equal pieces. Then take the piece of acetate and tape evenly around each window. You will want to assemble one house before the lesson

begins. In a few moments you will see how this is done.

The students will use a cardboard sheet for the awning. In Step 7 half the groups have the window facing the sun and half have their house facing away from the sun. They both use the awning leaning it against the back wall of the house. The window should remain uncovered.

Begin this session by asking students what types of energy they use at home.

Teacher: What kind of energy do you use every day?

Student: Electricity.

Student: Oil.

Teacher: You use oil.

Student: Gas.

Student: Coal.

Teacher: So we have four different types of energy. How do we use that energy? How do you use gas? How do you use electricity? How do you use coal and oil?

Narrator: The students identify TV, lights, cooking and heating. The teacher explains the forms of energy they identify are non-renewable fossil fuels. But there is one that's renewable, solar energy.

Teacher: So you are going to construct a house --

Narrator: The teacher explains that today they are going to construct model homes and investigate ways to heat them. Warming indoor areas is called space heating.

Student: Okay.

Narrator: The students make sure the thermometer bulb does not show through the window.

Student: Perfect.

Narrator: They fold the right wall flaps inward. Then they fold up the right wall and the back wall and insert the back wall tab into the right wall slot. They fold up the front wall and insert its tabs into the back wall slots. Make sure the finger tab is pulled out. Fold the left wall in and insert the flaps into the house. Finally push in the tab to close the finger hole. If the houses have been used many times, it may be a good idea to secure the assembly with rubber bands.

Student: It's 20.

Narrator: The students practice reading the temperature.

Student: It's close to 19.

Student: It's in the middle of 19 and 20.

Teacher: We're going to be going outside to use our solar boxes. And what are some different ways that we could orient our boxes?

Frank?

Student: You can turn the window towards the sun.

Teacher: How do you think --

Narrator: The teacher asks the students to think about how the orientation of the house might affect how warm the house gets.

Teacher: -- how warm it gets or how cool it stays?

Student: You can have the window facing the sun so heat will go in and if you don't, it will be too cold maybe.

Narrator: To find out, half the groups will have their windows facing the sun and half will have their windows facing away from the sun. To begin their investigation, the students stand in a shady location and open the left wall of their houses. They wait one minute and take the temperature reading.

Teacher: And read the temperature.

Narrator: They record it as their starting temperature at 0 minutes. The students move into the sun and position their houses. They place the awnings on the houses. Every five minutes the teacher calls time and the students record the temperature inside their houses. After 20 minutes, the students take their houses back to the shade and continue to take the temperature readings every five minutes for another 20 minutes.

Student: When we were in the sun --

Student: It went up and then you go in the shade, it goes low.

Student: 28 degrees Celsius.

Narrator: The students return to their classroom and share their data.

Student: 18.

Narrator: They transfer the data to their journals.

Teacher: Okay. So let's indicate that up here. C for Celsius. And across the bottom we need to put other information. What -- if you look at your paper, what has changed every certain time period?

Student: The minutes.

Teacher: The minutes. Y axis is 0. We're going to skip a space and put 5.

Narrator: The teacher helps them set up a graph to help them analyze the data they collected.

Teacher: What was the most number of minutes that elapsed during our trial?
Alfred?

Student: 40.

Teacher: 40 minutes.

Narrator: First the students graph the data collected for Solar House No. 1 with one color and then they graph the data collected for Solar House No. 2 with a different color.

Teacher: How do the two lines on your graph compare, the one that was facing the sun and the one that was not facing the sun?

Student: The sun orientation, the graph lines goes way higher in temperature. And the shade stays way down.

Teacher: Which house cooled down the fastest? Did they cool down at the same rate or did one cool down fastest?

Student: The orientation with the sun cooled down the fastest. And -- but at 20 they were both the same. They were both really high at their highest peak. But at the end they both were -- they ended up at the same. They both ended up at 10.

Narrator: The teacher leads the children in a discussion to make some generalizations from the data collected and asks what they could do to the houses to further investigate heating and cooling with solar energy.

Teacher: Any groups come up with other possible trials?
Leon, do you have an idea?

Student: Yeah. We could test how much more black absorbs than white does.

Teacher: So compare the temperatures of the house where would you put the block.

Student: Maybe on the floor.

Narrator: In this part, the students have learned that space heating is the transfer of heat energy to the air in an enclosed space. They have also learned that the orientation of a solar house affects how warm it gets inside. Again, be sure to check the folio for the FOSS Science Stories so that you may integrate the readings while doing this investigation.

<Investigation 4, Part 2>

Narrator: In this part, students will conduct experiments to determine the effect of color on heating solar houses. And here is what you'll need for this part: From the kit you will need cardboard sheets, transparent tape, black plastic squares, white plastic squares and rubber bands to hold the solar houses together in the case that they are worn. You will need to provide the solar houses and thermometers put together in Part 1 by the students and the watch with the secondhand and the student journals.

Copy the student sheets called Space Heating, Solar Energy Graph and Response Sheet - Solar Houses. Have Assessment Chart For Investigation 4 available.

Plan an activity for the wait time. You may want the students to think about how architects and interior decorators plan a solar home. You may also want to bring in the aspects of Native American cultures and how the indigenous peoples of North America use the sun to heat their homes. Also use the language extensions in the Teacher's Guide.

Look over the large white and black plastic squares from Investigation 3 Part 1. Make sure they are in good shape for this part. Begin this session by reviewing the results of the experiments from Part 1. After reviewing their experiments with color, the teacher suggests they use the black and white plastic squares inside their houses to see if the interior color affects the temperature.

The students take their models out to the schoolyard and once again take temperature readings in the sun every five minutes for 20 minutes. They then move into the shade and continue taking readings every five minutes. They record their data in their journals. After graphing and discussing the results, the students have learned that the houses with the black interiors heated up more and stayed warm longer than the houses with the white interiors. This is an important time for students to add questions and ideas to their Project Folder.

<Investigation 4, Part 3>

Narrator: In this part, students will investigate other factors that may affect solar heating and cooling. Here is what you'll need for this part: From the kit you'll need plastic containers with lids, cardboard sheets, extra pieces of acetate, one thermometer, transparent tape, black plastic squares, circles and rectangles, and rubber bands in case the solar houses are old. You'll need to provide the solar houses and thermometers put together in Part 1 by the students along with extra cardboard, scissors, student journals and a watch with a secondhand.

Copy the student sheet called Solar Energy Graph and the student sheet called Hot Air Challenges, which you will need to cut apart so each group gets one challenge. Have Assessment Chart For Investigation 4 available.

Once again there's going to be some waiting time so plan for it. Bring in some cardboard pieces. Students may want to use them as insulation or curtains. Some students might also want to use the plastic squares as curtains. Begin this session by reviewing with students the color experiment and how they might keep their houses warmer over a longer period of time.

Student: Put the plastic over here and then cut it.

Narrator: After the teacher introduces the challenges, the groups start to plan their house modifications. This group considers installing two panes of glass in the window.

Student: Don't put it way up there because you can't tape it.

Student: Put in the water heater to make it warm in the morning and give it heat at night.

Narrator: This group will place a solar water heater in the house to see if it will absorb enough energy to warm the house at night.

Student: If they go outside and freeze, when they get back in, they won't have to be cold.

Student: We put heavy black curtains on there since black absorbs heat instead of white because it will just reflect out of the window and the house will just be colder.

Narrator: This group is adding insulation to reduce heat loss at night.

Student: I put an extra layer of cardboard on this piece.

Narrator: The students record their plan and predictions in their journals.

Student: It stays warm at night.

Student: It got almost like five or six degrees hotter so far since we put the second piece of plastic on it.

Student: There we go.

Narrator: I would say this is a really well insulated house.

Student: Now no air can get in.

Narrator: The students take their models out to the schoolyard and once again take temperature readings in the sun every five minutes for 20 minutes. Then they move into the shade and continue taking readings every five minutes. They record their data in their journals. After graphing and discussing the results, students have learned that some methods of architectural design or interior decorating can warm homes or keep them cool.

<Investigation 4, Part 4>

Narrator: In this part of the module, students begin to work on their own investigations. As they begin to work on their projects, you will find out whether or not they have understood the key concepts of this module. This is the time to bring out the Project Ideas Folder. As much as possible, you want students to use their own ideas and investigate the questions that they have come up with during the module. If you don't have enough ideas in the Project Folder for everyone to investigate, you can use the project ideas sheet to help students think about more investigations.

The project proposal sheet should be completed by each student or team of students doing a project. This sheet helps you control materials and keeps tabs on what students are working on. You will need to decide whether or not you will be able to supply any additional equipment the students ask for. You will also want to make sure that the projects the students propose are realistic and will be of some benefit to the class.

FOSS suggests students give three-minute presentations following the Presentation Guidelines sheet. They can also make a poster to help them explain their investigation to the class. You should plan about two weeks for students to work on projects. You should plan time at school but also have them do some of the work at home.

The Assessment folio has suggestions for scoring the students' work on the projects. Also in that folio you will find information and masters for two kinds of summative assessment: An End-of-the-Module test given in a variety of formats and suggestions for assembling portfolios.

This is the end of the Solar Energy module. Keep in mind there are many details in the Teacher Guide that we were not able to cover. Also keep in mind that students develop concepts over a long period of time and the opportunities you provide are key to that understanding.