Scientific Experiments Using the Inquiry Activity “Pendulums”

Prep Time: 30 minutes  Class Time: 1 class period

Word Wall Words: experiment, independent variable, controlled variable, dependent variables, hypothesis, prediction, repeated trials

Overview
A pendulum is any mass that swings back and forth on a rope, string, or chain. Pendulums can be found in old clocks and other machinery. A playground swing is a pendulum.

Through this inquiry, students develop an understanding of experimental design as they design an experimental to answer questions about a pendulum swing. The central goal for this activity is to understand the need to control different variables and learn to adjust them to ask questions and seek answers to get needed results. The students record observations and results on the provided data sheet. This activity is purposeful, planned, and requires a lot of teacher guidance.

NGSSS
SC.5.N.1.2
SC.5.N.1.3
SC.5.N.1.4

Learning Goals
The student will be able to:
  1. Recall the difference between experiments and investigations.
  2. Understand that a scientific variable is a factor that can influence the outcome of an experiment.
  3. Recognize and explain that repeated trials in an experiment are important to minimize the effects of errors or outliers with the purpose of obtaining more accurate results.
  4. Identify a control group and explain its importance in an experiment.

Misconceptions to tackle
  1. There is no difference between predictions and hypotheses.
  2. All scientific inquiries are experiments.
  3. Scientists always do three repeats of a trial.
  4. More than one variable can be altered during an experiment.
Materials
Pendulum Picture (see below)  Student trays (# depends on # of groups)
Document camera  Each tray should have:

Pendulum Demonstration:
• 1 meter stick
• 1 string
• 1 roll of tape
• 2 to 3 washers
• 1 table/desk
• 1 stopwatch

Background
Variables: Scientists use experiments to search for cause-and-effect relationships in nature. In other words, they will design an experiment so that changes to one item cause something else to vary in a predictable way. These changing quantities are called variables. Variables are a key element of the scientific method.

1. **Independent** – also known as the *manipulated variable*. This is the one thing you change in your experiment. It can also be called the “I change” variable or “the treatment.” You want to see if changing this variable this will cause a change in the dependent variable.

2. **Controlled** – these are the variables you must keep the constant so the experiment is valid. There are usually MANY variables that must be controlled in any experiment.

3. **Dependent** – this is what changes as a result of changes in your independent variable. This is also known as the *respondent variable*. (The effect of the independent variable.) It should be measurable and recordable.

For example, plant growth depends on the amount of water it receives. In this case, plant growth is the dependent variable and the amount of water is the independent variable. Controls in this experiment would include the amount of sunlight, temperature, and the kind of plant.

Procedure
**Engagement**- 10 minutes

Prior preparation: Set up the pendulum on a desk. Tape a ruler to the desk and tie a string at the end of it, then tie a couple of washers to the other end of the string. Also, have a timer available in order to record the number of swings per unit time.
Additionally, place the “Pendulum Picture (below)” on the document camera.

• Ask students to quietly look at the pictures for a few seconds and start a class discussion. Below is an example of the questions that you can ask, with possible student responses, to assess students’ prior knowledge of pendulums.

**Teacher:** What do the pictures have in common?
**Students:** They all swing. (Other responses might follow.)
**Teacher:** Okay, how are they different?
**Students:** One is a tire swing; the other is a grandfather clock…etc.
**Teacher:** Well, do you think they all swing the same way?
**Students:** Well, no...
**Teacher:** What are some aspects that would make them swing differently?
**Students:** Length of the swing, weight of the tire, etc.
**Teacher:** So, what are all these designs called? Does anyone know?
**Students:** (Some may know) Pendulum.
**Teacher:** Well, they are called ‘pendulums’ (if the students do not use that word).
Teacher: If these are all called ‘pendulums,’ then what do you think pendulums are?
Students: Something that hangs off a string? (allow about 3 student responses)
Teacher: Let’s look closely at factors that can influence the pendulum movement.

- Now move to the pendulum demonstration you have set up and swing it.
- Ask students to explain the movement of the pendulum and start a class discussion. Refer to the transcript below for example questions and steps to guiding students to think about how the pendulum moves.

Teacher: Watch me swing this pendulum back and forth and tell me what you see.
Teacher: How many “swings” do you think I can get in 15 seconds?
Students: offer ideas
Teacher: Let’s try that out. Have students in pairs record the number of swings they see as you time.
Teacher: How many swings did you record?
Students: (will offer different answers)
Teacher: How can we get different answers? Didn’t we all use the same pendulum?
Students: (I counted a swing each time it moved from one side to another. OR, I counted a swing each time it moved from one side and back again.
Teacher: This is an important point, in an experiment, we all have to be measuring the same event the same way. What will we “count’ as a swing in our experiment?
Students: One swing can be going from one end of the pendulum and then returning back to its old spot.
Teacher: Allow at least 2 different opinions on what should constitute a swing. Take a quick vote to determine how students are going to count the number of swings.
Teacher: Okay, now I will start swinging the pendulum, but first I need a volunteer to help me with this. Calls one student to hold the pendulum to one end. You will start the timer
Teacher: Okay (to volunteer), when I say “go,” you will let go of the pendulum and I’ll start the timer. (To the class) Okay, I want all of you to silently count the number of swings that you see and record them on your paper.

After the timer goes off
Teacher: Okay, how many swings did you count? What other observations can you make from the movement of this pendulum?
Students: It’s swinging back and forth; the washers are tied to a string, (etc.)
Teacher: Now, if I add two more washers, what do you think will happen?
Let students make a couple of guesses before swinging the pendulum
Students: It will swing faster.
Teacher: Okay, what will I be controlling? Am I changing anything else?
Students: No
Teacher: Well, what stays the same?
Students: The length of the string.
Teacher: What are we changing?
Students: The number of washers
Teacher: Okay, I need a different volunteer this time to help me swing the pendulum. Again, I want all of you to start counting the number of swings silently.

**Teacher swings the pendulum (4 washers attached) for 15 seconds**

Teacher: Okay, what did you see this time?
Students: There were more swings.
Teacher: Why do you think there were more swings?
Students: Because there was more weight on the string.

- End the discussion by emphasizing the role of controls and variables without actually giving them the definitions of the terms.

**Exploration - 35 minutes**

The idea for the activity is for students to come to an understanding that you need to control all the variables except one in order to provide a basis of comparison between the number of swings and all groups.

Prior preparation: Place all string sizes (30-cm, 45-cm, 60-cm), 5 washers, 1 pair of scissors, 1 ruler, 1 stopwatch, 1 roll of masking tape, 1 meter stick, and 3 Data Sheets on each tray.

**Part one**

- Split students into groups (3 students each).
- During the first 10 minutes of the activity, students will make their pendulum. Have one tray at the front of the classroom to show the students the materials that they will receive. Before passing out the trays to each group, give the instructions on the activity to the students.

“You will create your pendulum using the materials on your tray. Each member of the group must be doing something. One person should be the recorder (records the number of swings), one person can be in charge of the timer, and another person can swing the pendulum. Take turns each time that you do a trial. For example, someone in your group can start by being the recorder, but will switch to swing the pendulum, etc. You can use any sized string and any number of washers. You will work on this for 10 minutes until the timer goes off. Do not write on your data sheets yet; however, you can use the back to record the number of swings.”
• As students are working on their pendulum, ask each group probing questions, such as “What size string are you using? How many washers? How many seconds are you going to use to time the number of swings? What do you think will happen to the number of swings?”
• At the end of 10 minutes have everyone stop working and begin a class discussion (~ 5 minutes). Ask each group what they did and whether they can provide a basis of comparison for the number of swings on the pendulum. Continue with part two, once the class realizes that they need a control in order to compare the variables. Make sure to also note that some groups timed their number of swings differently.

Part two

• Have students do the activity again, but this time, ask them to change some variables. Some guiding questions are “Should we do this once or several times? Why should we do it several times?” Students will decide what they want to control; however, make sure that all students use the same number of seconds to count the number of swings. Once they decide what they will control, have two groups use the same variables. For example, two groups can use a 30-cm string with 1 washer, two groups can use a 30-cm string with 3 washers, and 2 other groups can use a 30-cm with 5 washers. Also have students agree on the number of trials, keeping in mind that 10 minutes will be spent on the activity. The idea is to have students ‘own’ the activity by having them make their own decisions.
• Set a timer for 10 minutes and ask your students to record what they see on their data sheets and to answer the questions.
• As students are working, ask probing questions similar to part one.
• After 10 minutes have groups share the number of swings they got and write them on the board. Also ask what size string/how many washers they used.
• Start a class discussion (~ 5 minutes) asking students to find a pattern between the number of swings, and the control and variables used. Then ask if they can provide an explanation for the pattern.

Part three

• Have students change some more variables. For instance, if they changed the number of washers the first time, then have them change the size of the string. Once again, even out the number of groups working on the same sized string/same number of washers.
• Give students 10 minutes to work on this with their groups. Remind them to fill out their data sheets and switch roles.
• Again, ask probing questions as students work.
• After 10 minutes have groups share their data and record it on the board.
• Start a class discussion (~ 5 minutes) using probing questions such as, “What did you notice this time? What patterns do you see? Can you provide an explanation for the pattern? Which change had the most affect on the number of swings?”

Explanation - 5 minutes

Prior preparation: Write the words “control,” “independent variable,” and “dependent
variable” on the board.

• Have a class discussion these words. Refer to sample transcript below.

**Teacher:** Okay, after doing this activity, what do you think a “control” is? What did we “control” during the second part of the activity?

**Students:** We controlled the number of washers/length of string, so a control means that it is the material in an experiment that is not changed.

**Teacher:** Okay, now what do you think an “independent variable” is? What does “independent” mean?

**Students:** All by itself.

**Teacher:** Okay, what does vary mean?

**Students:** “Vary” means something that changes, so an “independent variable” must mean something you change an experiment. The dependent variable is the thing being changed (in this case the number of swings).

**Teacher:** Was this an investigation or an experiment? Why?

**Students:** It was an experiment because we had controlled everything except the independent variable.

**Teacher:** How is using a control and variables different from an investigation?

**Students:** You don’t have controls in an investigation.

**Teacher:** Why did we do our experiment several times? Why did I ask everyone to do it?

**Students:** (???)

**Teacher:** In an experiment we want to be sure that the same thing happens over and over when you change the independent variable, to be sure that our results aren’t simple mistakes or chance. In science is it important to repeat our trials until we are sure we are seeing a common pattern.

**Summarize the Main Points**

• Experiments and investigations are different things. In an experiment, you manipulate one variable to test its influence on another one.

• What is an independent variable? A variable is a single factor that is isolated and tested in an experiment.

• What is a dependent variable? The dependent variable is the thing being tested in an experiment, the thing that will change based on the independent variable.

• In an experiment, only one variable can be tested at a time.

• What is a pendulum? It is a suspended object from a fixed point so as to swing freely to and fro under the action of gravity.
Assessment
• Have students individually complete Design Your Own Experiment (10 minutes).
• Once students have completed their assessments, have some of them share their experiments. Make sure to ask why their “experiment” is an experiment.

Exit Tickets
• Review “control,” “independent variable,” “dependent variable.”
• Identify the definition of an experiment and an investigation.
• Discuss on the use of repeated trials in an experiment.