Swing Into the Scientific Method

SUBJECT AREA: Scientific processes, physical science and mathematics.

Grade Level: 5-8

OVERVIEW

This short unit was designed in order to help teachers to teach students how to conduct and evaluate a scientific investigation using a pendulum as the experiment apparatus. The unit is presented in a way that allows for inquiry-based learning. Students learn to identify variables, then to simplify the experimental process by controlling those variables in the tests. These concepts are explored while addressing several Washington and Oregon State Standards in science and mathematics.

OBJECTIVES

- To develop an understanding of variables
- To understand the need to change only one variable at a time
- To collect and analyze data

CONNECTIONS TO STANDARDS

- Math: Investigations, measurement, analysis, predictions and inferences, data collection, conclusions and verification
- Science: Systems, forces and motion, investigations, questioning

MATERIALS

Spool of string, yard sticks, 50-60 washers of various sizes/weights, box of paperclips, pencils, tape, index cards, stop watches for each pair of students (a single timer can be used) chalk board, copies of attached worksheet and graph paper.

A TEACHER'S GUIDE FOR THE ACTIVITY

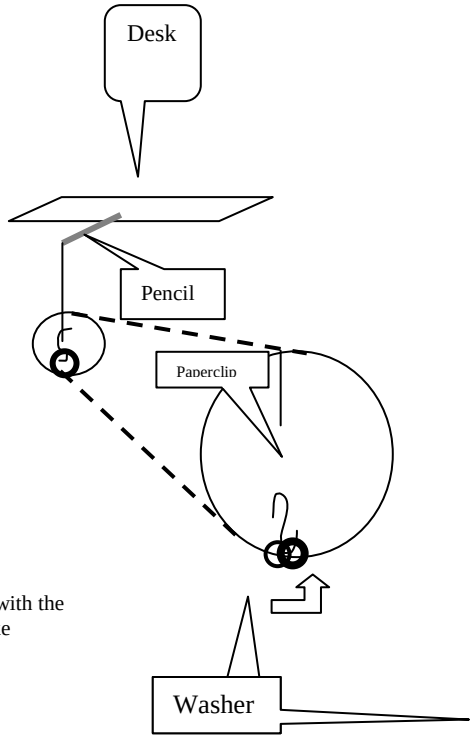
DAY 1 *Pendulums and Swing Rates*

Teacher Prep:

- Designate a materials center
- Cut pieces of string in ranges of 10-12 and 19-23 inches. Use a variety of lengths, one for each pair of students.
- Be prepared to assign each student a partner

PROCEDURE

1) Falling Paper
   A. Hold up two equal sized pieces of paper (parallel to the floor). Let them both float to the ground.
   B. Ask: What change could I make in order to have one piece of paper drop faster?
   C. Discuss several possible changes that could be made in order to cause the paper to drop faster (demonstrate a few suggestions)
   D. Ask if the students think there is a limit to how fast you can make a piece of paper drop. (Allow them to explain their answers)
   E. Explain to the students that the changes we made to the paper affected how fast the paper dropped. Understanding how to make changes, then observing the effects of those changes is what experimenting is all about.
2) Building Pendulums
   A. Explain to the students that they are going to be working with pendulums made out of string, paperclips, and washers. Then they will collect data about the pendulums and how they swing.
   B. Notify students how they will be grouped and assign a materials manager for each group.
   C. Instruct materials manager to go to the supply table to pick up a length of string, two pieces of tape, and 1, 2 or 3 washers.



This is what the washer with the paperclip should look like

D. Demonstrate how each group is to:

1) Construct a pendulum by tying the piece of string to a paperclip folded into an S-shape.
2) Put all the washers you have on the paperclip. Fold the paperclip so all the washers stay in place.
3) Tape a pencil down so that it hangs over the edge of the desk.
4) Tie the string to the pendulum so that it swings freely in a parallel motion from the edge of the desk.
5) Pull the pendulum back and release; use a stopwatch and count the number of full swings in 15 seconds. The total number of swings in a given time is called a swing rate. (As an option you could have your students count to the nearest half swing.)
6) After students have had a chance to find their pendulums' swing rate, call on groups and list their results on the overhead projector.

3) Were We Accurate?

Have the class examine the data gathered. Discuss the wide variety of swing rates listed. Guide students to question why each group didn't have the same

swing rate. Suggest to the class that maybe their swing rates were not accurately measured.

4) Let's try it Again

A. Have the class repeat their original experiment several times to make sure they measured time and counted swings accurately.
B. Call on groups and record the second set of data on the overhead projector.
C. Tell materials managers that as they turn in their string portion of their pendulum, that you want them to attach an index card with the swing rate on it. (These pendulums will be used in the next lesson)

5) What Changes Can We Make?

After pendulums have been turned in, discuss why the students think there is still such a wide variety of swing rates between each groups' pendulum. Ask: "What are some changes we could make in our pendulums that might affect their swing rate?" (Do not confirm which change is correct.)

NOTE: As each suggestion is made, list it where the entire class can see it. (Weight/diameter of washers, string length, how high the pendulum was held to begin the swing, etc.).

6) How Will We Conduct Our Investigation?

A. Ask the class how they could go about testing the change or changes they could make in their pendulums to alter the swing rate. (Lead to the idea of controlling variables and testing one change at a time.)
B. Tell the class they will be designing experiments that could determine which suggestion(s) are correct.
C. Each group is to test each change one at a time in order to determine what affects a pendulums swing rate. Both group members write a brief description of each experiment and the results. This is done so they don't forget how or what they tested.
D. Demonstrate an example on the board.
   First we counted the number of swings using 3 washers in 15 seconds.
   Then we counted the number of swings using 1 washer in 15 seconds
   We learned that changing the weight…

NOTE: Students should be encouraged to make one change at a time and test that change several times.

7) Begin Testing

Instruct material managers to get the necessary materials in order to conduct further testing. (String and more washers if necessary)

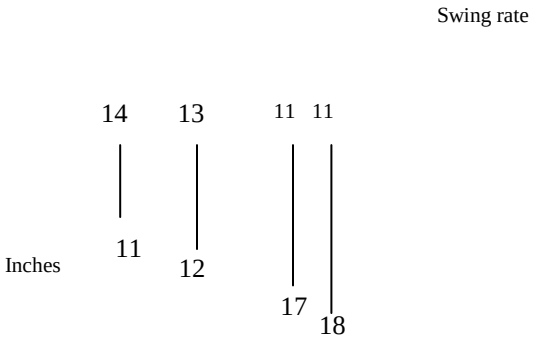
8) Sharing Our Results

Each group shares with the rest of the class what they did and the data they collected (the class should conclude that the difference in the number of swings is due to the different lengths of string.)

DAY 2 *Interpreting Our Results*

Teacher Prep:

- Measure each of the collected pendulums then hang them on the chalkboard in consecutive groups according to swing rate and length. Then label as shown.
- Provide a yardstick for each group.



1) Review The Last Lesson
   As a class, interpret and discuss the results of yesterday's experimentation. (Students should conclude that the number of swings in a fixed time decreases in a regular manner, as the length of the string gets longer.)
2) Create A Missing Pendulum
   Have same groups as before construct a pendulum that may not be represented on the board, for example having an 11 and a 13-swing rate, but no 12.
3) Hang Them Up
   As groups complete the challenge have them measure and label, then hang their new pendulums on the board in the appropriate position.
4) Saving The Data
   A. Discuss with students how they went about creating a pendulum for the missing rate. (Most likely with data from the board.)
   B. Ask what the data shows (relationship between string length and swing rate.)

C. Discuss why they think two or more different lengths would have the same rate. (In many cases, a partial swing may have been counted/ not counted as a whole swing.)
D. Explain to the class that the pendulums hanging demonstrate a lot of important information, but that the pendulums are going to be taken down.
E. Ask the class to accurately save the information in any way they choose. (Most students will draw the chalkboard with the pendulums of different lengths, but some may draw charts, graphs or make a listing of the data.)

5) Homework Suggestion

Challenge students to find examples of pendulums at home or in their neighborhoods.

DAY 3 *Making Graphs and using the Data.*

Teacher Prep:

- Graph paper for each student. (see attached copy)
- Write up an example version of a students collected data in "picture form" from the last lesson onto a transparency
- Prepare to demonstrate a 30 and 60 inch swinging pendulum. Use a location suitable for viewing by the entire class.

1) From Data To Bar Graphs
   A. Discuss how students collected data about swing rates from the last lesson.
   B. Demonstrate how easy it is to take an example of a pictograph, similar to this, and convert the pendulum strings into bars on a graph. Then add increments, labels for each axis and a title to show how to construct a bar graph with their data.
   C. Explain to the students that we can make our graphs easier to read if we had one representative length for each swing rate. This can be done by finding the average length of string for each swing rate.
   D. Hand out graph paper and instruct students to construct an accurate bar graph that represents their collected data. All bar graphs should include numbered increments, labels for each axis and a title.
2) Making Predictions Using Data
   A. Now students are challenged to envision a pendulum that is 30 inches long. What would be the swing rate? Using data from their bar graphs, have students predict the number of swings a 30-inch pendulum would have. (Allow time for students to think through and support their prediction.)
   B. Discuss with students some methods they used to calculate their predictions. (Students may mention extending the graph curve or finding relationships between strings of different lengths and their swing rate.)
   C. Before swinging the 30-inch pendulum, ask the class: "What part of your graph shows the greatest change in swing rates? For a swing rate to change in this range what is the difference in string lengths?" Does this information make anyone want to change his or her prediction? Why?
3) Swing the 30-Inch Pendulum
   A. In front of the class, time a 30-inch pendulum and have the class count to confirm their predictions.

B. Once the swing rate has been established, have students extend their graphs in order to show a 30-inch pendulum and it's swing rate.

4) Challenge!
   A. Now challenge students/groups to estimate the number of swings of a 60-inch and a 3-inch pendulum. (It is suggested that students use their graphs in order to rationalize their predictions in written form.)
   B. When predictions are written, discuss a few different rationalizations before swinging the 60 inch and 3 inch pendulums.

5) Extension Ideas
   A. Provide enough string for each group. Challenge students to make a pendulum that swings exactly 7 times.
   B. Have a student or students collect more accurate data on the swing rates of pendulum ranging from 3 to 30 inches. Have them graph the data, then explain why their graph is more precise than the class' data.

DAY 4 *Identifying Variables*

Teacher Prep:

- ***Identifying Variables*** worksheets for each student. (see attached copy)

1) Summation

Explain this to your class:

As you may recall, in lesson one we used a scientific approach in order to understand which part of the pendulum causes change in the swing rate. Trying to change all the parts of the pendulum at once would make this a very complex problem to solve. However, we used a systematic approach of changing only one part of the pendulum at a time. This made it much easier for us to see what parts had affects on swing rate and which parts did not.

REVIEWING

1) What changes did we test on our pendulums in order to see what affected the swing rate?

CHECK FOR UNDERSTANDING

1) What changes could be made to affect the taste of pizza?
2) What changes might affect the height a plant grows?

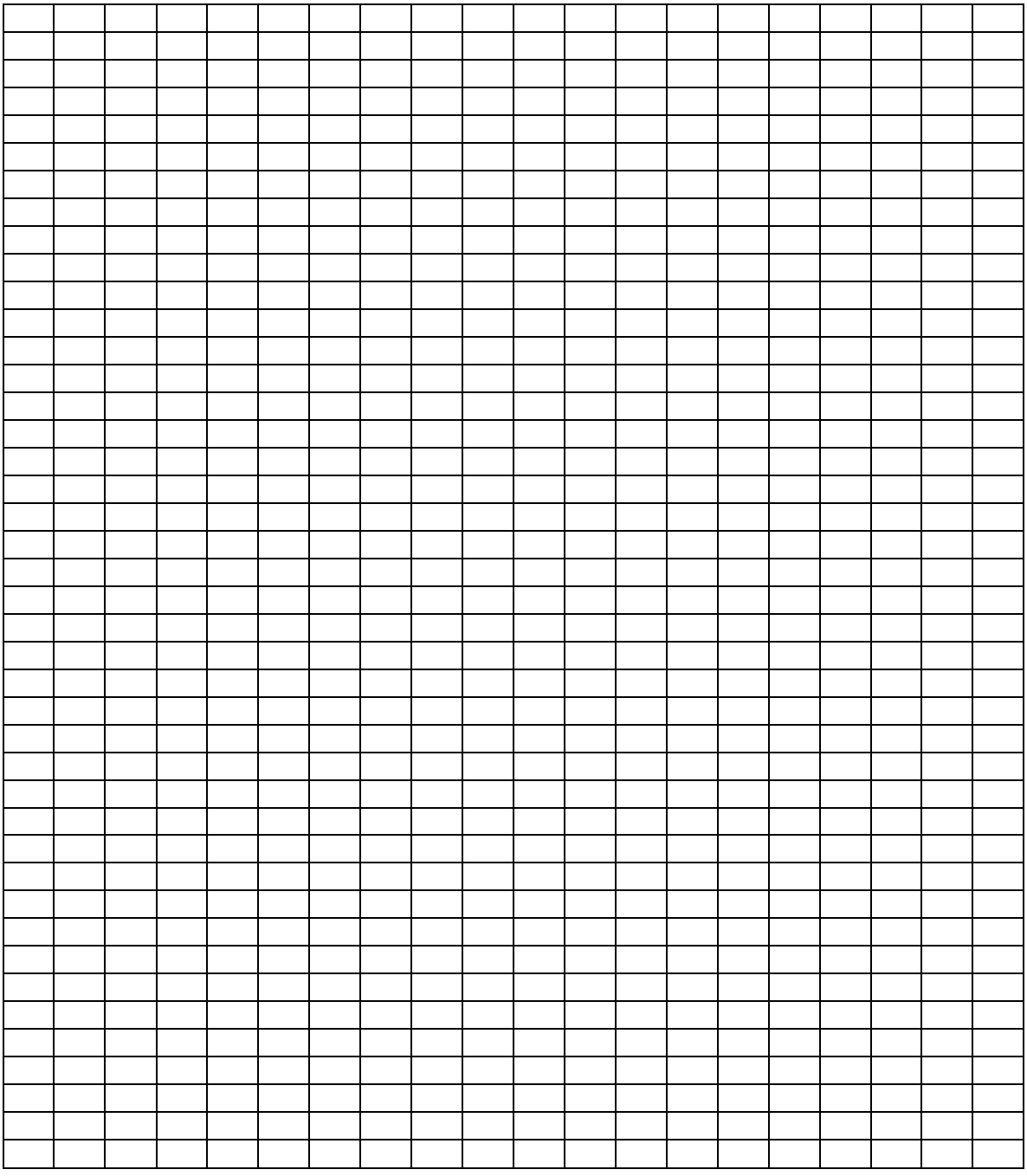
At this time, please pass out the ***Identifying Variables*** worksheet.

3) Have students read directions, then ask them to explain what a variable is.
4) Students complete worksheet.

Graphing Activity

Name: _____

Directions: Be sure to include numbered increments, labels and a title on your bar graph.



Variables Worksheet

Name _____

Directions:The parts of an experiment that can be changed are called variables. Changing one or more of these variables **may** cause the outcome of your experiment to change. So you can see the importance of being able to identify all the variables, in order to make sure you are keeping them all the same, except for the one variable you are testing.
Read each of the following statements, then identify at least four different variables that might affect the outcome.

1) What variables can affect attendance at a baseball game? _____
_____
_____

2) What variables can affect the taste of a soft drink? _____
_____
_____

3) What variables can affect how fast a race car can go around the track?
_____
_____

4) What variables can affect the rate at which an ice cube melts? _____
_____
_____

5) What variables can affect the distance a soccer ball can be kicked? _____
_____
_____

Knowledge/ Comprehension

6) What is a variable? _____
_____

Application

7) Given above are examples of experimental situations. You wrote about possible variables that could affect the outcomes. Now write an experimental situation of your own where identfying variables would be important, then explain the variables involved.
Situation:_____
_____
Variables_____
_____

Synthesis

8) What variables might be changed to help the toy car roll farther down the track?_____
_____
_____