FOSS © VARIABLES
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 with 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: This module is an introduction to experimentation, an important aspect of doing science. Students learn how to identify variables and how to control variables to see what effect each one has. Controlled experimentation is a capacity that can be developed successfully at the upper elementary level. In this tape you'll be introduced to FOSS materials that help children understand how variables can be manipulated and controlled. The materials will involve pendulums, airplanes, catapults and boats. Enjoy these experiences with your students as you watch them grow in their understanding of experimentation.

<Caroline Yee Introduction to Module>
Caroline Yee/Narrator: Hi, I'm Caroline Yee. And I'm here to help you get started on the FOSS Variables kit. The Variables module consists of four investigations that will help your students gain experience with the concept of variables as well as discovering relationships through controlled experiments.

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

From the FOSS measurement kit, you'll need to provide basins, plastic cups, syringes and graduated cylinders.
You'll also need to provide a number of common items. And I'll tell you which ones as we go through each part.

Before you begin teaching, it's important to look through the entire Teacher's Guide. First you'll find the Overview folio which points out the national standards addressed in this module as well as information about how to make best use of the Teacher Guide. It also includes valuable background information specially written for teachers who have not had extensive science training. 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 a 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 the Classroom. Both of these sections will give you helpful hints that will save you lots of prep time later.

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 investigations and helps you plan for assessment and extension activities.

Next you'll find background information specific to this investigation. There's a section called Teaching Children About which gives you some insight into research about how children think and learn.

Each investigation has several parts. And for each part of the investigation, you'll 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, duplicate the Letter To Parents and send it home with the students. This letter tells parents about the module and suggests 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 investigation and also gives you ideas for end-of-the-module testing or portfolio assembly. The folio contains scoring guides for each of the assessments suggested.

Next are the assessment duplication masters. Here you'll find all 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 science time, especially if you only teach science a couple of times a week. It's a perfect way to integrate science and language arts.

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. If it sounds like a lot to remember, be assured that everything will fall into place as you get started.

Now we're ready to begin.

<Investigation 1, Part 1>
Narrator: This investigation begins with students building and observing pendulums, which we'll call swingers throughout the activities. Here is what you'll need for this part: From the kit you'll need paper clips, string -- each pair of students will need a 50 centimeter length -- and meter tapes. You'll need to provide pennies, a file folder, a timer, scissors, lined paper, pencils, masking tape, glue and a stapler.

You'll need to duplicate Student Sheet No. 2 called Variables Notebook and Student Sheet No. 3, How To Build a Swinger. Also make one copy of Assessment Chart For Investigation 1.

To get ready, collect some pennies. You'll need 18 to 20 pennies for Part 1 and an additional 35 to 40 pennies for Part 2. To prepare swingers, cut a piece of string about 50 centimeters for each pair of students. The string doesn't have to be exact. Continue by tying a paper clip on the end of the string. Put the clip at the end of the meter tape folding the string over at 38 centimeters making a loop that will fit easily over a pencil.

Re-measure it to make sure that it's exactly 38 centimeters long. Trim the end, place a penny in the paper clip. Now you have a completed swinger.

Prepare a Variables Notebook Journal for each student by taking the duplicated cover and about ten sheets of paper and stapling them together. Prepare Word Bank and Content/Inquiry charts using large sheets of paper or a flip chart. Make a Project Folder for the class. As students think of ideas for projects during the investigations, ask them to write them down and put them in the folder to choose from for further study at the end of the module.

To begin this session, explain to the students that they will be starting a new science activity. First, they'll need to make the equipment.

Teacher: One of the jobs is the getter --

Narrator: The teacher reviews the group members' jobs and asks the getters to get materials for their groups.

Teacher: -- from the Materials Center here.

Student: Use some masking tape to make a loop.

Student: Yeah, perfect.

Student: Hold on.

Student: I can do it.

Student: Are you guys almost done?

Student: Okay.

Student: It’s a little bit long.

Student: Here. We need to measure it.

Student: Clip the penny in the paper clip.

Student: Hallelujah. Sorry.

Student: Okay.

Teacher: It looks like most of you have completed making your swingers. And what we're going to do now is talk a little bit about them. When we have something like this that swings back and forth with a weight, we call that a pendulum. Of course another name of that could be a swinger. So you could use either of those two names. What I would like you to think about is how many times you think this swinger will swing back and forth in 15 seconds.

Narrator: The students will probably suggest swinging the swingers to find out. Each pair tapes a pencil to the edge of the desk and hangs the swingers from the pencil. Now the question is: What constitutes one swing?

Student: When you swing it back and forth one or there one and back one, too?

Teacher: That is a swing, there and back.

Narrator: The teacher will be the timer.

Teacher: On your marks, get set, go. Stop.

Student: We got 12.

Teacher: 12. From this group?
Sam?

Student: We got 13.

Teacher: 13 in this group.

Narrator: Results should be 12 to 13 swings in 15 seconds. The students will conduct the test again to verify results.

Teacher: Begin.

Student: We got 12.

Teacher: What I would like you to be thinking about right now is what might be some things you could change in your swinger's system that might change the number of swings that it moves back and forth in 15 seconds. Okay.
Michael?

Student: The length of the string.

Teacher: The length of the string.
Allison?

Student: You could put more weight on the string.

Teacher: Allison mentioned weight. The word we're going to use instead of weight is mass. Mass means how much of something. Okay. Any other things that we could change?
Jenna?

Student: The height of where you drop it from.

Teacher: The height of where you drop it from, or the release position. What I would like you to do now is write down in your Variables Notebooks the three things that were just mentioned by your classmates.

Narrator: The teacher tells the students that the things they can change are called variables.

Teacher: So anything that you can change in the experiment that might affect the outcome is called the variable.
Georgina?

Student: We learned the word pendulum.

Narrator: To wrap up the session, ask students to contribute any new vocabulary with their definitions to the class Word Bank. Add key concepts to the Content/Inquiry chart.

Teacher: Where might you have seen a pendulum outside of school?
Will?

Student: Like in a grandfather clock.

Teacher: Good. Grandfather clock.

Narrator: In this part, students learn that anything you can change in an experiment that might affect the outcome is called a variable. There are readings in the FOSS Science Stories about variables. Be sure to check the Science Stories folio so you'll know the best time to have students read the stories.

<Investigation 1, Part 2>
Narrator: In this part of the investigation, students test the variables of mass, release

position and length. You'll need to supply swingers from the first session, pennies, pencils, glue, a timer, masking tape and a cardboard strip. Duplicate Student Sheet No. 4 called Swingers Number Line, Student Sheet No. 5 called Swingers Picture Graph, Student Sheet No. 6 called Response Sheet - Swingers, which you can use for assessment. Have Assessment Chart For Investigation 1 available so you can make notes as you work with the students. Consult the Assessment folio for details.

To prepare a class number line, make a copy of the Swinger Number Line sheet. Cut along the dotted lines and glue the strips onto your cardboard. Punch holes underneath the numbers and add on the paper clips leaving them slightly open. Your number line is ready.

Each pair of students will need a different length of string to make swingers measuring from 13 centimeters to 200 centimeters. The string will have to be cut longer to allow for making the loop. There are several options. You can simply tell each pair to go and cut the assigned length of string or you can prepare swinger length cards in advance by writing the numbers on index cards or paper and have the students cut their own strings. You can go one step farther but preparing the card and cutting the string for each pair.

Putting the strings and cards in envelopes will help prevent them from getting tangled. Think about where students can hang the long swingers in your room. You'll need to collect 35 to 40 pennies for this part.

Begin this session by reviewing the concept of variables. Stress with the students the importance of keeping notes in their notebooks.

Teacher: What about the variables that we talked about?

Narrator: The students are asked to recall the three variables they thought might affect the number of swings of a pendulum in 15 seconds: Mass, release position and length.

Teacher: Becky?

Student: Mass, length of string and the release position.

Teacher: Very good. Today what I want to do first is to introduce what we call the standard pendulum. So we have a 38 centimeter long string with a paper clip attached, a penny and the release position that we let go for 15 seconds. We're going to call that the standard pendulum system. Okay?

Today what we're going to do, first of all, is to do an experiment where we use one variable at a time.

Narrator: The teacher asks students for ideas on how to change another variable. In this case, release position. They suggest dropping the release position halfway. He asks how they think that will affect the number of swings in 15 seconds. Some think there will be more swings. Others think there will be fewer. The teacher shows where to hold the swinger for a 45 degree angle and the students conduct the test.

Teacher: Ready. Get set. Go.

Teacher: Stop.
Allison, what did your group come up with?

Student: We got 13 swings.

Narrator: The teacher asks the students to check their data in their notebooks from the day before to compare results.

Teacher: -- a standard release that we did yesterday.
Alex, what about your group?

Student: Well, we got the same as them so it didn't make much of a difference.

Narrator: They find there was no difference. They record the data for a 45 degree release point. Now the students test mass as a variable by adding one more penny to their swingers so that they have two pennies in the paper clip. They have returned to the standard release point parallel to the tabletop. So again, they are only testing one variable at a time.

Teacher: Stop.

Student: We got 12.

Teacher: Okay. Was that what you got yesterday?

Student: Yeah.

Teacher: For the standard?

Student: Uh-huh.

Teacher: Okay.
Nina?

Student: For us it didn't really make a difference between adding mass. We still got the same thing we did yesterday.

Narrator: The teacher reminds students to record the new data in their notebooks. They conclude that adding mass to the swinger does not affect the outcome.

Teacher: Is that true? Okay.

Narrator: To test the variable of length, students need to make new swingers. For each pair of students, this teacher has placed an index card with the swinger length and the string in an envelope.

Student: Ours is really short.

Teacher: Just a reminder as you are constructing your swingers, the length of the swinger is measured from the top of the loop to the bottom of the paper clip. The top of the loop to the bottom of the paper clip. That's your measure.

Narrator: The long swingers may take a little longer to measure and construct.

Student: There is 100. This would be 70.

Teacher: If you have a longer one, you need more space, please find the appropriate spot so that you can tape a pencil to it.

Student: Perfect.

Narrator: Allow students time to practice with their new swingers.

Student: 200 centimeters, though. That's big. Here, let's do it again.

Student: It hits, though.

Student: Well, I don't care.

Student: It does.

Student: It sort of does. But what are we going to do?

Student: Oh, goody. Now I'm getting excited. No. I'm joking. Here we go. Okay. Boom. That was the biggest one. That was the best.

Teacher: Get set. Go.

Class: One, two, three, four, five, six, seven, eight, nine --

Student: Three, four.

Class: Five, six, seven --

Teacher: Stop.

Narrator: The students hang their swingers on the number representing the number of swings they got in 15 seconds. Some students rounded off half swings so you see two swingers on the same hook.

Student: I told you I did it.

Narrator: Later they conduct the test two more times to verify their results and got a more perfect curve.

Student: Go get some tape. Go get some tape on it.

Teacher: We have our number line here going from shortest to longest.

Narrator: By looking at the swingers and seeing the line formed by them, the students are asked to discuss the relationship between the length of the string and the number of swings.

Teacher: Anna?

Student: We can conclude that the longer the string, the fewer the swings and the shorter the string, the more the swings.

Narrator: After the students have recorded their findings in their notebooks, the teacher puts the results on a class T chart.

Teacher: The length of the swinger and the number of swings it made in 15 seconds.

Narrator: The teacher demonstrates with a transparency how to use the information on the T chart to complete the Swingers Picture Graph. The teacher asks three questions. The answers become the concept statements for this part.

Student: You can change the variable of length.

Teacher: Change the variable of length. Okay. No. 2. Why is it important to identify variables?
Patrick?

Student: Because if -- you identify the variables so you can test each one and see which ones change the results. Mass and release position didn't change the results but length did.

Teacher: Very good. No. 3. What's a controlled experiment?
Jared, what's a controlled experiment?

Student: You change one variable at a time.

Teacher: Excellent. Okay. Only one variable is changed at a time.

Narrator: Before ending the session, introduce the students to the Project Folder. This is a wonderful place for students to start putting ideas and questions they may have. Explain to them that at the end of the module, they will be able to select a project they wish to study or learn more about.

<Investigation 1, Part 3>
Narrator: In Part 3 of this investigation, students are introduced to the Two-Coordinate Graph and they learn to make predictions from it. Here is what you'll need for this part: From the kit you'll need paper clips, a ball of string and meter tapes. You'll need to provide completed picture graphs from Part 2, pennies, scissors, masking tape and pencils.

Duplicate Student Sheet No. 7 called Swingers Two-Coordinate Graph. Have Assessment Chart For Investigation 1 available so you can make notes as you work with the students.

Begin this session by reviewing the picture graph students made in the previous session. The teacher uses the information from the students' picture graph and the T chart to introduce the two-coordinate graph. Let’s take a closer look at how to present graph-making to students.

Explain that the horizontal line is called the X axis. In this case, it tells us the length of swingers. And the increments are already entered. Introduce the Y axis, which is the vertical line. In this case, we have the number of swings in 15 seconds. Using the complete Swingers Picture Graph, we can take student data and record it onto the Two-

Coordinate Graph.

Here we find a 15 centimeter length swinger produces 20 swings in 15 seconds. Now we transfer the data to the Two-Coordinate Graph. A 15 centimeter length swinger produced 20 swings in 15 seconds. We put the dot on the line, not in the space. The length of the next swinger was 25 centimeters and produced 15 swings in 15 seconds. Transferring the student data over, a 25 centimeter length swinger produces 15 swings in 15 seconds. We put the dot on the line, not in the space. The students continue transferring the data onto the Two-Coordinate Graph.

Student: 120 centimeters.

Teacher: Good. That's a good observation. What about this group?

Student: 10.

Student: Halfway here, 15 and 20. Is that what you got? So it went like this in the order, right? So if you compared these together --

Narrator: This comparison on the two types of graphs will continue in a class discussion. After the students connect their dots, they can see trends on the graph and use them to make predictions.

Here is how students can use graphs to make predictions: Returning to our Two-Coordinate Graph, I can predict that an 80 centimeter length swinger will produce 9 and a half swings in 15 seconds. In this part, students learn that a Two-Coordinate Graph can be used to make predictions.

This brings us to the end of Investigation 1. Be sure to select the interdisciplinary activities for your students. And remember to do the math problem of the week before moving on.

<Investigation 2, Part 1>
Narrator: In this part of the investigation, students continue to explore variables using boats made from paper cups. Here is what you'll need: From the kit you'll need paper cups, meter tapes and sponges. From the FOSS measurement kit you'll need to provide basins, plastic cups, syringes and graduated cylinders.

You'll also need to supply a couple of textbooks, pennies, permanent marking pens, scissors, pencils, the Variables Journals, water and paper towels. Duplicate student sheets called Boat Building and Measuring Life Boat Capacity. Make a copy of the Assessment Chart For Investigation 2, which you should keep with you so you can make notes about how your students are working.

Plan to do this part of the investigation in a place where students have level surfaces on which to put their basins. Following the directions of the Boat Building sheet, the students will construct their set of life boats. The setup will look something like this with a pencil and a book and a student turning a cup around to mark where to cut the line. Be sure to allow the sponges to dry overnight to prevent mildew from forming.

Beginning in 1983, pennies were no longer solid copper but were mixed with zinc. They weigh different amounts. So for this part, collect about 50 pennies made after 1983.

Begin this lesson by telling students that they will be building boats from paper cups to see what variables affect how many passengers each boat can carry.

Teacher: Now, as we're measuring, you want to make sure that the point of the pen or pencil sticking out of the book is exactly 3 centimeters from the base of the table. Get it as close to 3 centimeters as possible. And when you put pressure on the pen, it should measure right at 3 centimeters. Again, applying pressure to the book, take your cup and make a line for cutting to make your paper boat. Once you have your mark made, go ahead and cut along the line. Get your 3 centimeter high paper boat.

So to be accurate, what I would like you to do with your partners is to set your paper boat on the tabletop and then have somebody else make sure it's exactly at 3 centimeters. This group did a good job.

Narrator: After filling the basins two-thirds full with water, the students test their boats several times to see how many pennies each boat can carry without sinking.

Teacher: Take the pennies onto the paper towel so that they can kind of be dried off before you do it again.

Student: 10, 11, 12, 13, 14.

Student: 14.

Teacher: What I would like to do right now is to find out from the reporters how many passengers your life boat supported.

Student: Our boat held about -- like around 22. We tested it three times and we got different answers. Like one of them was 12 and the other ones were 25 and 21.

Teacher: Thank you. Okay.

Brandon?

Student: Our boat held about 16, 17. When we tested it three times, the first time we got 13, the second time, 16 and the third time 17.

Teacher: All right.

Student: We found it held 28 passengers.

Narrator: Even though the boats appear to be all the same size, the results really varied. The students thought the differences could be because of the position of the passengers, how fast they were loaded or possibly the boats aren't exactly the same size. After the discussion, the teacher writes ideas from the class on the board and the students record them in their notebooks. The students measure the capacity of their boats by seeing how much water each will hold to see if, in fact, they are all the same size.

Student: Look you guys. It's over 50.

Student: I have an idea.

Narrator: When the water from the boat is transferred to a graduated cylinder, there is more than 50 milliliters. The students have to figure out how to get an accurate reading.

Student: Are we going to pour that out into there, though? Because we already know it's 50.

Student: No.

Student: Yeah.

Student: Just for the excess water. That's a good idea. So should we start? You guys tell me.

Student: Just like stop a few times and see.

Student: Yeah, stop.

Student: Add a little more.

Student: Okay.

Student: Okay. That's exactly 50.

Student: And then we'll pour that back in here. Just pour this back in there. And then we'll see --

Student: How much over 50 it was? Okay. So it was about 8.

Student: Yeah, 8.

Student: We have 58 then.

Student: So our thing is 58.

Student: So let's record 58.

Narrator: Although the boats were cut the same height, measuring the capacity shows that the boats are not all exactly the same size. Since capacity can be measured more accurately, this is the variable that will be used. Each group will construct four new boats of different sizes and measure and record the capacity of each.

In this part, students should have learned that variables that might affect the number of penny passengers that a paper cup boat can hold are: How the pennies are placed in the cup, where the pennies are placed in the cup and the capacity of the cup. Check the folio for the FOSS Science Stories so that you can plan to do the reading activities while working on this investigation.

<Investigation 2, Part 2>
Narrator: In this part, students conduct controlled experiments to see how many penny passengers each boat can hold before sinking. Here is what you'll need for this part: From the kit you'll need the sponges. From the measurement kit you'll need plastic cups and basins. You'll need to provide life boats made from the previous sessions, pennies, the Variables Journals, water and paper towels. Duplicate student sheets called Life Boat Inspection and the response sheet Life Boats, which you can use for assessment. Have the Assessment Chart For Investigation 2 available, also.

To begin Part 2, remind students that in a controlled experiment, only one variable is changed at a time. Today they will look at the variable of capacity.

Student: I found out that you could also just put them in gently and also level them out. So like the boat doesn't sink.

Teacher: You're agreeing with Maxina that by putting the pennies in gently and leveling them out evenly, distributing them in the life boat, that will help support more passengers. How many of you agree with that? Alright. So what we're going to do, we're going to call that method our standard.

Narrator: It's important that students understand that in order to conduct a controlled experiment, you must have a standard.

Teacher: -- passengers evenly into the boat.

Narrator: The students prepare for the investigation by filling in on their sheet the names of the boats and the capacity of each.

Student: Okay. This isn't working.

Student: Okay. 11.

Student: That was 10.

Student: Put the pennies on the sponge I think.

Narrator: Remind students to dry their pennies with the sponge between trials.

Student: 10.

Student: 10.

Student: Yeah.

Student: Taking out one?

Student: Yeah. Because it sunk at 11.

Student: Okay.

Narrator: When students have completed their investigations and have recorded the results, point out Part 2 of the student sheet and ask them to graph their data. The horizontal or X axis represents the capacity of the boats. Tell students to run their fingers up the line until they get to the number of passengers the boat held. They place a pencil dot where the two lines intersect.

Teacher: Capacity for this group over here as it increased, so did the number of passengers.

Narrator: The teacher leads the students to discover the relationship between the capacity of the boats and the number of passengers the boats can carry.

Teacher: Can anybody explain what this graph means?
Jill?

Student: The relationship I think to the number of -- the capacity and the number of passengers for this project is that the more the milliliters of the boat, the more passengers it can support. And the less milliliters of the boat, the less passengers it can support.

Teacher: Alright. Very good.

Narrator: In this part, students should understand that the greater the capacity, the more passengers a boat can hold. This is a good time to encourage students to add questions or ideas to the Project Folder.

<Investigation 2, Part 3>
Narrator: In this part, students trade boats and use their graph to predict how many passengers the boats in their neighbors' fleet will hold. This is what you'll need in this part: From the kit you'll need the sponges. From the measurement kit you'll need the plastic cups and the basins.

You'll need to provide the partially completed Life Boat Inspection sheets, life boats made from the previous sessions, rulers, pennies, the Variables Journals, water and paper towels. Have Assessment Chart For Investigation 2 available.

Begin this session reviewing information students have on their graphs.

Teacher: As a group I would like you to swap your fleets -- that means to exchange them with another group -- and test out their boats the same way we did this before. Write down the boat name, the capacity in milliliters. And then the next thing: Predict. Predict how many passengers you think that boat is going to support before you actually put it in water and put passengers in it.

Narrator: You may need to go over the graph and help students see how to use it to make predictions.

Student: Carpathia because it's 32 in capacity. Look around 32. I'm guessing it would be about 14.

Narrator: Visit the students to assess how they are working with a variable. Ask questions like: What variable is being tested? What makes this a controlled experiment?

And why do you need a standard for loading passengers?

Student: 32.

Student: So 32.

Student: Wait, which one is that?

Student: That was SS 4.

Student: 32. That's a lot.

Student: Okay. Our prediction was only 26 because we compared it with the 75 --

Student: It was -- but it was probably how we placed it. Because maybe we like --

Student: Maybe we did it too fast.

Student: The other time. Because we were in a rush.

Student: Actually it seemed like we did it pretty fast this time. Because like -- and we even got 32.

Student: Yeah.

Narrator: If results don't match predictions, assist the students in analyzing the discrepancies. They may want to decide which measurements need to be rechecked. This is also a good time to have the class consider how well the other variables have been controlled such as the placement and position of passengers in the boat. You may want to encourage the students to put their ideas and questions in the Project Folder for later study.

In this part, students should learn that predictions can be made by using the information on Two-coordinate Graphs. And in the case of discrepancies, students should understand that unexpected results may have come from changing more than one variable at a time or that variables may be inadequately controlled.

This brings us to the end of Investigation 2. Be sure to select several of the interdisciplinary activities for the students to do. And also remember to do the math problem of the week.

<Investigation 3, Part 1>

Narrator: This investigation will take you to new heights. The students will have an opportunity to work with a special plane, the FOSS plane. Here is what you'll need for Part 1: From the kit: Propellers, tail hooks, sandpaper -- which you'll cut into quarters -- craft sticks rubber bands, super jumbo straws, jumbo straws, fishing line, meter tapes and plastic zip bags.

You'll need to supply a stapler and some scissors. Duplicate the Student Sheet called Plane Construction. Make one copy of the Assessment Chart For Investigation 3.

Each collaborative group will construct a FOSS plane. The goal of the group will be to construct a plane that looks like this. Following the FOSS Plane Construction sheet, we can begin by taking two craft sticks, sanding down their ends and tapering them so that they fit into this form. Next we take the super jumbo straw, find its midway point, and cut it in half. Taking a hole puncher, we punch a hole near the end within one centimeter of the end. Okay. We take the jumbo straw and slide it through the holes.

After assembling the straws, you'll flatten the ends, put them between two craft sticks with the tapered ends up, staple them together, attach the propeller, the plane hook, the tail hook and the rubber band. Your completed plane will look like this. It will be ready to attach to the flight line. The flight line will go through the upper strap.

Begin this section by showing the students a FOSS plane and telling them how to construct one. The students learn from the construction sheet that the first thing they need to do is sand the craft sticks to taper the ends. Next they cut the super jumbo straw in half.

Student: If this is roughly 20, you want it at the 10. So can I have a pen --

Student: Mark it at half maybe.

Student: Yeah. There. And then cut -- see that mark. Yeah; yeah. Right there.

Student: Perfect.

Student: Yeah, it's perfect.

Narrator: The holes should be punched not more than one centimeter from the end.

Student: So we slide it on this end. And then attach this.

Teacher: That's because you have the propeller clipped the wrong way. It has to be clipped this way. But good observation, though. So then now it shouldn't hit. See.

Student: What's the string for?

Teacher: I'll explain that.

Student: Okay.

Teacher: Now, the thing you want to do before you do anything else is go ahead and staple this into place.

Student: How do you staple through the wood?

Teacher: Oh, you would be amazed how durable those staples are.

Student: The staples?

Teacher: The getter -- whoever did the hole punching should probably go do the stapling.

Narrator: Remind students to check to see that the staples show on both sides of the sticks. After the straws are trimmed, the students attach the rubber bands.

Student: When you turn --

Student: When you turn this -- when you turn the propeller and it gets all wound up.

Student: Then when you let it go --

Student: Whee!

Narrator: Once the planes are assembled the, teacher explains that a plane and its flight line make up a system whose parts can be investigated.

Teacher: And this system with the fishing line or the flight line is called the FOSS Plane System. Now, remember a system is a set of objects that are related in some way and where each object in the system could be isolated to study it -- its effect on the system. Okay?

So we're going to work with these right now. And have you set up your flight line in an area in the room where it's not going to run into another groups' flight line. Right here. This group back here. Same way except on the opposite side of the room. A chair over here. A chair here. That's two groups.

Narrator: The teacher assigns airspace to each group so that everyone has enough room to test their plane.

Student: I got mine.

Narrator: The teacher distributes the flight line.

Student: I can't go back anymore, you guys.

Student: There you go.

Narrator: The getter picks up a piece of duct tape to fasten it with. They may get additional duct tape if they need it. But the duct tape stays at the Materials Station and the flying begins.

Student: Okay. Let's start from this side. Ready?

Student: Let go.

Student: Hey, it flies.

Narrator: This is an exploration time. This group winds the propeller in the opposite direction. Which way will it go, front wards or backwards?

Student: Ready?

Student: Wow. That spins faster.

Student: Okay. Let go when it comes toward you.

Student: Okay. It's not tight enough.

Narrator: In this part, students should learn that all parts of the system work together to make the plane fly. Every part affects how the plane flies. There are several readings in the FOSS Science Stories about flight. Be sure to check the Science Stories folio to know when is the best time to use these selections. This is another opportunity to integrate language arts with science.

<Investigation 3, Part 2>

Narrator: In this part, students identify the variables that affect the flight of the FOSS plane and work on controlling them. Here is what you'll need for this part: From the kit: jumbo paper clips, fishing line that will be used as flight line; you'll need to cut in a four meter line for each group; duct tape, meter tapes and extra rubber bands.

You'll need to provide the FOSS planes in baggies constructed in Part 1, masking tape and various sizes of rubber bands. Duplicate the student sheet called Flight Log and the response sheet Plane Sense which you can use for assessment. Have the Assessment Chart For Investigation 3 available.

To begin this part, ask students if they had any problems getting their planes to fly.

Teacher: Okay. Yesterday when we finished up with our investigations using our FOSS Plane Systems, I asked you to name your plane. I call mine The Zinger. And I hope that all of you had a chance to put your names on yours. When you were doing this investigation, did any of you come up with problems that you had to overcome before you could get your FOSS plane to fly on the flight line?

Student: The string kept coming out from the tape so it wouldn't stay.

Teacher: So you had a problem keeping the flight line attached to the chair. Okay. Allison, what did you do to solve that problem?

Student: We had someone hold the string on the back of both chairs so that it wouldn't come out.

Teacher: Okay. That sounds like a good solution.

Narrator: The students record the answers to the first two questions in their notebooks. They will need to investigate the third question. But what is a complete wind?

Teacher: From top all the way around back to the top position. That's one wind. So as you're counting the winds, that's how you're going to get the answer to Question C.

Narrator: The students need to record the name of their plane, the length of the flight line and the number of winds needed to fly the length of the line. They guess how many winds it will take.

Student: 28, 29 -- so what do you think? 45 maybe?

Student: Yeah.

Student: 41, 42, 43, 44, 45. Okay, 45. Get this off. Ready?

Student: Let's try it.

Student: Oh, it's not even. The little -- oh, there. The plastic thing -- okay. Ready. Come on, 45.

Student: Oh.

Student: It made it.

Student: So 48.

Teacher: When we completed our investigation, we found out that it took a certain number of winds of the propeller for our planes to travel the full four meters along the flight line. It's really important as scientists and as investigators to keep a flight log just like pilots do when they go on a trip. They have to record all kinds of information such as the date, the time, the weather conditions, the number of passengers that are on the plane, the weight of the plane as it's loaded with baggage, the elevation and the performance of the aircraft.

Student: It was 49. But our flight line is how many centimeters long I think?

Student: He said four.

Student: No. That's meters.

Student: That's meters.

Student: It means --

Student: 49.

Student: There's 100 centimeters in a meter. And the stick was four meters long. It was 400 centimeters. Does everyone else agree? Because it's 100 in a meter length.

Student: Yeah. That sounds good.

Student: And we needed 40 winds of the propeller to fly the length.

Narrator: The students guess how many winds it will take for the plane to fly halfway down the line. In order to be accurate, these students measured the length of their line, found the halfway point and have placed a small piece of tape on the floor to mark it.

Student: How come it's not working?

Student: More power!

Narrator: Some planes need servicing between flights.

Student: Oh, there's something wrong with it. It's making it go like that.

Narrator: It may take several attempts before the students find the exact number of winds needed to fly halfway down their lines. The reporters share their experiences.

Teacher: Georgina?

Student: The first time we tried, it didn't go -- it went further than halfway. So we reduced the amount of winds that we did before we let it off. And then it didn't go halfway. So we had to go somewhere in between.

Narrator: The teacher explains that when the students adjusted the number of winds, they were changing one thing that affected the outcome. And he reminds them that this is called a variable. The teacher asks the group to discuss among themselves what additional variables might affect the flight. After each group has a chance to discuss their ideas, the reporters will share their conclusions with the class.

Teacher: Patrick?

Student: Weight is a variable.

Teacher: All right. Weight.

Student: The size.

Teacher: The size of what?

Student: The propellers.

Teacher: The size of propeller. Okay.

Student: The slant of the string. Like if it's going uphill or downhill.

Teacher: Good.
Jerry?

Student: The tightness of the rubber band. Because the first one we did, it was really tight. And then it broke. And we picked up a looser one. And it didn't go as far.

Student: The tightness of the flight line.

Teacher: Nina?

Student: Maybe the length of the string.

Teacher: Good. The length of the flight line.

Narrator: The students record the possible variables in Part 3 of their logs while the teacher lists them on the board. The groups discuss their flight plan. The teacher reminds the class to choose only one variable to test. Everything else is standard so that they will be able to observe how changing one variable affects the outcome.

The class has agreed that the standard number of winds is 35. Now they begin their test. This group is testing weight. This flight line slants up.

Student: Okay.

Narrator: This group has added rubber bands to their plane.

Student: Go.

Narrator: Wow, look at it go.

Student: That was fast.

Student: Oh, my gosh. Do it again. That was so cool.

Narrator: Students should understand that the number of winds, how many weights, the length and number of rubber bands, have an affect on the flight of the plane. This is a good time to add ideas to the Project Folder.

<Investigation 3, Part 3>

Narrator: In this part, students are encouraged to use their imagination and design their own controlled experiments. Here is what you'll need for this part: From the kit: jumbo paper clips, fishing line to be used as flight line. You'll need to cut a four meter length for each group. Duct tape, meter tapes and extra rubber bands.

You need to provide FOSS planes from the previous lessons, scissors, staplers, and rubber bands of various sizes. Duplicate the Student Sheet called Design An Experiment: Plane Sense. Have the Assessment Chart For Investigation 3 available.

To begin this part, review what constitutes a controlled experiment. A controlled experiment is actually two investigations. First conduct an experiment to set the standard for comparison. Then conduct more investigations in which all the variables stay exactly the same except for one.

In this way, when the two outcomes are compared, any change in outcome can be attributed to the variable that was changed. The students are recording the standards on their Design An Experiment: Plane Sense Student Sheet.

Student: Our experimental variable is rubber bands.

Student: Yeah. And then the next one is one rubber band because we have to experiment with only one.

Student: One rubber band at a time.

Student: One.

Student: I don't get that incremental change of experimental variables.

Student: Incremental is how much you're going to increase it each time.

Student: So we say --

Student: So we say we're going to increase it one each time.

Student: Yeah. But down on the chart we have to --

Student: We'll just put one.

Student: It says outcome and we put the distance.

Narrator: The concept of changing a variable in increments to give more precise control is being introduced. The students will conduct their test three times changing the variable one increment each time but keeping everything else to the standard.

Student: Our first one is 190, okay?

Student: Write it down, please.

Student: 190.

Student: Okay. Test No. 1. In the first column we did one passenger and the distance was 190 centimeters. Okay.

Student: Whoa, that was a big difference.

Student: A big difference.

Student: That was kind of pathetic.

Student: That's okay.

Student: Will, can you hold this and tell me where it's at?

Student: It's about --

Student: Pull it taut.

Student: There's 100 and--

Student: Right here.

Student: 2.

Student: 3.

Student: 103.

Narrator: This time the students are much more precise and keep careful records of what they are doing.

Student: Stop, Will.

Student: Will, stop.

Student: Come on, Will.

Student: Watch out, Will.

Student: Will, move.

Student: Okay. Ready.

Student: Let's go. Three paper clips.

Student: I don't think it will reach that far.

Student: Whoa.

Student: That was really weighted down.

Student: Can it make it farther than this with eight paper clips?

Student: Let's measure it. Can someone grab this end and tell me what it is?

Student: Our rubber band is like --

Student: It's fine. Don't worry.

Student: Oops. Wrong side.

Student: It's at 9- -- no. 89 and a half.

Student: 89.

Student: 89.

Student: That was a big change.

Narrator: Students should have learned that if they change more than one variable at a time, they will not know how any one of the variables affected the results.

<Investigation 3, Part 4>
Narrator: In this part, students graph the results of their controlled experiment to help them see the relationship between the identified variable and the distance the plane flies. Here is what you'll need for this part: You'll need to provide student sheets from Part 3 called Design An Experiment: Plane Sense. Duplicate Student Sheet No. 16 called Two-Coordinate Graph. Have Assessment Chart For Investigation 3 available. Optional materials you can use to demonstrate making graphs are an overhead transparency of the Two-Coordinate Graph and a transparency pen.

To begin, distribute the Two-Coordinate Graph sheet to the class.

Teacher: What you have is called a Two-Coordinate Graph, in that this graph displays the relationship between two different variables. The X down here is what you know. And the Y along the vertical is what you want to find out.

Narrator: The teacher continues to explain that this is a graphing convention that all scientists use. The X axis will represent the variable they tested, the independent variable. The Y axis describes the effect of that variable on the system. The units on the vertical line are called the dependent variable because their value depends on the test variable.

The teacher uses the transparency to model how to plot information on the graph. Using one group, he asks: What was the independent variable in your experiment? He may need to explain that the independent variable was the one they tested. He labels the X axis.

Teacher: Georgina, what units did you use to mark the horizontal line on your graph?

Student: We did it in increments of 10.

Teacher: 10 what?

Student: 10 centimeters.

Narrator: The increment varies depending on the variable tested. Passengers increase by two. Motors or rubber bands increase by one. He points out that he is placing the numbers on the lines, not in the spaces.

Teacher: Could you mark along the vertical side?

Student: Maybe tens.

Narrator: Some of the students will need additional help figuring out the increments for the Y axis. Some may use 50 centimeter increments, depending on their longest flight. After the Y axis is numbered, it is labeled distance.

Teacher: We have centimeters. And that's the distance that your plane flew along the flight line.

Student: That's all right. Okay. Here we go.

Narrator: Most students will remember from the earlier investigations how to plot the points. They may need to be reminded that points go on the lines and not in the spaces. The students may see some discrepancies on their graphs, which can lead to questions for study in Investigation 4. These questions should be added to the Project Ideas Folder.

Teacher: Now that you've had a chance to plot your results on the graph, what I would like to find out from each group is the result that they came up with and be able to explain the variable that they tested.
Lizzy?

Student: We found that as we moved our string out more and more for the level of the flight line, that it got harder for the plane to go farther in the amount of swings that we did, which was the standard, 35. And so it didn't go as far every time.

Narrator: At this point students understand how changing different variables affects the flight of their planes. This brings us to the end of Investigation 3. Be sure to select several of the interdisciplinary activities for the students to do. And have the students do the math problem of the week before going on.

<Investigation 4, Part 1>
Narrator: In this investigation, students construct a small catapult called the Flipper System. Don't worry. The students won't flip out. But they certainly will have fun. Here is what you'll need from this part: From the kit: Craft sticks and craft stick pieces. You'll need to provide glue and scrap paper. Duplicate Student Sheet No. 17 called Flip-Stick Construction. Make one copy of Assessment Chart For Investigation 4.

Begin this session by demonstrating the flipper system for your students. In this part, they'll make their own flip sticks.

To begin this part, students make their own flip stick. The diagram shows how the flip stick is assembled. These indicate where you put the cross pieces. So to begin, you would lay a craft stick on the diagram. Apply two spots of glue and apply the cross pieces. Let it dry overnight. Be sure to check your Science Stories folio to plan time for student reading.

<Investigation 4, Part 2>
Narrator: In this part, students explore the flipper system by varying the mass of the object flipped. Here is what you'll need for this part: From the kit: angle braces, flipper bases, rubber stoppers, corks, craft sticks, meter tapes, plastic bags, and aluminum foil. Each group will need a length of 20 centimeters and one of 10 centimeters.

You'll need to provide flip sticks made in Part 1 and pencils. Duplicate Student Sheet No. 18 called Flipping Aluminum Balls and No. 19 called Response Sheet - Flippers. You can use this for assessment. Have Assessment Chart For Investigation 4 available.

Begin this part by explaining to students that their flip sticks need to be calibrated in order to be useful for experiments. The diagram on the board shows students how to calibrate their flip sticks. They will use meter tapes to mark one centimeter increments on their sticks.

Student: Okay.

Student: Label that as 1, 2, 3, 4 --

Narrator: The teacher asks each group to label their sticks since they will use them for several sessions.

Teacher: And I would like you to explore and investigate with the flipper system what you can do with the corks. What happens when you use the corks with the flipper system? Any questions?

Student: Okay. With the cork.

Student: Can I try?

Student: Whoa!

Narrator: The teacher allows several minutes for the groups to explore the system to find out how it works.

Student: Oh!

Student: Yeah,

Student: Whoa! That went far.

Student: Not really.

Teacher: Okay. When you were flipping the corks in the flipper system, did the rubber stoppers and the corks go the same distance.
Garnet?

Student: Well, my group and I found that because -- we're guessing because the rubber cork was heavier, it didn't go as far, even when we had the same length of when we did the regular cork.

Student: I found that with our group, like the farther out the stick went, the less far the cork or the rubber stopper went.

Narrator: The teacher encourages students to share their experiences. Then he explains that what they described were variables that might affect the outcome of their experiments.

Teacher: -- in the experiment is called a variable. And the third one was how hard you pressed the flip stick down.

Narrator: As students identify possible variables, they are listed on the board.

Student: Well, another variable might be where you put the cork on the stick.

Teacher: Good. That's one we didn't think of. The position of the object on the flip stick.

Narrator: To keep track of their explorations, students record the variables in their notebooks.

Student: As small as you possibly can. And really round.

Narrator: The getters return the corks and stoppers to the Materials Station. Now the students will make new projectiles from a material that can be measured in increments. They will make balls from 10 centimeter and 20 centimeter lengths of aluminum foil.

Teacher: Some of these or maybe all of them ought to be written down as those that you're going to consider.

Narrator: The students are challenged to find out how to make the highest and longest flip. It's an exploration, not a controlled experiment. They can change whatever variables they like.

Student: Yeah.

Student: Up there.

Student: So from here that was --

Student: 57.

Student: 57. And that was on 0.

Student: Yeah.

Student: And now try 2.

Student: Okay.

Student: Whoa.

Student: No. We aren't supposed to change it at all. We're supposed to do it only one way.

Student: Let's just try it again. Ready.

Student: Use the flipper stick.

Student: Okay. Now let's go to one. We have to push it all the way in.

Student: No. You're not supposed to push it. Just do it like that.

Student: No, Christy. You can't change anything.

Student: There's only one change. Remember we can only change one thing.

Student: You aren't supposed to change it, though. So don't count it.

Student: Let's just start it with closed and closed with the big ball. Okay?

Student: Let's write it down.

Student: 117.

Student: You guys, we have to be writing these down.

Student: I know.

Student: The variable we changed was the position of the flip stick in the base. And we found out that the small ball with the stick all the way in the base went the highest.

Teacher: Great. A new variable that we're going to work with is called this angle brace. And this angle brace is designed to hold the flipper base at different angles. So I'm going to add that variable to the list. We talked about some variables that would affect how high the aluminum ball will flip. And what we want to do is look at the variables that worked the best. And those were the size of the aluminum ball, which was the smaller ball, worked best. The position of the flip stick in the base. It sounds like out to one worked best. And then pressing it down all the way hard and putting the aluminum ball right in the middle of the two small pieces of popsicle stick.

When we introduce a new variable like this one -- this is called the angle brace. And it holds the flipper base at different angles. It will hold it at a 10 degree angle just like this, a 20 degree angle, a 30 degree angle and a 40 degree angle. So when we're adding a new variable, we have to control all the other variables in order to watch for differences of the new variable that we're working with.

Narrator: The students refine their testing procedure by listing the variables and how they can be controlled by making careful measurements and by recording the data.

Student: Right here. 97.

Student: It looked like it was gone anyway.

Student: So that's about --

Student: That's 100.

Student: It landed right there.

Teacher: Okay. Brandon?

Student: We found out that to get the aluminum ball the farthest, we had it on 40 -- a 40 degree angle. And we used it three centimeters out, the flip stick. And we put the aluminum ball in the middle of the two sticks.

Teacher: And which aluminum ball did you use?

Student: We used the small one.

Teacher: The small one.

Narrator: In this part, students should learn that the mass of the object, angle of launch and length of the flip stick are among the variables that can affect the distance and height the object can travel. This is a really good time for students to add ideas and questions to the Project Folder.

<Investigation 4, Part 3>

Narrator: In Part 3, students design their own controlled experiments to test the affects of different variables. Here is what you'll need for this part: From the kit you'll need flipper bases, meter tapes and angle braces. You'll need to provide flipper sticks and aluminum balls both made from the previous lessons along with pennies. Optional items include a transparency of the Two-Coordinate Graph, marking pens for each group and calculators.

Duplicate Student Sheet No. 20 called Design An Experiment: Flippers and Student Sheet No. 16 called Two-Coordinate Graph. Have Assessment Chart For Investigation 4 available.

Begin this part with a review of controlled experiments. Review the variables and a description of the standard launch. This group insisted on testing the size of the ball.

Student: Okay. That's about 129.

Student: Now you can do this.

Student: Yeah.

Student: A lot easier.

Student: Let's go.

Student: That was 57.

Narrator: This group is using pennies to test the variable of how far the stick is depressed. This group is testing the length of the flip stick.

Student: Whoa. That was like right over here. That was high.

Student: That was like right there.

Student: Right there.

Narrator: This group is testing the position of the ball on the flip stick.

Student: Whoa.

Student: So right here.

Student: Put a little sticky there.

Narrator: The students find the averages after recording four tests for each increment. The students now use the information on their student sheets to make a Two-Coordinate Graph. Some students will still need help with this process.

Student: Our results showed that the further we pulled the stick out of the base, the less height it went.

Narrator: In this part, students should see the relationship of the variable to the change in the test results.

<Investigation 4, Part 4>

Narrator: In the last part of this module, students will work on their own investigations. As they work on their projects, you'll gain insight into how well the students understand the concept of variables. 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 plan sheet should be completed by each student or team of students doing a project. This sheet helps you control materials and keep tabs on what the students are doing. You will need to decide whether or not you will be able to supply any additional equipment the students ask for. You'll 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 guidelines on 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 the students to work on their projects. You can give them some time at school to work on it and also suggest that they work on it at home.

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

This is the end of the Variables module. Keep in mind that there are details in the Teacher's Guide that we weren't able to present in the video. I love this module and the kids love it, too. I know that you'll have a wonderful time and love each part of it. You'll want to do it over and over again.