How Does a Pipe Organ Work?

The Pipe Organ is an amazing instrument of engineering, math, and science. As established in the History of the Pipe Organ, it has progressed from hydraulic power to fiber optics. The mathematic and scientific aspects of this instrument can provide for some terrific cross curricular lessons between music, math, and science.

Contents

SUMMARY

This lesson introduces the pipe organ and explains the two types of pipes used, how sound is produced by vibrating objects, how vibrating objects produce sound waves that travel through the air (and other substances), and shows that the faster an object vibrates the more sound waves it produces per second and the higher the pitch of the sound. Math is also used to determine the number of pipes in an organ and how those pipe sizes determine size. Students will conduct experiments with sound.

LEARNING OBJECTIVES

Students will:

- Describe how different organisms and objects vibrate in order to produce sounds
- Learn what the relationship between the speeds at which an object vibrates and the pitch of the sound produced
- Describe different timbres an organ can make and how they are produced.

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- Describe the parts of an organ and how they connect to sound production.
- Design investigations that determine what factors affect the pitch of organ pipes based on their length.
- Create and record a meaningful hypothesis as well as accurate data sets reflecting knowledge gained through their investigation

Teaching Approach	Teaching Methods	Assessment Type
• Project-Based Learning	• Cooperative Learning	• Informal Assessment
• Arts Integration	• Large or Small Group Instruction	
	• Hands-On Learning	
	• Multimedia Instruction	
	• Guided Listening	

RESOURCES

- ***King of Instruments* Part 2**: How Does a Pipe Organ Work?
- Vocabulary
- http://artsedge.kennedy-center.org/interactives/perfectpitch/
- http://www.physics.org/tricks/straw-oboes/
- Arts Edge Woodwind experiment worksheet

Required Materials

- Bottles
- Water
- Straws
- Scissors
- Recorder

Required Technology

Computer and Screen or Smartboard
Speakers

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VOCABULARY

vibration: a periodic motion of the particles of an elastic body or medium in alternating opposite directions from the position of equilibrium when the equilibrium has been disturbed as when a stretched cord produces musical tone or particles of air transmit sounds to the ear

acoustics: the science of sound

pitch: how low or high the sound is; the frequency of a sound wave determines the pitch: the higher the frequency, the higher the pitch

sound: is a mechanical wave that results from the back and forth vibration of the particles of the medium through which the sound wave is moving. If a sound wave is moving from left to right through air, then particles of air will be displaced both rightward and leftward as the energy of the sound wave passes through it.

flue pipe: an organ pipe that produces sound through the vibrations of air molecules in the same manner as a recorder or whistle. The frequency is determined by length. There are no moving parts in a flue pipe.

reed: a flexible strip of cane or metal set into the mouthpiece or air opening of certain instruments to produce tone by vibrating in response to a stream of air.

reed pipe: an organ pipe that produces sound by a vibrating brass strip known as a reed**.** The frequency is determined by length.

timbre (pronounced TAM bur): also known as tone color, describes the tone or unique quality of a sound.

STANDARDS

Common Core Standards

- Grades K-4 History Standard 3: Understands the people, events, problems, and ideas that were significant in creating the history of their country

Georgia Standards of Excellence (GSE)

- S4P2. Obtain, evaluate, and communicate information about how sound is produced and changed and how sound and/or light can be used to communicate.
    - a. Plan and carry out an investigation utilizing everyday objects to produce sound and predict the effects of changing the strength or speed of vibrations.
    - b. Design and construct a device to communicate across a distance using light and/or sound.

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- S5CS2. Students will have the computation and estimation skills necessary for analyzing data and following scientific explanations.
  - a. Add, subtract, multiply, and divide whole numbers mentally, on paper, and with a calculator.
  - b. Use fractions and decimals, and translate between decimals and commonly encountered fractions – halves, thirds, fourths, fifths, tenths, and hundredths (but not sixths, sevenths, and so on) – in scientific calculations.
  - c. Judge whether measurements and computations of quantities, such as length, area, volume, weight, or time, are reasonable answers to scientific problems by comparing them to typical values.
- S5CS3. Students will use tools and instruments for observing, measuring, and manipulating objects in scientific activities.
  - a. Choose appropriate common materials for making simple mechanical constructions and repairing things.
  - c. Use computers, cameras and recording devices for capturing information.
- S5CS4. Students will use ideas of system, model, change, and scale in exploring scientific and technological matters. a. Observe and describe how parts influence one another in things with many parts. b. Use geometric figures, number sequences, graphs, diagrams, sketches, number lines, maps, and stories to represent corresponding features of objects, events, and processes in the real world. Identify ways in which the representations do not match their original counterparts. c. Identify patterns of change in things—such as steady, repetitive, or irregular change—using records, tables, or graphs of measurements where appropriate. d. Identify the biggest and the smallest possible values of something.

- S5CS8. Students will understand important features of the process of scientific inquiry. Students will apply the following to inquiry learning practices:
  - a. Scientific investigations may take many different forms, including observing what things are like or what is happening somewhere, collecting specimens for analysis, and doing experiments.
  - b. Clear and active communication is an essential part of doing science. It enables scientists to inform others about their work, expose their ideas to criticism by other scientists, and stay informed about scientific discoveries around the world.
  - c. Scientists use technology to increase their power to observe things and to measure and compare things accurately.

INSTRUCTION

ENGAGE

1. **Review the members of the woodwind instrument family.**
2. **Play instrument listening clips for the woodwind family from Perfect Pitch**
3. **Play King of Instruments Part 2: How Do Pipe Organs Work?**

BUILD KNOWLEDGE

1. Have students explore the following sites to learn more about woodwind instruments, either individually or in groups, depending on availability of computers:

- *ArtsAlive.ca Music: Instrument Lab: **Woodwinds**:* here, students can learn more about string instruments and play clips

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- *ArtsAlive.ca Music: Woodwind* ***Interviews:*** students can read interviews with musicians and view demonstration videos

2. Refer back to the 'Instrument Families of the Orchestra' handout located within the Resource Carousel. As a class, share any information discovered in the course of the research

APPLY

1. Review the Vocabulary adding the following term to the discussion:

2. Distribute and review the Scientific Process Guidelines for Woodwinds handout located within the Resource Carousel. As a class, have students create a sample hypothesis regarding the pitch that will be created by blowing over the tops of water bottles with air columns of different sizes. The size of the air column is based on the amount of water in each bottle. As a class, create a prediction based on the hypothesis, using the following format: “If our hypothesis is true then the pitch created should be higher /lower when the air column is longer /shorter.”

3. Divide students into cooperative groups of four. Assign one student to each of the following duties:

- *Recorder:* note taker
- *Group leader:* decision maker, dispute settler, teacher liaison
- *Equipment adjuster:* makes adjustments to test equipment
- *Tester:* performs the tests

4. Test the hypothesis within the groups. Students should fill four water bottles to different, measured levels. Students should record their observations on the 'Scientific Process Outline for Woodwinds' handout located within the Resource Carousel.

5. Review the procedural guidelines for Creating Woodwind Instruments handout located within the Resource Carousel and distribute supplies. Play listening examples while students create their instruments, using either the websites or the recordings suggested in Sources.

6. Have students work independently to create their own instruments. Follow the procedural guidelines for 'Creating Woodwind Instruments' handout located within the Resource Carousel.

7. Have students work in small groups to create a hypothesis and prediction regarding the relationship between air column length or size and the pitch it will create.

8. Have small groups test the second hypothesis and prediction using student-created instruments. Have students record their experimental data onto their own 'Scientific Process Outline For Woodwinds' handouts located within the Resource Carousel. Each student must complete the analysis section and the conclusion section independently.

REFLECT

1. Discuss the following questions:

- What is the relationship between pitch and the size of the air column?
  A longer air column creates a lower pitch. Since a breath travels a shorter distance in a shorter air column, the molecules move faster, creating a higher frequency and thus a higher pitch.
- What is the name of the branch of science that we have studied?
  Acoustics.
- What elements of the listening example influenced the design you created on your windpipe?
  Answers will vary.

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WOODWIND WORKSHEET

Worksheet

Scientific Process Guidelines For Woodwinds

Student Name: ____

Group Members: ____

Question: 1. How does the length or size of the air column or windpipe determine the pitch?

Hypotheses: 1.

2.

Predictions: 1.

2.

Please complete each column by labeling pitch, numbering from low to high.

Water level	Bottle 1	Bottle 2	Bottle 3	Bottle 4
0"				
1"				
2"				
3"				
4"				
5"				
6"				
Straw length	**Instrument 1**	**Instrument 2**	**Instrument 3**	**Instrument 4**
2"				
3"				
4"				
5"				
6"				
7"				

Analysis:

Conclusion:

Lesson Connection: Woodwind Instruments and Pitch

The Kennedy Center ARTSEDGE

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WOODWIND CRAFT ACTIVITY

Student Guide

Procedural Guidelines for Creating Woodwind Instruments

Read all directions before beginning this project.

Materials Needed:

1. 6 Plastic drinking straws per student
2. Cardboard or stiff paper
3. Scissors
4. Glue
5. Art Supplies (markers, colored pencils, crayons)

Step 1: Planning phase

1. The back of your air pipe should reflect something about the woodwind listening example your teacher will play for you. Design a windpipe that reflects the emotions or images the listening example creates in your imagination.
2. On a piece of paper, draw a picture of your future instrument or write a short paragraph describing what your instrument will look like.
3. Be prepared to explain your choices to your classmates.
4. List the art supplies you will need to decorate your air pipe.

Step 2: Decorating your air pipe

1. The sides of your air pipe will be cut from cardboard or stiff paper. Using a ruler, cut two pieces that are 6" long and 1½ " wide.
2. Using the arts supplies listed above, decorate the two outer sides of your air pipe. If you make changes from the original design, note the changes on the original design and circle the changes on your original drawing.

Step 3: Setting up your instrument

1. Using a ruler, measure and cut your six straws to the lengths listed on the Scientific Process Guidelines.
2. Line your straws up in order from shortest to longest.
3. Spread glue along the inside of one cardboard strip.
4. Glue the straws to the cardboard strip at equal distances, with the tops of the straws in line. The top end of each straw should just barely appear beyond the end of the cardboard piece.

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5. Allow the glue to dry before proceeding to the next step.
6. Apply glue to the inside of the other cardboard strip.
7. Glue this strip to the other side of the straws.
8. Allow time for the glue to dry.

Step 4: Playing your instrume nt

1. Hold the air pipe so that the even end of the straws is facing up.
2. Hold your mouth at the top of each straw and blow across the top of the straw. You will hear a quiet, flute-like sound.

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